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Atherogenic Lipid Profiles in Filipino Adolescents With Low Body Mass Index and Low Dietary Fat Intake

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ABSTRACT This study reports mean lipid levels and their association with body composition, diet, and activity level in 300 male and 308 female adolescents (14–16 years) living in Cebu City, the Philippines. Participants were selected from the Cebu Longitudinal Health and Nutrition Survey (CLHNS), a 1-year birth cohort study begun in 1982–83. Lipid profiles suggest high cardiovascular disease (CVD) risk in this sample, despite low intake of dietary fat (22% for both sexes) and an absence of obesity (0.3% of sample). Mean lipid levels for males and females were, respectively, 153.2 mg/dl and 182.5 mg/dl for total cholesterol (TC), 91.9 mg/dl and 104.6 mg/dl for low-density lipoprotein cholesterol (LDL-C), 38.3 mg/dl and 41.3 mg/dl for high-density lipoprotein cholesterol (HDL-C, geometric mean), and 73.9 mg/dl and 79.6 mg/dl for triglycerides (TG, geometric mean). The atherogenic ratio of TC/HDL-C was high at 4.16 and 4.55 for males and females. Adjusting for maturational changes, the body mass index (BMI) and skinfold measures were positively associated with most lipids in males. Among females, BMI and skinfolds related positively to LDL-C and TG, and inversely to HDL-C. Although males had a higher waist hip ratio (WHR), WHR only predicted lipid profiles in females. Activity level had a beneficial association with lipid profiles in both sexes, while dietary fat intake was positively associated with LDL-C in males and with HDL-C in females. In sum, diet, adiposity, and physical activity predict variability in lipid profiles in this adolescent Filipino population. However, the low fat intake and near-absence of obesity raise questions about the causes of the high apparent risk for future CVD in this young population. Am. J. Hum. Biol. 15:688–696, 2003.

Contrary to traditional notions of cardiovascular disease (CVD) as a "Western" disease of "affluence," more than three-quarters of global CVD mortality now occurs in middle- and lower-income nations (WHO, 2001). Current disease patterns in the Philippines typify these global health trends. Between 1973–1993, mortality related to conditions of the heart increased by roughly 60%, while prominent infectious diseases declined in importance. CVDs are now the leading cause of death in the Philippines, which has rates of ischemic heart disease that exceed those found in many nations in Western Europe and the Asia Pacific region (WHO, 2002). It is widely believed that changes in activity level, diet, and rising obesity rates are the principal factors driving these trends in the Philippines and other developing economy populations (Baker et al., 1986; Popkin et al., 2001).

Despite the rising burden of CVD in the Philippines, few data are available on cholesterol or lipoprotein profiles among Filipinos, or the association between lipids and lifestyle and anthropometric risk factors, such as body composition, diet, or physical activity. This is particularly important for younger generations, who represent the future population at risk (Webber et al., 1991). The few studies reporting lipid profiles in the Philippines document low levels of high-density lipoprotein cholesterol (HDL-C) among both adult males and boys (Knuiman and West, 1983; Knuiman et al.,

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1983) and low total cholesterol, HDL-C, and low-density lipoprotein cholesterol (LDL-C) and fasting triglycerides in boys (West et al., 1990). The Fifth National Nutrition Survey conducted by the Philippine government found very low levels of HDL-C (30 mg/dl) in a large representative sample of 20–39-year-olds (Sy, 1999). These values were reported without information on the proportion of males and females in the survey, and we are unaware of any previous study reporting cholesterol values for females in the Philippines.

In this study, we document lipid profiles and their association with behavioral and lifestyle risk factors in a population of adolescent Filipinos living in and around metropolitan Cebu City, the second-largest and most rapidly growing urban area in the country.

SUBJECTS AND METHODS

Sample characteristics

Data come from the Cebu Longitudinal Health and Nutrition Survey (CLHNS), a community-based birth cohort study of infants born in 1983–1984 (Adair et al., 2001). The study area is Metropolitan Cebu, a city of 1.5 million inhabitants. The 33 Metro Cebu communities randomly selected for the survey include densely populated urban neighborhoods, peri-urban neighborhoods, and rural villages in the surrounding mountains and islands. All pregnant women in the selected communities were initially invited to participate and were included in the longitudinal study if they gave birth between May 1, 1983 and April 30, 1984 ($n = 3{,}327$). The child sample (3,080 single live births) is thus representative of singletons born during that 1-year interval. At the most recent survey (1998–1999), 2,089 adolescents (all ages 14–16) were located and interviewed. Of these, 2,056 had birth and current measurements, from which a subsample of 308 females and 300 males were selected for blood sample collection. This subsample was selected at random within each of two strata of birthweight (for analyses not presented here). In the 1998 survey, ~50% (155/327) of all individuals with a birthweight <2.6 kg were randomly selected for lipid measurement, while roughly 25% of individuals (453/1,729) of higher birthweight were randomly selected. Consistent with this sampling design, females included in the CVD study had significantly lower birthweight, current height, and current weight (all $P < 0.05$) compared to those excluded, while these differences were not significant in males. Comparing individuals who were and were not included in the CVD substudy, there were no differences for either sex in body mass index (BMI), skinfold thickness, income, or dietary fat intake among the CVD subsample. We correct for this sampling design in analysis (see below).

Data collection protocol

For measurement of lipid profiles, participants were asked to fast overnight for 12 hours, and blood samples were collected in clinics the following morning using EDTA-coated tubes. After separation, samples were frozen and shipped on dry ice to the Emory Lipid Research Laboratory (Atlanta, GA) for analysis of lipid profiles. All samples remained frozen at –80°C until ready for analysis. Total lipids were determined by enzymatic methods using reagents from Beckman Diagnostics (Palo Alto, CA) on a CX5 chemistry analyzer. HDL-cholesterol and LDL-cholesterol were determined using the homogenous assay direct HDL-C and direct LDL-C (Equal Diagnostics, Exton, PA). The Emory Lipid Research Laboratory is a participant in the CDC/NHLBI Lipid Standardization Program to ensure accuracy and precision of the determinations.

Body weight, height, waist and hip circumferences, and triceps and subscapular skinfold thicknesses were measured using standard anthropometric techniques (Lohman et al., 1988). The BMI was calculated as the ratio of weight (kg)/height (m^2). Among males, maturational status was assessed by self-rated 5-level pubic hair staging, which was validated against physician assessment (unpubl. data). In females, longitudinally assessed menarcheal age estimates in females were used to construct a five-level maturational status variable. The child's dietary intake was measured using two 24-hour recalls on consecutive days and the mean was used in analyses. Energy and fat intake were calculated using Philippines Food Composition Tables produced by the Food and Nutrition Research Institute of the Philippines (FNRI, 1990). Physical activity was assessed using Caltrac, a small device that attaches to the waist and records a cumulative tally of motion, which in turn is

used along with body weight to estimate expended calories (Westerterp, 1999). Caltracs were put on children by interviewers, who returned roughly 24 hours later to remove the devices and record the cumulative kcal score registered by the device. Caltrac readings were adjusted for time worn using linear regression and log-transformed before analyses. When data were collected for the 1998–2000 survey, girls were completely surveyed before boys. Consequently, boys are roughly 1 year older than girls. All analyses were run separately by sex. All research reported here was conducted under conditions of informed consent of children and their mothers and human subjects clearance was obtained from the Institutional Review Boards of the Emory University Medical School and the University of Chapel Hill, North Carolina.

Statistical analyses

Version 8.0 of the STATA statistical package was used for all analyses (Stata Corp., College Station, TX). In order to get an unbiased estimate of distributional characteristics (e.g., mean LDL-C or dietary energy intake of children), we downweighted the observations in the low birthweight children, so that both birthweight strata would be represented in the estimate in proportion to their occurrence in the population. Probability sampling weights (pweights) for each strata were calculated as the inverse of the within-strata sampling fraction, and the survey mean (svymean) procedure of STATA was used to estimate distributional characteristics. Individuals were also classified with respect to clinical cut points for CVD risk among adolescents and prevalences were calculated using survey procedures (svytab in Stata) (Kwiterovich, 1991). The significance of sex differences in mean risk factors and lipids were evaluated using linear regression, while logistic regression was used to test for significant sex differences in the prevalence of clinical cutpoint categories. Pearson's partial correlation coefficients were calculated to evaluate the associations between lipid levels and anthropometric measures of body composition, lifestyle factors, and socioeconomic factors, adjusting for potential confounding factors (maturational status for all variables, energy intake for % kcal from fat, BMI for activity level, and all behavioral risk factors for income). We find that estimating correlations using the survey regression command yields results that are highly consistent with standard Pearson's correlation procedures. Therefore, for clarity we report Pearson's correlation coefficients. The distributions of dietary energy and fat intake, triceps and subscapular skinfold, household income, high-density lipoprotein cholesterol, and triglycerides were highly skewed and thus log-transformed before analysis.

RESULTS

Males were taller and heavier and had higher intake of energy and total dietary fat compared to females, but fat intake as a percentage of calories and the BMI were equivalent in the sexes (Table 1). Females had thicker triceps and subscapular skinfold thicknesses than males. Using CDC age- and sex-specific reference points for BMI in the US (Kuczmarski et al., 2002), the prevalence of overweight and obesity were very low in both sexes.

Females had higher levels than males for all lipid outcomes other than the LDL-C/HDL-C ratio, which was not different by sex (Table 2). Total cholesterol was roughly 30 mg/dl higher in females than in males. According to clinical cut-points (Table 3), a majority of males and females were classified as "at risk" owing to at least borderline-low HDL-C. Of the majority of the population with low or borderline-low HDL-C, many also had at least one other risk factor categorized as borderline or high risk (Fig. 1).

Triglycerides increased with maturation in boys and decreased with maturation in girls (Table 4). In females, there were also maturational increases in HDL-C and decreases in LDL-C and in both atherogenic ratios. Adjusting for maturation, the BMI was positively related to most lipid measures in both sexes, but was inversely associated with HDL-C in females. Skinfolds were significant predictors of most lipids other than HDL-C (both sexes) and TG (females). Because both the WHR and activity level are correlated with maturation and BMI, we report correlations for these factors adjusting for BMI and maturational status. The WHR was a poor predictor of lipids in males, but was a significant predictor of HDL-C, TG, and the atherogenic ratios in females. Activity level had beneficial associations with lipid

TABLE 1. Current anthropometrics, diet, and activity among Cebu adolescents[a]

	All (n = 608)	Male (n = 300)		Female (n = 308)	
	Mean (SD)	Mean (SD)	Range	Mean (SD)	Range
Height (cm)	153.7 (7.8)	158.4 (6.4)	(136.6, 175.7)	148.9 (5.8)	(129.8, 167.3)
Weight (kg)	44.2 (7.8)	46.5 (8.4)	(30.0, 95.0)	41.7 (6.4)	(22.7, 61.0)
Body mass index (kg/m^2)	18.6 (2.4)	18.5 (2.5)	(13.9, 34.9)	18.8 (2.4)	(12.6, 26.8)
Waist circumference (cm)	63.6 (5.2)	64.4 (5.5)	(53.2, 97.0)	62.7 (4.9)	(50.9, 76.3)
Waist-hip ratio	0.83 (0.08)	0.90 (0.06)	(0.72, 1.0)	0.77 (0.04)	(0.67, 0.89)
Triceps skinfold (mm)	11.3 (4.8)	8.1 (3.6)	(4.0, 30.7)	14.6 (3.5)	(7.0, 24.3)
Subscapular skinfold (mm)	9.6 (3.6)	7.7 (3.0)	(4.0, 30.1)	11.5 (3.2)	(5.0, 25.0)
Overweight[b] N (%)	12 (2.0)	5 (1.7)	—	7 (2.3%)	—
Obese[b] N (%)	2 (0.3)	2 (0.7)	—	0 (0.0)	—
Energy intake (kcal/day)	1643 (723)	1946 (764)	(565, 5529)	1342 (542)	(366, 3698)
Fat intake (g/day)	43.4 (36.1)	49.3 (38.0)	(2.56, 281.8)	37.6 (33.4)	(2.3, 187.9)
Fat intake (% kcal)	22.0 (11.8)	21.4 (11.3)	(2.6, 57.5)	22.5 (12.3)	(3.3, 62.5)
Activity (kcal/day)	352 (175)	413 (203)	(116, 1402)	291 (113)	(33, 856)
Age (years)	15.6 (0.63)	16.0 (0.34)	(15.3, 16.8)	15.0 (0.34)	(14.2, 16.2)

[a]$P < 0.0001$ for all sex differences, except BMI and % fat kcal N.S.
[b]Prevalence of overweight and obesity using sex- and age-specific BMI cut-points (Kuczmarski et al., 2002).

TABLE 2. Lipid levels in Cebu adolescents[a]

	All (n = 608)	Male (n = 300)		Female (n = 308)	
	Mean (SD)	Mean (SD)	Range	Mean (SD)	Range
Total cholesterol (mg/dl)	167.8 (39.1)	153.2 (32.3)	(89, 268)	182.5** (39.6)	(89, 322)
LDL-C (mg/dl)	98.3 (29.9)	91.8 (28.3)	(34, 189)	104.6** (30.1)	(29, 198)
HDL-C[b] (mg/dl)	38.6 (33.3, 45.0)	37.2 (32.5, 43.0)	(19.9, 104)	40.2** (34.3, 47.2)	(19.7, 80.2)
TRIG[b] (mg/dl)	69 (51, 94)	66 (50, 90)	(5, 219)	72* (54, 98)	(8, 256)
Total/HDL-C	4.36 (1.07)	4.16 (1.06)	(1.46, 7.87)	4.55** (1.04)	(1.88, 8.66)
LDL-C/HDL-C	2.58 (0.90)	2.53 (0.97)	(0.39, 5.91)	2.63 (0.83)	(0.47, 5.16)

[a]Sex difference *$P < 0.05$, **$P < 0.0001$.
[b]Geometric mean (interquartile range).

TABLE 3. Percentage (SE) of total, male, and female individuals characterized as "high risk" or "borderline risk" by clinical criteria for fasting lipids in adolescents[a]

Criteria	All	Male	Female	Sex difference
High risk:				
TC $\geq$ 200	20.8 (1.7)	11.1 (1.9)	30.5 (2.7)	F > M***
LDL-C $\geq$ 130	15.1 (1.5)	10.1 (1.7)	20.1 (2.4)	F > M***
HDL-C < 35	33.0 (2.0)	39.3 (2.9)	26.7 (2.6)	F < M**
TR $\geq$ 130	8.9 (1.2)	9.6 (1.7)	8.3 (1.6)	
TC/HDL-C $\geq$ 5	23.4 (1.8)	19.0 (2.3)	27.8 (2.6)	F > M*
Borderline or high:				
TC $\geq$ 170	41.6 (2.0)	26.4 (2.6)	56.7 (2.9)	F > M***
LDL-C $\geq$ 100	32.5 (1.9)	26.9 (2.6)	38.1 (2.8)	F > M***
HDL-C < 45	75.3 (1.8)	81.3 (2.3)	69.3 (2.7)	F < M***
TRIG $\geq$ 100	14.7 (1.5)	13.4 (2.0)	16.1 (2.1)	

[a]Lipid cutpoints in mg/dl (Kwiterovich, 1991).
*$P < 0.05$, **$P < 0.01$, ***$P < 0.001$.

profiles in both sexes that were independent of maturation and BMI. Adjusting for energy intake and maturational status, the percentage calories from fat was positively related to LDL-C in males and to HDL-C and TC in females.

DISCUSSION

The lipid values reported here suggest elevated CVD risk among Filipinos relative to other populations in the Asia Pacific region (Table 5). Mean total and LDL-C in Cebu

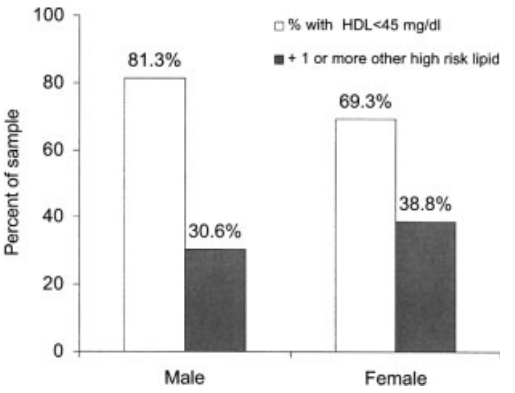

Fig. 1. Percentage of Cebu adolescents with HDL-C <45 mg/dl (white bars) and HDL-C <45 mg/dl + at least one other lipid level (total cholesterol, LDL-C, or triglycerides) characterized as borderline risk or higher (see Table 4 for cutpoints).

females was higher than that documented in US females of comparable age, and roughly equivalent to levels in Northern European populations characterized by high CVD incidence (Larsson et al., 1991). In Taiwan, a close neighbor to the Philippines, more favorable lipid profiles were reported among adolescents, who had lower levels of total and LDL-C, and higher levels of beneficial HDL-C (Chu et al., 1998). As a result of relatively high total and low HDL-C in both sexes, greater than 30% of the Cebu sample had borderline-to-low HDL-C and high levels of at least one other lipid risk factor (Fig. 1), yielding one of the highest ratios of total/HDL reported for any adolescent population (Fig. 2). These findings highlight cholesterol profiles as a potentially important modifiable risk factor for CVD in the Philippines.

The contemporary rise of CVD in the Asia-Pacific region is widely believed to result from changes in diet, activity level, obesity, and other lifestyle factors with effects on CVD development (Galanis et al., 1999; Popkin et al., 2001). Our findings illustrate that these prominent lifestyle factors are associated with cholesterol-related CVD risk among adolescent Filipinos. In both sexes, anthropometric measures of adiposity were positively associated with CVD risk, a finding consistent with other studies of adolescents in Asia (Chu et al., 1998). Adiposity measures tended to be better predictors of lipids in females, a finding which may reflect the fact that female skinfold thicknesses were, on average, 50–60% greater than those in males. Independent of body composition, activity level was associated with beneficial lipid profiles in both males and females, being inversely related to triglycerides and positively related to HDL-C (males $P = 0.13$). In females, activity level was also inversely associated with LDL-C, TC, and both atherogenic ratios. The effect sizes of the relationships with activity were modest, and likely reflect the limitations of our Caltrac-derived activity measures. However, they suggest that physical activity may improve lipid profiles in both sexes, perhaps more strongly in females.

The predominant CVD risk factor for both sexes was low HDL cholesterol, which affected the majority of the population. The

TABLE 4. Partial correlation coefficients relating lipids to anthropometric measures, dietary fat intake, and activity level[a]

	Male (n = 300)						Female (n = 308)					
	TC	LDL-C	HDL-C	TG	TC/HDL-C	LDL-C/HDL-C	TC	LDL-C	HDL-C	TG	TC/HDL-C	LDL-C/HDL-C
BMI	0.15**	0.12**	−0.01	0.14**	0.14**	0.10*	0.07	0.11**	−0.12**	0.10*	0.20***	0.21***
Waist-hip ratio[b]	0.00	0.01	−0.09	0.03	0.10*	0.09	0.00	−0.01	−0.16***	0.13**	0.18***	0.11*
Triceps skinfolds	0.12**	0.12**	−0.03	0.13**	0.13**	0.11*	0.12**	0.16***	−0.06	0.06	0.20***	0.22***
Subscapular skinfold	0.13**	0.12**	−0.02	0.17***	0.13**	0.09	0.06	0.13**	−0.05	0.02	0.14**	0.18***
Maturity	0.04	0.08	−0.07	0.13**	0.09	0.08	−0.04	−0.11*	0.15***	−0.16***	−0.18***	−0.20***
% fat[c]	0.08	0.13**	0.03	0.06	0.06	0.10*	0.10*	0.06	0.13**	0.07	−0.06	−0.08
Activity[b]	0.04	0.06	0.09	−0.20***	−0.03	0.01	−0.10*	−0.10*	0.03	−0.11*	−0.12**	−0.11*

[a]All adjusted for maturational status unless noted otherwise, *$P < 0.1$, **$P < 0.05$, ***$P < 0.01$.
[b]Adjusted for maturational status and the body mass index.
[c]Adjusted for maturational status and energy intake.

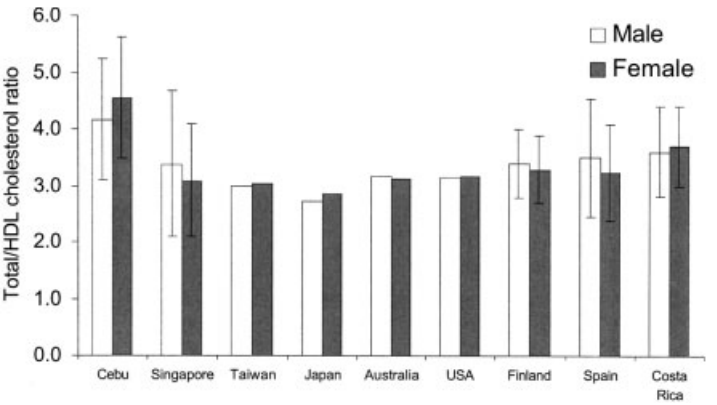

Fig. 2. Total/HDL cholesterol ratio in Cebu males and females compared to values reported for other adolescent populations (see Table 5 for sources).

low HDL-C in Cebu males and females is consistent with past reports of lipids among Filipinos (Knuiman and West, 1983; Sy, 1999), and not unexpected given the low fat intake and high carbohydrate consumption of the population (Knuiman et al., 1983). Cebu adolescents consume, on average, only about 22% of energy from fat, while, based on data from NHANES III, 12–19-year-old US adolescents consume 33–34% of energy from fat (Trioano et al., 2000). However, dietary fat intake was a relatively poor predictor of lipid profiles in both sexes. Our ability to identify associations between dietary fat intake and lipids was likely limited by the absence of separate data on saturated and unsaturated fat in the Filipino food composition tables. Filipinos regularly consume dietary sources of both saturated and polyunsaturated fatty acids, which could have opposing effects on the atherogenicity of the lipid profile. The most common cooking oil is coconut oil, notable for its high content of saturated and trans-fatty acids, while fish—high in beneficial polyunsaturated fatty acids—is typically consumed on a daily basis. Although meat consumption tends to be low, it varies substantially by SES and may be increasingly influenced by the recent advent of local, inexpensive fast food chains. The contribution of these novel institutions to the Filipino diet has not been assessed, but may be particularly important among youth.

As expected, lipid profiles varied in relation to maturational status among males and females. In Cebu males, TG was higher among more mature individuals, while the opposite was true for females. Older females also had higher HDL-C and lower LDL-C and both atherogenic ratios. These cross-sectional relationships were consistent with longitudinal studies of changes in lipid profiles at puberty, which have been related to the production of gonadal steroids, particularly estrogens and testosterone (Berenson et al., 1981; Tell, 1985). Follow-up of the Cebu population will be necessary to establish whether their high apparent level of CVD risk will track into adulthood or is a transient effect of hormonal changes at puberty. However, the cross-sectional differences in lipids in Cebu males and females suggest that lipid profiles may improve with age in females and deteriorate in males.

While lipid levels were relatively high compared to other populations, sex differences in lipid levels in the Cebu sample were also more pronounced than those typically documented (Table 5). Of the 29.3 mg/dl sex difference in total cholesterol, roughly half was explained by differences in HDL-C (3.0 mg/dl) and LDL-C (12.8 mg/dl). The remaining difference in total cholesterol likely resides in the triglyceride-rich lipoprotein fraction, including VLDL and IDL remnant lipoproteins. The high cholesterol content in triglyceride-rich lipoproteins could reflect altered activity of lipid transfer enzymes, impaired removal of partially hydrolyzed, cholesterol-rich lipoproteins, or excess production of

TABLE 5. Lipid profiles reported for adolescent populations[a]

Location (age range)	Total cholesterol				HDL-C				LDL-C			
	Male	SD	Female	SD	Male	SD	Female	SD	Male	SD	Female	SD
Cebu (14–17 years)	153.2	32.3	182.5	39.6	37.2	—	40.2	—	91.8	28.3	104.6	30.1
Singapore (14–18 years)	145.9	32.0	152.9	29.0	46.9	14.0	52.7	15.6	81.0	31.2	83.1	29.3
Taiwan (12–16 years)	151.5	—	161.4	—	53.6	—	55.3	—	83.9	—	90.7	—
Japan (12–15 years)	163.7	—	172.2	—	—	—	—	—	—	—	—	—
Australia (12–15 years)	158.3	—	172.2	—	—	—	—	—	—	—	—	—
USA (12–15 years)	158.3	—	164.1	—	—	—	—	—	—	—	—	—
USA NH3[b] (12–15 years)	158	—	164	—	48	—	51	—	88	—	94	—
Finland (15 years)	172.6	30.5	182.6	31.7	49.8	9.3	54.4	10.4	108.5	27.4	113.5	29.3
Sweden (15 years)	162.2	27.0	181.5	30.9	50.2	11.6	57.9	11.6	96.5	27.0	108.1	27.0
Spain (15–20 years)	163.3	27.8	178.0	29.7	48.3	12.4	56.8	13.9	98.8	27.0	105.8	27.4
Costa Rica (12–18 years)	146.7	23.2	162.2	23.2	42.5	7.7	42.5	7.7	84.9	19.3	92.7	19.3
Iran (14–16 years)	162	36	170	31	43	10	43	11	98	31	104	28

Location (age range)	Triglycerides				Total/HDL-C				LDL-C/HDL-C			
	Male	SD	Female	SD	Male	SD	Female	SD	Male	SD	Female	SD
Cebu (14–17 years)	66	—	72	—	4.16	1.06	4.55	1.04	2.53	0.97	2.63	0.83
Singapore (14–18 years)	89.9	42.6	84.5	30.6	3.38	1.30	3.08	1.00	—	—	—	—
Taiwan (12–16 years)	70.3	—	77.1	—	2.98	—	3.03	—	—	—	—	—
Japan (12–15 years)	—	—	—	—	2.71	—	2.85	—	—	—	—	—
Australia (12–15 years)	—	—	—	—	3.17	—	3.12	—	—	—	—	—
USA (12–15 years)	—	—	—	—	3.15	—	3.17	—	—	—	—	—
USA NH3[b] (12–15 years)	87	—	96	—	—	—	—	—	—	—	—	—
Finland (15 years)	71.7	27.4	73.5	23.9	3.40	0.61	3.29	0.59	—	—	—	—
Sweden (15 years)	70.8	26.5	79.6	26.5	3.13	0.60	3.13	0.6	—	—	—	—
Spain (15–20 years)	69.9	30.1	65.5	23.9	3.50	1.05	3.24	0.85	2.19	0.93	2.00	0.78
Costa Rica (12–18 years)	106.2	26.5	115.0	26.5	3.6	0.8	3.7	0.7	—	—	—	—
Iran (14–16 years)	107	63	114	59	—	—	—	—	—	—	—	—

[a]Data from: Cebu (this study), Singapore (Schmidt et al., 1997), Taiwan (Chu et al., 1998), Japan/Australia/USA (Dwyer et al., 1997).
[b]US NHANES III (Hickman et al., 1998), Finland (Viikari et al., 1985), Sweden (Larsson et al., 1991), Spain (Leis et al., 1999), Costa Rica (Monge and Beita, 2000), Tehran (Azizi et al., 2001).

cholesterol-rich VLDL by the liver (Kwiterovich, 2002). Preliminary analysis of LDL phenotype by nondenaturing gradient gel suggest no sex difference in LDL particle size, a factor that could have a direct effect on LDL clearance (unpubl. data).

Our finding of atherogenic lipid profiles at low levels of obesity and dietary fat intake add to the growing list of studies suggesting population differences in the physiologic response to dietary or behavioral change. In a recent comparative study of prepubertal children, levels of total cholesterol among Japanese children were high despite low BMIs, a low intake of saturated and total dietary fat, and relatively high intake of unsaturated fats (Couch et al., 2000). Adult Singaporeans exhibit high levels of CVD risk factors, including atherogenic lipid profiles, at levels of BMI and WHR below WHO recommended cut points (Deurenberg-Yap et al., 2001). Similarly, the strength of the relationship of BMI to hypertension, and the level of BMI at which risk is elevated, differs between Asian, African-American, Mexican-American, and non-Hispanic populations (Colin Bell et al., 2002).

Such findings suggest population-level variation in CVD susceptibility, possibly tracing to differences in body composition not reflected in BMI, genetic differences across populations, or differential response to changes in nutrition, obesity, or fat patterning (Couch et al., 2000). We have previously shown that birthweight and maternal nutritional status during pregnancy relate inversely to lipid profile-related CVD risk in offspring, but only in males (Kuzawa and Adair, 2003). Thus, while poor prenatal growth has been associated with high cholesterol levels later in life (Barker et al., 1993), it seems unlikely that this could account for the high cholesterol levels of the females in our sample. The frequency of allelic variants with known effects on lipid metabolism are poorly characterized for Filipino populations, but may

be important. A single study of 84 Filipino workers in Saudi Arabia reported a high frequency of an allele at the A-I/C-III gene cluster that is associated with coronary heart disease in populations of European descent (Johansen et al., 1990). Characterization of allelic frequencies of genes with well-established effects on lipid metabolism, such as Apolipoprotein E, are needed to clarify their potential contribution to the high CVD risk in this population.

Cardiovascular diseases are rapidly emerging as a key public health challenge for many developing nations, particularly in the Asia-Pacific region (Popkin et al., 2001). Our results suggest that cholesterol profiles are likely to play an important role in future CVD in Cebu. The Filipino adolescents in our sample had high total and LDL cholesterol despite low HDL cholesterol. This atherogenic lipid profile, in a population early in the nutrition transition, underscores the need for additional research aimed at clarifying the lifestyle, genetic, and early life influences on lipid profiles in the Philippines, and to establish their contribution to current national CVD trends.

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