Indices of Obesity, Dyslipidemia, and Insulin Resistance in Apparently Healthy Caribbean Subjects

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Reports from developing countries indicate that a rise in the socioeconomic level is a risk factor for metabolic disorders. We aimed to assess the indices of obesity, dyslipidemia, and insulin resistance among fairly literate healthy adults in a multidisciplinary institution in Trinidad. The study included 156 volunteers (46 males and 110 females, 17–40 years old). The subjects provided information on age, ethnicity, educational attainment, and occupation in self-administered, closed-ended questionnaires. Waist and hip circumferences (cm), weight (kg), and height (m) were measured. Fasting blood samples were taken for glucose, insulin, and lipid determinations in 78 subjects who volunteered for laboratory measurements. Insulin resistance was determined with homeostasis model

assessment (HOMA). Of the 156 subjects studied, 83% had received tertiary education, and had no previous record of body mass index (BMI); 8% were obese, 17% were overweight, and 27% were underweight. Laboratory measurements in 78 subjects revealed 28% hypercholesterolemia and 20% hyperinsulinemia. There were no significant gender-related differences in these prevalence rates ($P > 0.05$). The identification of obesity, underweight, hyperinsulinemia, and hypercholesterolemia in this healthy population suggests that screening for the indices of metabolic disorders in a healthy population would be potentially useful for the early identification and treatment of metabolic-related disorders. *J. Clin. Lab. Anal.* 17:6–11, 2003.

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INTRODUCTION

Studies in developing countries have shown that a rise in the socioeconomic level is a risk factor for diabetes and other chronic disorders (1,2). This is in contrast to observations in developed nations, which indicate that individuals in higher socioeconomic strata have a lower prevalence of these disorders (3,4). The problems observed in developing countries may be due to changes in lifestyle and diet that result in overnutrition, caloric excess, decreased physical activity, and increased body weight (5–8). In developing countries, obesity is a major public health problem, and it is more prevalent in women than in men (9,10). In many of these developing countries, both underweight and overweight people are observed, although excess weight appears more frequently among the affluent and then among the low-income classes (11). Although obesity-related traits can be inherited in genetically-related populations (12), the obesity prevalence rate increases in countries undergoing socioeconomic transformation. Trinidad and Tobago is an example of a medium-income population currently undergoing socioeconomic transformation

and cultural changes due to its proximity to the United States, and hence to the influence of the American lifestyle and diet. The prevalence of obesity and increased blood lipid concentrations has been reported in diabetic patients (13) as well as in apparently healthy factory workers in this population (14). Similarly, a previous study has shown that healthy offspring of patients with type 2 diabetes have increased risk factors for metabolic syndromes (15). Given the economic cost of managing metabolic-related diseases, surveillance and prevention strategies against obesity/overweight, insulin resistance, and dyslipidemia are necessary to reduce the

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risks of metabolic syndromes. For the current study it was reasoned that the target population should be healthy adults who are most inclined to adopt a modern lifestyle and diet. Thus, we aimed to assess the indices of obesity, insulin resistance, and dyslipidemia among workers and students in a multidisciplinary institution in Trinidad, West Indies.

MATERIALS AND METHODS

Subjects and Study Protocol

This study was conducted at the Eric Williams Medical Sciences Complex (EWMSC) from 1 August to 30 January 2001, and included 156 adults (17–40 years old). The male and female participants were not matched for age. The subjects were recruited through poster advertisements (posted at strategic locations within the EWMSC) and announcements during lecture and laboratory sessions (for the students). The EWMSC comprises the Medical Faculty of the University of the West Indies, Mount Hope Hospital, and the National Institute of Higher Education, Research, Science, and Technology (NIHERST). All of the participants were from Caribbean countries (including Barbados, the Bahamas, Jamaica, and St. Lucia) and were students or employees of the EWMSC. All subjects gave informed voluntary consent to participate, and our institutional ethics committee approved the protocol. The subjects came to the Diabetes and Metabolism Research Unit during the morning (0800–0900 hr) of any work day of the week. The subjects answered questions as to their age, ethnicity, educational attainment, occupation, and previous record of body mass index (BMI). Then measurements were obtained by tape measure of the waist (cm), at the level of the umbilicus with the patient standing and breathing normally, and hip circumferences (cm), at the largest projection of the buttocks. Weight (kg) and height (m), were measured (in light clothing, without shoes) using a Health O Meter (Pro-Series, with metal rule; Health O Meter, Bridgeview, IL). For 78 subjects who volunteered for dyslipidemia screening, a 7-ml overnight fasting (10–14 hr) venous blood sample was taken from each participant and put into fluoride (for plasma glucose measurement) and plain (for serum lipid measurement) tubes. Blood samples were separated within 30 min of collection, and the plasma and serum were stored at -20°C until laboratory analysis (within 2 months).

Definitions and Desirable Cut-Off Points

Based on the recommendations of the Adult Treatment Panel (ATP III) (16), hypercholesterolemia was defined as total cholesterol (T-chol) levels >5.2 mmol/L

(>200 mg/dl); high low-density lipoprotein-cholesterol (LDL-chol) as LDL-chol >2.6 mmol/L (>100 mg/dl); hypertriglyceridemia (TG) as TG levels >2.26 mmol/L (>200 mg/dl); and low high-density lipoprotein (HDL-chol) as HDL-chol <1.04 mmol/L (<40 mg/dl). Obesity was defined as BMI >30 kg/m²; overweight as BMI >25 kg/m² (females) and BMI >27 kg/m² (males); and underweight as BMI <20 kg/m² (17). Fasting hyperinsulinemia was defined as fasting insulin values >90 th percentile (>119 pmol/L) of our study population (18).

Biochemical Analysis

Plasma glucose, serum T-chol, triglycerides (TG), and HDL-chol concentrations were measured using commercial kits (dry slides) in multichannel auto-analyzers (Johnson & Johnson, Ortho-Clinical Diagnostics, Inc., Rochester, NY). LDL-chol was calculated using the Friedewald equation (19). Serum insulin concentrations were measured by a standard radioimmunoassay method using commercial insulin kits (Coat-A-Count Insulin; Diagnostic Products Corp., Los Angeles, CA). The inter- and intra-assay coefficients of variations were 2.6 pmol/L and 4.6 pmol/L, respectively.

Statistical Data Analyses

The results are expressed as mean $\pm$ SE. The index of generalized obesity (the BMI) was calculated as weight (kg) divided by height (m) squared. The index of upper body obesity, waist-to-hip ratio (W/H), was calculated as waist circumference (cm, WC) divided by hip circumference (cm, HC). Insulin resistance (IR), defined as the product of fasting serum insulin and plasma glucose divided by 22.5, and insulin sensitivity (%S) were assessed using values of fasting serum insulin and fasting plasma glucose concentrations in homeostasis model assessment (HOMA) (20). Percentage insulin sensitivity (%S) was calculated using the HOMA-CIGMA Calculator Program V 2.00 (graciously supplied by Dr. Jonathan Levy of the Diabetes Research Laboratory, Oxford University, London). The HOMA-derived parameters (IR and %S) have been shown to correlate with “gold standard” methods such as the euglycemic clamp technique and minimal model analysis (21,22). The fasting hyperinsulinemic index was derived as the ratio of fasting serum insulin to fasting plasma glucose concentration. For all statistical analyses, the serum insulin, IR, and %S parameters were log-transformed to normalize data distribution. The Statistical Package for the Social Sciences (SPSS) software was used in all analyses (23). Mean comparisons between male and female subjects were performed using Student's *t*-test, and a chi-squared test was used for

categorical parameters. A P -value <0.05 was considered statistically significant on two-tailed testing.

RESULTS

A total of 156 subjects (46 males and 110 females) participated in the study. More than half (55.8%) of the participants were students and 44.2% were workers. The majority of the subjects (83.3%) had received tertiary education (Table 1). The majority of the subjects (83.3%) had no knowledge or record of their BMI before the study. Table 2 shows that the male and female participants were of similar ages ($P>0.05$). Although male participants were significantly taller and heavier than the females ($P<0.01$), the BMI did not differ between gender ($P>0.05$). As expected, the male subjects had significantly higher waist circumference than the females ($P<0.01$, Table 2). Although there were no significant differences in insulin resistance indices, the male subjects had significantly higher mean triglyceride, T-chol-to-HDL-chol ratios, and lower

HDL-chol than the female subjects ($P<0.05$; Table 3). Table 4 shows that more males than females were overweight, whereas more females than males were obese and underweight (Table 4). In the 78 participants who were screened for metabolic abnormalities, hyperinsulinemia was observed in 20.3%, hypercholesterolemia in 28.2%, high LDL-chol in 60.3%, and reduced HDL-chol in 9.0% (Table 4).

DISCUSSION

The results of the present study on workers and students in the Medical Sciences Complex in Trinidad, West Indies, showed that 1) 83% of the subjects had no previous knowledge or record of their BMI before the study, 2) obesity/overweight and underweight were identified, and 3) hypercholesterolemia and hyperinsulinemia were observed in 28% and 20% of the subjects, respectively.

These findings constitute predictors of metabolic-related disorders such as diabetes, hypertension, and

TABLE 1. Background characteristics of the study subjects

Parameters	All N = 156 (%)	Male N = 46 (%)	Female N = 110 (%)
Occupation			
Employed	69 (44.2)	17 (37.8)	52 (46.8)
Unemployed	87 (55.8)	28 (62.2)	59 (53.2)
Education			
Primary	8 (5.1)	2 (4.4)	6 (5.4)
Secondary	18 (11.5)	4 (8.9)	14 (12.6)
Tertiary	130 (83.3)	39 (86.7)	91 (82.0)
Ethnicity			
African	46 (29.5)	9 (20.0)	37 (33.3)
East Indian	80 (51.3)	30 (66.7)	50 (45.0)
Mixed Race	30 (19.2)	6 (13.3)	24 (21.6)
Previous record/knowledge of BMI			
Yes (have record/knowledge)	26 (16.7)	7 (15.6)	19 (17.1)
No (no knowledge/record)	130 (83.3)	38 (84.4)	92 (82.9)

TABLE 2. Anthropometric indices of the subjects

Parameters	All N = 156	Male N = 46	Female N = 110
Age (year)	26.7 ± 0.6	25.2 ± 1.1	27.3 ± 0.8
Weight (kg)	62.8 ± 1.2	70.7 ± 2.2	59.6 ± 1.3**
Height (m)	1.6 ± 0.1	1.7 ± 0.01	1.6 ± 0.01**
Body mass index (kg/m ²)	23.1 ± 0.3	23.6 ± 0.7	22.9 ± 0.4
Waist circumference (cm)	79.6 ± 0.9	85.6 ± 1.6	77.2 ± 1.1**
Hip circumference (cm)	96.7 ± 0.8	97.8 ± 1.4	96.3 ± 0.9
Waist/hip ratio	0.82 ± 0.01	0.87 ± 0.01	0.80 ± 0.01**

** $P<0.01$ for comparison between male and female subjects.

TABLE 3. Metabolic parameters of the subjects

Parameters	All N = 78	Male N = 22	Female N = 56
Plasma glucose, mmol/L, (mg/dl)	4.3±0.1 (77.4±2.0)	4.6±0.4 (82.8±7.2)	4.1±0.04 (73.8±0.7)
Serum insulin (pmol/L)	75.0±5.7	85.9±14.4	70.8±5.7
Fasting insulin/glucose	17.5±1.3	19.2±3.4	16.9±1.3
Insulin resistance (pmol/mmol/L)	14.8±1.4	18.9±4.2	13.3±1.1
Insulin sensitivity (%S)	102.2±6.9	91.3±10.1	106.4±8.7
B-cell function (%B)	163.5±7.9	166.2±19.5	162.5±8.1
Total cholesterol, mmol/L, (mg/dl)	4.7±0.1 (181.4±3.9)	4.6±0.3 (177.6±11.6)	4.7±0.1 (181.4±3.9)
Triglycerides, mmol/L, (mg/dl)	1.0±0.05 (88.5±4.2)	1.2±0.2 (106.2±17.7)	0.9±0.04* (79.7±3.5)
HDL-cholesterol, mmol/L, (mg/dl)	1.5±0.03 (57.8±1.2)	1.3±0.1 (50.1±3.9)	1.6±0.03* (61.6±1.2)
LDL-cholesterol, mmol/L, (mg/dl)	3.0±0.1 (115.8±3.9)	3.1±0.3 (119.7±11.6)	3.0±0.1 (115.8±3.9)
Total chol/HDL-cholesterol	3.2±0.1	3.6±0.3	3.1±0.1*

* $P < 0.05$.**TABLE 4. Obesity, dyslipidemia and hyperinsulinemia among the subjects**

Parameters	All (%)	Male (%)	Female (%)
Obesity (%)	12 (7.7)	4 (8.9)	8 (7.3)
BMI > 30 kg/m ²			
Overweight (%)	27 (17.4)	13 (28.9)	14 (12.7)
BMI > 25 (M) and 27 (F) kg/m ²			
Underweight (%)	42 (27.1)	9 (20.0)	33 (27.1)
BMI < 20 kg/m ²			
Hypercholesterolaemia (%)	22 (28.2)	5 (22.7)	17 (30.4)
T-cholesterol > 5.2 mmol/L (> 200mg/dl)			
Hypertriglyceridaemia (%)	0.0	0.0	0.0
Triglycerides > 2.26 mmol/L (> 200mg/dl)			
High LDL-cholesterol (%)	47 (60.3)	10 (45.5)	37 (66.1)
LDL-chol. > 2.6 mmol/L (> 100mg/dl)			
Low HDL-cholesterol (%)	7 (9.0)	6 (27.3)	1 (1.8)**
HDL-chol. < 1.04 mmol/L (< 40mg/dl)			
Fasting hyperinsulinemia	16 (20.3)	5 (22.7)	11 (19.3)
Fasting Insulin > 119 pmol/L			

** $P < 0.01$ for comparison between male and female subjects.

cardiovascular diseases. The finding that the majority of the participants had no knowledge or record of their BMI before the study suggests that many individuals do not consider obesity or overweight as medical problems (24). Obesity is a serious medical disease, with an annual estimated cost of £2 billion (US\$3 billion) in Britain (25) and US\$69 billion in the United States (24). It has been suggested that in addition to routine assessment of BMI in primary care for both adults and children, obesity should be treated with drugs in the same manner as any other chronic disease would be treated (25). Although the efficacy of surgical and medical approaches to treating obesity is still controversial (25), surgery for

obesity is becoming increasingly popular in the United States, with vertical banded gastroplasty and gastric bypass offering huge successes in weight reduction (26). It is of concern that we observed both overweight and underweight among the participants, since they are features commonly seen in populations with a history of malnutrition and nutrition-related disorders (11). We recognize that the inheritance of obesity-related traits is consistent in genetically-related populations (12). However, the obesity and overweight observed in the present study may also be related to a transition to the lipid-rich diet, reduced physical activity, and less energy expenditure often associated with populations

undergoing economic expansion (5–8). Indeed, the “oil boom” experienced in Trinidad and Tobago in the 1970s placed this country among the middle-income developing nations, with a per capita gross national product of US\$3,670 in 1991 (27). Since the oil boom, the general population has been experiencing nutritional (intake of lipid-rich diets) and lifestyle (physical inactivity) changes, which was encouraged in part by the country’s proximity to North America.

It should be noted that obesity and overweight are important risk factors for metabolic syndromes, including diabetes, hypertension, dyslipidemia, and insulin resistance (28,29). Obesity is perhaps the greatest risk factor for diabetes: a BMI > 35 kg/m² increases diabetes risk by 93-fold in women and by 42-fold in men (24). The observation of higher prevalence rates of hypercholesterolemia, high LDL-chol, and hyperinsulinemia in the female than male subjects, albeit insignificant, had significant health implications for the region with high prevalence rates of diabetes (30,31). For instance, a previous report from South Africa (32) showed a reduced rate of glucose disposal and a greater degree of insulin resistance in obese black women than in obese white women. The higher absolute number of female subjects with hypercholesterolemia and hyperinsulinemia also suggests a greater cardiovascular disease risk burden for the females (29). Although we recognize that a high proportion of the subjects were underweight (27%), subanalysis of our data (not shown) showed that the observed hypercholesterolemia and hyperinsulinemia were significantly higher in obese/overweight (62.5% and 45.5%, respectively) than underweight (12.5% and 9.1%, respectively) participants. The implication of this is that there is a greater risk for diabetes and cardiovascular disease among the obese and overweight female subjects, given that obese black women have a higher BMI minimum mortality risk than obese white women (33). This risk should be particularly emphasized for the workers who had a higher BMI than the unemployed subjects, even though their metabolic parameters did not differ (data not shown).

Although the high prevalence of underweight subjects in the present study is of some concern, it may not be attributable to malnutrition, given the background characteristics of the subjects (Table 1). However, we speculate that the high prevalence of underweight, especially among female participants, may be related to 1) ethnicity (the majority of the subjects were females of East Indian ethnicity, and anecdotal evidence shows that young females of this ethnic group are slimmer than their counterparts of other ethnic groups); and 2) self-motivation (the majority of the subjects were fairly literate and worked or studied at a medical institution, which may have increased weight-control awareness

among the subjects). Although sometimes extreme weight reduction is brought about by strict adherence to diet and vigorous exercise, other causes of extreme weight loss should be investigated further. This is indeed a serious issue given that extreme weight reduction has been associated with a reduced probability of achieving pregnancy in women receiving assisted reproduction treatment (34). Although this latter finding has yet to be confirmed in other studies, the present results are especially worrisome because a greater proportion of the underweight subjects are females (Table 2). It should be noted that the higher number of female participants in the present study is a reflection of the general population. Females predominate in schools and work places; for example, about 71% of the medical laboratory technicians who participated in a previous hospital-based research survey were females (35).

Our results should be interpreted with caution because our sample, although it was a likely reflection of apparently healthy individuals in this population, may have been affected by overrepresentation (self-selection bias) of highly enthusiastic individuals who are more conscious of their body composition. Even then, overweight and obesity were observed in our study sample, consistent with previous reports conducted in larger samples from other Caribbean Islands (36–38). Furthermore, we did not ascertain the family history of the subjects who participated in the laboratory studies, although the offspring of Caribbean patients with type 2 diabetes have been shown to have increased insulin resistance and cardiovascular risk factors compared with subjects with no family history of diabetes (15,39).

In conclusion, similar to other developing populations, both obesity and underweight were identified in this group of subjects with potentials of affluent lifestyle. The identification of obesity, underweight, hyperinsulinemia, and hypercholesterolemia in this healthy population suggests that screening for the indices of metabolic disorders in a healthy population would be potentially useful in the early identification and treatment of metabolic-related disorders.

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