Altered Lipid Profile, Leptin, Insulin, and Anthropometry in Offspring of South Asian Immigrants in the United States

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South Asians who immigrate to the United States have a propensity toward insulin resistance, central obesity, and elevated total cholesterol:high-density lipoprotein (HDL) ratio. To evaluate whether these alterations are apparent at a younger age, we studied 32 offspring of South Asian immigrants and compared them with 29 of European descent between 18 to 30 years of age. American-born South Asian males had significantly higher total cholesterol, low-density lipoprotein (TC:LDL) ratios, triglycerides, and fasting insulin levels (13.9 ± 7.1 and 10.0 ± 5.5 μU/mL, $P < .01$) than their European counterparts. The South Asian females only had increased plasma insulin levels (15.3 ± 8.8 and 10.0 ± 5.1 μU/mL, $P = .05$). The entire South Asian group had higher truncal skinfold thickness (40.1 ± 18.1 and 30.3 ± 12.6 mm, $P = < .05$) and lower insulin-like growth factor binding protein (IGFBP)-1 levels (46.8 ± 33.4 and 56.0 ± 33.4 μg/L, $P = .05$). Plasma leptin levels were also significantly higher in both males (4.3 ± 2.5 *v* 2.8 ± 1.3 ng/mL, $P = .0001$) and females (20.5 ± 10.3 *v* 10.3 ± 6.3 ng/mL, $P = .002$) South Asian subjects. A significant correlation between plasma leptin and insulin, triglycerides, TC, and body mass index (BMI) was seen in the South Asian males. South Asians born in the United States show evidence for an altered metabolic profile in young adulthood. The relative contributions of inheritance and nutritional practices early in life to this alteration remain unclear.

EPIDEMIOLOGIC DATA SHOW that immigrants to the Western hemisphere from the countries of South Asia (India, Bangladesh, Pakistan, and Sri Lanka) are at increased risk for cardiovascular disease when compared with the majority population of their respective countries of residence.[1-7] Among South Asians who have immigrated to the United States, prevalence of coronary artery disease (CAD) was shown to be 3 times higher than the general population of the Framingham Offspring Study.[1,2] Furthermore, South Asian immigrants in the United States had greater prevalence of type 2 diabetes mellitus, hypertriglyceridemia, and lower serum levels of high-density lipoprotein (HDL). These, in spite of the lower prevalence of cigarette smoking, systemic hypertension, and obesity as defined by body mass index (BMI).[1,2] Even though they have lower BMI, South Asian immigrants have a tendency toward central obesity as evidenced by higher waist:hip ratios and increased truncal subcutaneous fat deposition.[3] A similar profile demonstrating an increased propensity to insulin resistance, central obesity, elevated total cholesterol (TC):HDL ratio has been reported in several studies of South Asian immigrants living in the United Kingdom.[3-7]

Other studies have examined the role of the atherogenic molecule lipoprotein (a) [Lp(a)] as a genetically determined risk factor for cardiovascular disease in South Asians. When compared with individuals of European origin in North America, South Asian immigrants have been found to have increased levels of Lp(a).[9]

Several etiologic theories for this alteration have been proposed. They include (1) an inherent predisposition to insulin resistance, (2) a result of the stress of immigration, (3) an inability to adapt to the Western environment, and (4) a result of unique diet and lifestyle practices carried out in the initial years of life.[3,10-13] The relative contribution of heredity and the effects of moving to the Western society have not been fully unraveled. Furthermore, whether the observed metabolic alterations exist early in life has not been examined. In the present study, we hypothesized that the offspring of South Asian immigrants, when compared with their European American (EA) counterparts, would demonstrate metabolic alterations similar to those seen in the immigrant generation, despite being born and raised in North America.

SUBJECTS AND METHODS

This was a cross-sectional study comparing 2 populations (1) American-born, nonsmoking children of immigrants from India, Bangladesh, Sri Lanka, and Pakistan aged 18 to 30 years old and (2) American-born, nonsmokers of European origin within the same age range. The study group of South Asian Americans (SAA) consisted of 20 males and 12 females. The control group consisted of 19 males and 10 females. Two subjects from the EA group were excluded, 1 who reported familial hyperlipidemia syndrome and the other was found to meet criteria for diabetes mellitus (fasting glucose, 142 mg/dL) at the time of study. The study was approved by the Institutional Review Board of MetroHealth Medical Center (Cleveland, OH). Subjects were recruited from the greater Cleveland area through advertisement. The majority were students at Case Western Reserve University. All subjects were studied in the General Clinical Research Center (GCRC). Written informed consent was obtained from each subject after fully explaining the procedures. They were not paid for participation in the study. A brief questionnaire assessing current diet and lifestyle practices, family medical history, medication and vitamin use, and past medical history was completed by each subject prior to participation in the study.

The dietary recall was obtained by the GCRC nutritionist and examined using commercial software, Nutritionist Five (1998, First Data Bank, San Bruno, CA). Twenty-four-hour dietary recall data did not show any significant differences in total daily calorie intake (2,375 ± 719 *v* 2,643 ± 843 kcal/d, SAA *v* EA) or the proportion of protein

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(SAA, 13.9% ± 4.1%; EA, 14.5% ± 4.2%), carbohydrate (SAA, 60.4% ± 10.9%; EA, 57.7% ± 10.0%), or fat (SAA, 27.0% ± 8.7%; EA, 26.8% ± 8.6%) consumed. However, among micronutrients, calculated folate consumption was significantly lower in the South Asian American group (SAA, 371.6 ± 225.8; EA, 511.2 ± 283.4 μg/d; $P = .03$). The slightly higher calorie intake in the EA group was proportional to their higher body weight.

Subjects reported to the GCRC between 8:00 AM and 10:00 AM on the day of the study following an overnight fast of approximately 10 hours. They rested in supine position for 15 to 30 minutes. Blood samples were drawn from an antecubital vein. Assays of TC, HDL, low-density lipoprotein (LDL), and triglycerides were performed in the clinical laboratory on the day of sample collection. Serum samples for Lp(a) were collected in serum separation tubes (Becton Dickinson Vacutainer, Franklin Lakes, NJ), centrifuged within 30 minutes of collection, and stored at –70°C. Heparinized blood samples were obtained for the measurement of plasma glucose, insulin, insulin-like growth factor binding proteins 1 and 3 (IGFBP-1 and IGFBP-3), tumor necorsis factor (TNF)α, and leptin. Plasma samples for homocysteine were collected in EDTA-containing tubes (Becton Dickinson Vacutainer) cooled to 4°C. The samples were immediately placed on ice, and plasma was separated by centrifugation within 30 minutes and then stored at -70°C.

Blood pressure measurements were taken in duplicate 5 minutes apart using the same automated cuff on all subjects. The results were averaged for each subject. Height and weight determinations were made. Waist and hip circumferences were performed using a nonstretchable anthropometric measuring tape. Hip measurement was made at the maximum circumference in the hip area. Waist measurement was made at the narrowest dimension between the umbilicus and the xyphoid process. Measurements were made in duplicate for each site, the results averaged, and a waist:hip ratio was calculated for each subject.

Bioelectric impedance assay (BIA) was performed using a RJL Systems (Whittier, MI) body composition analyzer. Patients were placed in the supine position, and electrodes were placed in the distal first metatarsal area, the distal second metacarpal area, and between the styloid process of the ulna and radius. Percent body fat and lean body mass were calculated from the bioimpedance using the equations of Kotler et al.[14]

Skinfold measurements were obtained using a precalibrated Harpendon caliper and performed by 1 of 2 trained staff members with confirmed interexaminer reliability. Skinfolds were measured at 4 sites (triceps, suprailiac, abdomen, and thigh) in male subjects and 5 sites (triceps, subscapular, suprailiac, abdomen, and thigh) in female subjects. The average of duplicate measurements at each site was used for calculations. Percent body fat was calculated using the estimation tables of the YMCA Physical Fitness Battery.[15] Truncal skinfold sums were calculated by adding the abdominal and suprailiac skinfolds. Peripheral skinfold sums were calculated by adding the triceps and thigh measurements.

Body density was determined by weighing each subject under water using a Precision Biomedical (State College, PA) weighing system.[16] A correction was made for the weight of the bathing suit. Residual lung volume was determined using nitrogen washout technique. The subject breathed room air while being weighed underwater followed by administration of 100% oxygen, and the change in nitrogen concentration in expired air was measured over 5 to 7 minutes. This value was used to calculate the residual lung volume.[17] Body fat percentage was estimated from body density using Brozek's equation.[18]

Assays of TC, triglycerides, and HDL were performed using standard methods in the clinical laboratory. Very–low-density lipoprotein (VLDL) cholesterol was calculated as 0.16 multiplied by the triglyceride content, and LDL was calculated by subtracting HDL and VLDL from the TC. Glucose analysis was performed using the glucose oxidase method on a YSI2300 Stat Glucose/L-Lactate Analyzer (Yellow Springs Instrument, Yellow Springs, OH). Insulin was determined by double antibody radioimmunoassay.[19] Plasma leptin was measured using a commercially available human leptin radioimmunoassay kit (Linco Research, St. Charles, MO). Plasma TNFα levels were also determined using a commercially available kit (R&D Systems, Minneapolis, MN) in the GCRC core laboratory.

Lp(a) was measured using the Apo-Tek Lp(a) enzyme-linked immunosorbent assay (ELISA) kit (Sigma Diagnostics, St Louis, MO). Absorbance was determined with a Bio-Rad Benchmark microplate reader at a wavelength of 450 nm. Sample concentrations were interpolated from the standard curve generated from the kit's calibrators. IGFBP determinations were made using Active Total IGFBP-1 and Active Total IGFBP-3 ELISA kits (Diagnostic Systems Laboratories, Webster, TX). Absorbance was determined with a Bio-Rad Benchmark microplate reader at a wavelength of 450 nm. Sample concentrations were interpolated from the standard curve generated from the kit's calibrators.

Plasma homocysteine was determined by high-performance liquid chromatography (HPLC).[20] Isocratic reverse-phase HPLC was performed using a Prodigy ODS 2 analytical column, 150 × 3.2 mm, 5 μm (Phenomenex, Torrance, CA) heated to 29°C with a 3-cm LC-18 guard column. A 10-μL injection volume was used. The samples were run at a flow rate of 0.7 mL/min. The mobile phase consisted of 0.1 molar acetic acid-acetate buffer, pH 5.5, containing 30 mL/L methanol. Cysteamine (2-mercaptoethylamine) was used as the internal standard. Calibration curves were constructed twice each day using pooled plasma.

Statistical Methods

Statistical analysis was performed using Statistix software (Analytical Software, La Jolla, CA). Distributions for categorical variables were determined using χ^2 test. Comparisons between South Asian Americans and European Americans for continuous variables were made using 2-sample *t* tests within same gender groups, as well as for the total study population. In addition to unadjusted *t* tests comparing groups, serum chemistries were adjusted for BMI and were compared using analysis of covariance. Pearson correlation coefficients were calculated to determine the relationship of insulin to other metabolic factors.

RESULTS

Table 1 illustrates the general characteristics of the study population. The subjects' ages were similar across the 2 groups. The χ^2 tests showed no differences in exercise habits, past medical history, or family history of cardiovascular disease. South Asian Americans more often had a family history of diabetes and weighed significantly less than European American subjects (Table 1). There were no differences in blood pressure between the groups. South Asian American men had significantly lower BMI.

No statistically significant differences were apparent in truncal or peripheral skinfold thickness or in any of the 3 determinations of lean body mass (skinfold thickness, bioelectric impedance, hydrodensitometry). The data from hydrodensitometry measurements are displayed in Table 1. The truncal skinfold thickness was significantly higher in the South Asian Americans than the European Americans when the entire group (both males and females) was compared.

Results for lipid profile are summarized in Table 2. Among men, when analysis of covariance controlling for BMI was

Table 1. General Characteristics

Variable	Males		Females		All Subjects	
Ethnicity	SAA	EA	SAA	EA	SAA	EA
No.	20	19	12	10	32	29
Age (yr)	24.2 ± 1.9	23.9 ± 2.3	23.2 ± 2.2	24.0 ± 2.4	23.8 ± 2.0	23.9 ± 2.3
Family history DM (no.)	3	0	2	0	5*	0
Weight (kg)	66.9 ± 10.4*	79.9 ± 10.2	55.8 ± 9.4	61.1 ± 9.6	62.7 ± 11.3*	70.8 ± 12.2
Height (cm)	174.2 ± 7.3	177.2 ± 6.0	158.3 ± 6.9	164.2 ± 7.1	168.2 ± 10.5	172.7 ± 8.9
BMI (kg/m^2)	22.0 ± 2.9*	24.1 ± 2.5	22.3 ± 3.4	22.9 ± 5.1	22.1 ± 3.0	23.7 ± 3.6
Waist:hip ratio	0.83 ± 0.05	0.83 ± 0.06	0.74 ± 0.04	0.72 ± 0.03	0.79 ± 0.06	0.79 ± 0.07
Truncal SF sum (mm)	39.5 ± 21.1	30.4 ± 12.9	40.9 ± 12.5	30.2 ± 12.7	40.1 ± 18.1*	30.3 ± 12.6
Peripheral SF sum (mm)	25.4 ± 9.80	21.4 ± 5.4	49.3 ± 14.9	44.8 ± 11.1	34.3 ± 16.6	29.5 ± 13.6
% LBM	81.4 ± 4.50	83.4 ± 4.70	70.6 ± 2.60	70.9 ± 6.30	78.8 ± 6.20	78.5 ± 8.10

NOTE. Mean ± SD.

Abbreviations: SAA, South Asian American; EA, European American; truncal SF sum, sum of abdominal and suprailiac skinfold thickness; DM, diabetes mellitus; peripheral SF sum, sum of triceps and thigh skinfold thickness; % LBM, percent lean body mass as determined by hydrodensitometry.

*$P < .05$.

performed, South Asian Americans had significantly higher TC, lower HDL, higher LDL, elevated TC:HDL ratio, and higher triglycerides than European Americans. South Asian American females and European American females had no significant differences in any of the lipid profile measurements.

Using analysis of covariance and controlling for BMI, South Asian American males had significantly higher insulin levels than their European American counterparts (Table 3). South Asian American females had higher insulin and higher glucose levels than European American females. When all South Asian Americans (both males and females) were compared with the entire study population of European Americans, glucose and insulin were significantly higher, and IGFBP-1 was significantly lower. Plasma leptin levels were significantly higher in the South Asian Americans in the total group ($P = .004$), as well as individually in males ($P = .0001$) and females ($P = .002$). Plasma TNFα levels were similar when the entire South Asian and European groups were compared (SAA, 2.94 ± 0.77; EA, 3.37 ± 1.04 pg/mL; $P = .08$). However, the TNFα levels were significantly higher in the EA group when only male subjects were compared (SAA, 2.97 ± 0.77 *v* EA 3.63 ± 1.15; $P = .04$). There were no significant differences between the groups for Lp(a) and homocysteine.

Pearson correlation coefficients for insulin in relation to selected metabolic factors for the entire study population are shown in Table 4. In males, a significant positive correlation was identified between insulin and leptin, BMI, and truncal skinfold thickness. In addition, among males, significantly positive correlations were seen between insulin and triglycerides, TC, and TC:HDL ratio. In men, insulin was inversely correlated with IGFBP-1 and HDL. In females, insulin was positively correlated with leptin, BMI, and truncal skinfold thickness, and an inverse correlation existed with IGFBP-1. In addition, among South Asian males, plasma leptin was significantly positively correlated with triglycerides ($r = .722$, $P = .0003$), BMI ($r = .765$, $P = .0001$), TC ($r = .655$, $P = .002$) and negatively correlated with plasma IGFBP-1 ($r = -.618$, $P = .004$).

Because subjects with a family history of diabetes may already have manifest changes in the metabolic phenotype, the data were examined after excluding these 5 subjects in the SAA group. Exclusion of subjects with a family history of diabetes resulted in a more significant difference in body weight ($P = .0007$) and BMI ($P = .009$) between the SAA and EA group and no impact on other anthropometric parameters or the lipid profile. Although the plasma glucose levels in the SAA subjects without a family history of diabetes were not significantly different from the EA group ($P = .19$), the plasma insulin and leptin levels were higher in this group, although not as statistically significant as the entire group (both $P = .06$). Plasma TNFα levels were significantly higher in the EA group when compared with the SAA without a family history of diabetes (EA, 3.37 ± 1.04; SAA, 2.79 ± 0.59 mL; $P = .014$).

Table 2. Lipid Profile

Variable	Males		*P**	Females		*P**	All Subjects		*P**
Ethnicity	SAA	EA		SAA	EA		SAA	EA	
TC (mg/dL)	180.0 ± 32.4	163.7 ± 47.4	.03	168.1 ± 28.4	179.0 ± 38.1	.49	175.5 ± 31.1	169.0 ± 44.3	.25
HDL (mg/dL)	48.1 ± 10.0	51.2 ± 9.80	.04	58.0 ± 10.1	56.4 ± 9.60	.75	51.8 ± 11.0	53.0 ± 9.90	.33
LDL (mg/dL)	109.4 ± 28.4	95.3 ± 40.9	.02	94.8 ± 22.9	104.2 ± 32.8	.48	103.9 ± 27.1	98.3 ± 37.9	.22
TC:HDL	3.90 ± 1.00	3.30 ± 1.10	<.01	2.90 ± 0.60	3.30 ± 1.00	.42	3.53 ± 1.00	3.30 ± 1.10	.07
TG (mg/dL)	141.3 ± 80.1	108.7 ± 56.6	.01	95.4 ± 50.5	114.6 ± 55.6	.45	124.1 ± 73.1	110.7 ± 55.4	.15

NOTE. Mean ± SD.

Abbreviations: TC, total cholesterol; TG, triglycerides.

**P* value determined with analysis of covariance controlling for BMI.

Table 3. Plasma Glucose, Insulin, IGFBP, LP(a), and Homocysteine Levels During Fasting

Variable	Males		*P**	Females		*P**	All Subjects		*P**
Ethnicity	SAA	EA		SAA	EA		SAA	EA	
Glucose (mg/dL)	87.5 ± 6.7	86.0 ± 4.5	.26	84.9 ± 3.0	80.3 ± 7.5	.03	86.5 ± 5.7	84.0 ± 6.2	.03
Insulin (mIU/L)	13.9 ± 7.1	10.0 ± 5.5	<.01	15.3 ± 8.8	10.0 ± 5.1	.05	14.5 ± 7.7	10.0 ± 5.2	<.01
IGFBP-1 (μg/L)	44.9 ± 32.0	46.0 ± 28.2	.22	49.9 ± 36.8	75.1 ± 35.4	.08	46.8 ± 33.4	56.0 ± 33.4	.05
IGFBP-3 (μg/L)	5.00 ± 0.6	5.20 ± 0.7	.82	4.90 ± 0.8	5.50 ± 0.7	.06	5.00 ± 0.7	5.30 ± 0.7	.07
Lp[a] (mg/dL)	35.6 ± 32.7	36.3 ± 30.8	.44	42.6 ± 35.9	30.3 ± 35.3	.28	38.2 ± 33.5	34.3 ± 31.9	.18
HCY (μmol/L)	8.3 ± 2.8	7.4 ± 0.9	.21	6.1 ± 1.3	7.3 ± 2.0	.12	7.4 ± 2.5	7.3 ± 1.4	.87
Leptin	4.31 ± 2.47	2.76 ± 1.29	.0001	20.56 ± 10.3	10.238 ± 6.25	.002	10.4 ± 10.26	5.37 ± 5.20	.004

NOTE. Mean ± SD.

Abbreviations: IGFBP, insulin-like growth factor binding protein; Lp[a], lipoprotein(a); HCY, homocysteine; *P* value determined using 2-sample *t* test.

**P* value determined with analysis of covariance controlling for BMI.

DISCUSSION

The results of the present study showed that even when born and raised in North America, individuals of South Asian origin have altered metabolic profiles when compared with their European American counterparts. Of interest, these findings persist even after the exclusion of subjects with a family history of diabetes. These findings represent the first examination of American-born offspring of South Asian immigrants compared with American-born individuals of European origin. Several studies have documented that immigrants from the Indian subcontinent have an increased risk of cardiovascular disease and poor prognostic risk profiles when compared with the majority population in their country of residence. The possible mechanisms of acquiring cardiovascular risk include: a genetic predisposition to insulin resistance, the stress of immigration, an inability to adapt to their new environment, and a metabolic adaptation "programming" to nutrient and other influences early in life.[3,10-13]

By studying a group of young first-generation South Asian Americans, we have tried to control for the potential environmental factors that have been postulated to be responsible for the increased cardiovascular risk seen in immigrants. The South Asian American subjects in the present study were born and raised in the Western world, were not subjected to the stressors of immigration, and had lived their entire lives in the same geographic environment as the comparison group. We could thereby assess if being of South Asian origin, through either genetic or cultural factors, was responsible for any metabolic alteration seen.

Table 4. Pearson Correlation Coefficients for Insulin in Relation to Selected Metabolic Factors for the Entire Study Population

Variable	Males	Females
BMI	.36*	.46*
Truncal SF sum	.57*	.58*
IGFBP-1	−.68*	−.64*
Triglycerides	.61*	.01
TC	.48*	.00
HDL	−.34*	−.13
LDL	.45*	.04
TC:HDL	.64*	.14
Leptin	.61*	.7235*

Abbreviation: IGFBP-1, insulin-like growth factor binding protein 1.

*$P < .05$.

A preponderance of central, upper body obesity, as evidenced by greater truncal skinfold thickness and elevated waist: hip ratios, has been shown in South Asian immigrants.[5,8] In the present study, South Asian Americans' truncal skinfolds were not significantly greater when males and females were analyzed separately, but the entire group of South Asian Americans (both males and females together) had significantly greater truncal skinfold thickness than the European American group. This is probably due to insufficient statistical power when the groups were divided by gender. Of significance, there was no difference in estimates of lean body mass between the groups. The lack of significant difference in lean body mass, coupled with the difference in truncal skinfold thickness, suggests a redistribution of fat to the subcutaneous compartment in South Asian Americans. However, we have only measured skinfold thickness at 4 sites rather than the usual 9 sites used by most investigators. A full examination of body fat distribution, including estimation of intra-abdominal fat mass, in the offspring of South Asian immigrants in the United States would be warranted to either confirm or refute these preliminary findings.

The higher levels of leptin in the South Asian population are of interest, particularly since these subjects did not have an overt increase in the total fat mass. The increased leptin could be the consequence of higher subcutaneous fat mass (Table 1) or a consequence of higher plasma insulin.[21-23] The contribution of truncal obesity or hyperinsulinism to increased leptin levels cannot be separated from the present data.

Male immigrants from South Asia have been shown to have higher total cholesterol:HDL ratios and elevated triglyceride levels when compared with individuals of European origin.[1-7] In the present study, young, American-born, South Asian males also had higher TC, LDL-cholesterol, triglycerides, and total cholesterol:HDL ratio, as well as lower HDL levels than their European American male counterparts. The absolute values were not elevated in relation to the usually accepted values for increased cardiovascular risk, but the elevated levels at this age may reflect a harbinger of worsening profiles over time. The lack of any difference in lipid profile in females may reflect the dominance of favorable effects of estrogen in this population of premenopausal women.

The high frequency of cardiovascular disease and alteration

in lipid profile seen in immigrants from the Indian subcontinent has been attributed to a unifying theory of insulin resistance.[7] Insulin resistance not only confers an increased risk of type 2 diabetes, but also has been associated with dyslipidemia and has been postulated to be independently associated with ischemic cardiovascular disease.[24] Our data show that plasma insulin levels were elevated in the offspring of South Asian immigrants, regardless of gender. Elevated insulin levels do not necessarily confirm the presence of insulin resistance, however, insulin levels in our study correlated inversely with IGFBP-1 level, a binding protein that is lower in other insulin-resistant states. In male subjects, plasma insulin levels were positively correlated with TC, LDL, triglycerides, and TC:HDL ratio, and inversely with HDL. This correlation in lipid profile was not present in female subjects. The insulin level also correlated with truncal skinfold thickness. These data suggest that increased plasma insulin levels may be an important feature of the altered metabolic profile and body composition seen in South Asian subjects.

Even though the offspring of South Asian immigrants in this study were born and raised in North America and had lived in the same geographic environment as the comparison group, they may have continued their unique cultural factors (such as diet and activity level) in the early years of life that may impact their metabolic profiles. The elevated plasma insulin levels seen in South Asian group may be due to a genetic predisposition. Alternatively, it may be the result of "metabolic programming" and result from specific metabolic and nutritional influences during pregnancy and childhood that foster an adaptation that persists throughout life.[10-13] We lack sufficient information from our subjects to distinguish between these 2 possibilities. Objective measures of acculturation among South Asian American subjects or information about dietary and lifestyle practices in the early years of life would have been helpful and would be appropriate information to gather in follow-up studies. Due to recall bias and the barriers to objective measurement of "cultural" factors, these are difficult issues to address. Only carefully planned prospective long-term studies in a large population can answer these questions. Although no significant differences in total calories and macronutrient intake were apparent on dietary recall, certain qualitative differences such as consumption of animal versus vegetarian protein, etc, could have significant impact on our observations. The present study could not have identified such differences.

Lp(a) has been suggested to be an independent marker of cardiovascular risk.[25] We found no differences in Lp(a) levels between South Asian American and European American subjects. The absence of a difference between the 2 study groups in the present study is likely due to the combined effects of high variance in the Lp(a) assay and a lack of statistical power. Plasma homocysteine levels have also been demonstrated as a risk marker for atherothrombotic disease.[26] No differences exists in homocysteine levels between South Asian American and European American groups. Given that homocysteine levels are influenced by vitamins B12, B6, and folic acid intake, the absence of any difference may be a reflection of the 2 study groups having similar vitamin intake.[27]

Regardless of etiology, the important finding in this study is that offspring of South Asian immigrants in the United States show significant metabolic alterations in young adulthood. These alterations are similar to those documented in their immigrant parents. The significantly higher leptin levels, particularly in the males, and their positive correlation with measures of lipid profile in the absence of significant increase in total fat mass are of interest. Future studies are required to determine the specific mechanism of these alterations and to examine if this altered profile confers an increased risk of cardiovascular morbidity.

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