

Lipid Profiles of Yanomamo Indians of Brazil¹

J. J. MANCILHA-CARVALHO, M.D., PH.D., AND DOUGLAS E. CREWS, PH.D.²

Department of Community Health and Preventive Medicine, Northwestern University Medical School, 680 North Lake Shore Drive, Suite 1102, Chicago, Illinois 60611

To determine serum lipid levels and their correlates in one of the world's most isolated populations, 62 adult Yanomamo Indians from the Amazonian rain forest were examined. After measurement of body weight and height, and estimation of age, casual blood samples were obtained. Estimated age ranged from 20 to 68 years, with men averaging 37 and women 35 years. Mean serum total cholesterol was very low among both men (123 mg/dl) and women (142 mg/dl) compared with western samples, whereas triglycerides—112 and 110 mg/dl, respectively—were lower among men and slightly higher among women than for U.S. men and women. Yanomamo women had significantly higher total cholesterol ($P = 0.02$) and body mass index (BMI) ($P = 0.05$) than men. HDL-cholesterol ($P = 0.08$) and LDL-cholesterol ($P = 0.21$) were also somewhat higher among women. Multivariate regression analysis indicated that estimated age was independently related to cholesterol in both sexes, while BMI was of borderline significance. The very low serum lipid levels in this isolated population are apparently attributable mainly to their largely vegetarian diet, low in fats and cholesterol and high in fiber, with concomitant high physical activity associated with low BMI. © 1990 Academic Press, Inc.

INTRODUCTION

Elevated serum cholesterol, cigarette smoking, and hypertension are firmly established as major risk factors for cardiovascular diseases, (CVD) particularly coronary heart disease (CHD) (1, 2). Extensive research demonstrates that dietary factors, particularly saturated fats and cholesterol, are associated with serum cholesterol levels (3). In addition, studies in isolated populations subsisting on diets naturally low in fat and cholesterol have reported low blood lipid values (4-10).

In this study serum lipid levels among a sample of Yanomamo Indians (the most isolated tribe in South America and probably the world) were examined. Previous studies have shown that Yanomamo Indians have low blood pressure levels and show no increase in blood pressure with age (11-14). To date there have been no studies on blood lipid levels. The hypothesis was that serum total cholesterol (TC) among the Yanomamo would be significantly lower than among populations of the United States and other cosmopolitan societies. On the basis of results from other isolated populations we expected to see some differences between men and women, but minimal age differences in mean TC and its components.

¹ Supported in part by Grant 20.0161/87 MP from the Brazilian Research Council (CNPq).

² To whom reprint requests should be addressed.

POPULATION AND METHODS

Study Population

The Yanomamo live in an area of about 100,000 square miles located along the border between Brazil and Venezuela. The total population consists of approximately 18,000 individuals scattered throughout the Amazonian rainforest in approximately 200 villages, each containing from 40 to 250 people. In the almost inaccessible Surucucu Plateau region of northwest Brazil reside the most isolated members of the Yanomamo, some of whom have never seen a non-Indian.

The Yanomamo are generally seminomadic "slash-and-burn" agriculturalists (12, 15). They subsist on a diet of locally produced crops and game, supplemented by wild fruits and insects. Dietary staples are cooked bananas and manioc. Other traditional crops, mainly roots, and introduced plants, such as sugar cane, sweet potato, and tobacco, are also grown. The Yanomamo practice no animal husbandry; thus domestic swine, cattle, and chicken are not eaten. What meat does enter the diet comes from the hunt and is thus relatively lean. Furthermore, the method of preparation assures that the major part of available fat is lost during cooking over an open fire. On the Surucucu plateau there is little, if any, access to processed sugar, salt, alcohol, milk and other dairy products, or eggs from domesticated fowl.

Data Collection and Analysis

In July 1987, J.J.M.C. arrived at the Brazilian government post (FUNAI) in the Surucucu area. From there he and an interpreter/guide visited two Yanomamo villages, numbering about 130 persons each, approximately a 7-hr walk from the FUNAI post. At that time every adult member of both villages, approximately 90 individuals, was invited to come to the FUNAI post for a medical examination and to receive a gift such as a machete, a highly valued tool in this population. About two-thirds of the adults (41 men and 21 women) made the 14 hr round trip and were measured and interviewed.

Before blood was drawn, weight and height were measured using a balance-beam scale with an extension stadiometer (Brazilian Filizola). All measurements were made by a single observer (J.J.M.C.) who also drew the blood samples. Since none of the Surucucu Indians spoke Portuguese, all interviews were conducted by the interpreter. Age was estimated by physical appearance of the participant and from additional information about the number and ages of the participant's children. The personal knowledge of the interpreter, who knew these two villages well, was also used. There was no method available to independently validate estimated ages and therefore they should be interpreted as approximations. All procedures were conducted in accordance with ethical standards for human experiments outlined by the Brazilian government.

Blood samples were collected without knowledge of the time of the individual's last meal. Approximately 10 ml of venous blood was drawn into plain tubes via venipuncture. Within 1 hr of collection, sera were separated by centrifugation and frozen for later transport to the Public Base Hospital of Brasilia. Blood samples collected from three women and eight men, Brazilian employees of FUNAI and

army personnel who were in Surucucu at the time of this fieldwork, were submitted to the Base Hospital's laboratory along with the Yanomamo samples. This was done without the knowledge of the laboratory personnel. Results for these 11 people were within the range commonly reported for Brazilian citizens of the same age group: mean values for women of 200 mg/dl serum TC and 113 mg/dl for triglycerides (TG), and for men, 196 mg/dl and 138 mg/dl, respectively. Although not the ideal method to evaluate laboratory techniques, it was the only option available at the time of the study. The laboratory maintained its own internal quality control standards.

The blood samples were thawed at room temperature for laboratory analysis. Serum TC and TG were determined by enzymatic methods (16, 17). HDL-cholesterol (HDL-C) was determined after VLDL-cholesterol (VLDL-C) and LDL-cholesterol (LDL-C) were precipitated from the specimen using phosphotungstate and magnesium (18). LDL-C and VLDL-C were then calculated: $LDL-C = TC - HDL-C - (Triglycerides/5)$, and $VLDL-C = Triglycerides/5$. Data on HDL-C, LDL-C, and VLDL-C were available only for a reduced sample: 34 men and 14 women. The body mass index (BMI) [Weight (kg) / Height (m²)] was also calculated.

Sex differences in lipid profiles were examined. Average values for each lipid fraction were determined and differences between the sexes were assessed for statistical significance using Student's *t* test. Lipid values among the Yanomamo were also compared by sex to those from two U.S. samples (19, 20). Correlations among the lipid values and with age and BMI were examined. Stepwise linear regression, with forced entry of all independent variables, was used to estimate the independent effects of age, sex, and BMI in explaining variance in serum TC, HDL-C, LDL-C, and TG. Sex was entered as an indicator variable (women = 0, men = 1) to allow direct estimation of sex differentials and inclusion of the entire sample for estimation of the effects of age and BMI.

RESULTS

Among the Yanomamo Indians who participated in this study the median estimated age of the men was 32 years (mean 36.8; range 21 to 68), and for the women the median estimated age was 28 years (mean 35.0; range 20 to 64). These Indians exhibited low mean levels of serum TC, HDL-C, LDL-C, and BMI (Table 1). Mean serum TC among Yanomamo men was about half that among U.S. men aged 20–74 years studied in the National Health and Nutrition Examination Survey (NHANES-II), 211 mg/dl (19). TC was also below the fifth percentile of U.S. men aged ≥ 20 years who participated in the Lipid Research Clinics Population Study (LRC) (20). Among Yanomamo women mean serum TC was about two-thirds that of women aged 20–74 years studied in the NHANES-II, 215 mg/dl (19). Yanomamo women were below the 10th percentile of U.S. women aged ≥ 35 years and almost equal to the 10th percentile of women aged 30–34 years who participated in the LRC study (20).

Among Yanomamo men, mean LDL-C was below the 5th percentile of men aged ≥ 25 years, and HDL-C was below the 25th percentile, of U.S. men aged ≥ 20 years who participated in the LRC study (20). Similarly among Yanomamo

TABLE 1
PHYSICAL CHARACTERISTICS AND SERUM LIPIDS OF YANOMAMO INDIANS

Variables	Men			Women			P
	n	Mean	SD	n	Mean	SD	
Age (years)	41	36.8	12.5	21	35.0	14.2	0.604
Weight (kg)	41	46.9	4.4	21	43.0	5.2	0.003
Height (cm)	41	151.5	3.3	21	142.0	5.2	0.001
BMI (kg/m ²)	41	20.4	1.4	21	21.3	1.9	0.051
Cholesterol (mg/dl)	41	121.9	31.5	21	142.5	29.5	0.015
Triglycerides (mg/dl)	41	111.7	36.8	21	109.8	35.1	0.848
HDL-C (mg/dl)	34	33.9	7.0	14	39.6	10.5	0.077
LDL-C (mg/dl)	34	68.1	24.5	14	78.2	20.4	0.206
VLDL-C (mg/dl)	34	22.3	7.4	14	22.0	7.0	0.848

women mean LDL-C was below the 10th percentile of U.S. women aged ≥ 35 years, but only below the 25th percentile of women 20–34 years old, while mean HDL-C in Yanomamo women was about equal to the 10th percentile of women aged ≥ 25 years who participated in the LRC study (20). Serum TC/HDL-C and LDL-C/HDL-C ratios among both Yanomamo men and women were 3.6 and 2.0.

Yanomamo women had significantly higher serum TC and BMI than men, who were taller and heavier. HDL-C was higher for women than for men, a difference of borderline significance, as was LDL-C, a difference not statistically significant. Both sexes of Yanomamo were of lower height and weight, and had much lower BMI than comparable U.S. samples of men and women, 25.3 and 25.0 kg/m², respectively (21). The range of BMI in Yanomamo was 16.9 to 23.6 for men, and 17.4 to 24.1 for women.

Between estimated ages 20 and 44 years, cross-sectional mean serum TC levels appeared to be age related in Yanomamo women, after which they were apparently stable (Fig. 1); however, there were no women estimated to be between 30 and 39 years of age. In Fig. 1, the first three age groups are represented by 6, 5, and 6 women and the last two by only 1 and 3 women. Men, numbering 6, 17, 6, 8, and 4, are slightly better represented in the second and fourth age groups. These are all small numbers and ages are estimated; however, the data still show apparent age solidus class differences. The difference in mean serum TC among younger and older women was largely due to a 37 mg/dl difference between the 25 to 34 and 35 to 44 year-old age groups. Among Yanomamo men, cross-sectional mean serum TC levels also appeared to be age-related. Older men had higher serum TC than younger men (Fig. 1). At every estimated age, mean serum TC was lower among Yanomamo men and women than among U.S. men and women (19). Serum TC was correlated significantly with estimated age and triglycerides, but only weakly correlated with BMI (Table 2) among Yanomamo men. Among Yanomamo women serum TC correlated significantly only with estimated age.

Linear regression, using a stepwise model with forced entry of estimated age, sex, and BMI, indicated that serum TC was significantly and independently related to estimated age and sex. Together, estimated age and sex explained 33% of

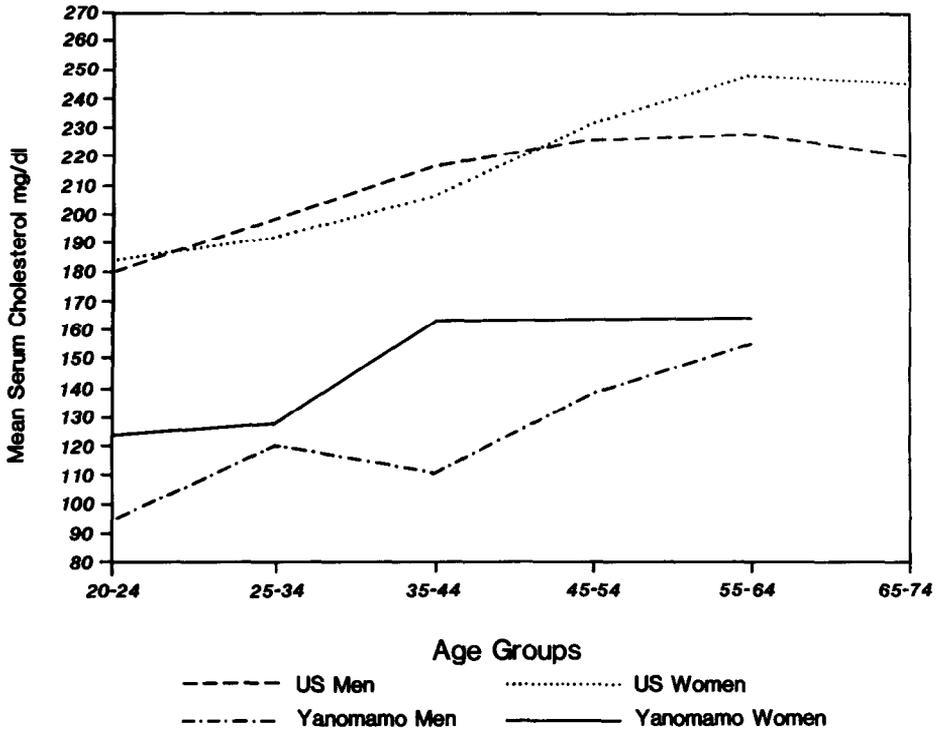


FIG. 1. Mean serum cholesterol levels in Yanomamo Indians compared to U.S. men and women by age. U.S. data are from the National Health and Nutrition Examination Survey (NHANES-II), 1976-1980 (19).

the variation in serum TC (Table 3). Inclusion of BMI explained an additional 3.7% of the total variation ($P = 0.07$). The regression method further indicated that HDL-C exhibited a significant sex-related difference, being 5.88 mg/dl higher among Yanomamo women. However, neither estimated age nor relative weight as

TABLE 2
SIMPLE CORRELATIONS AMONG PHYSICAL CHARACTERISTICS AND SERUM LIPIDS OF
YANOMAMO INDIANS

	Men					
	Age	BMI	Tc	TG	HCL-C	LDL-C
Women						
Age		0.06	0.51**	0.18	0.29	0.49**
BMI	-0.51*		0.27	0.06	0.08	0.36*
Tc	0.51*	-0.15		0.60***	^a	^a
TG	0.36	-0.15	0.39		0.12	0.52***
HCL-C	-0.16	-0.06	^a	-0.19		0.40*
LDL-C	0.44	0.03	^a	0.37	0.09	

^a Not reported—inappropriate to correlate a part with the whole from which it was derived.

* $P < .05$.

** $P < .01$.

$P < .001$.

TABLE 3
 THE DEPENDENCE OF YANOMAMO SERUM LIPIDS ON AGE, SEX,^a AND BODY MASS INDEX (BMI) USING STEPWISE REGRESSION WITH FORCED ENTRY OF ALL INDEPENDENT VARIABLES^b

Serum total cholesterol				High-density lipoprotein cholesterol				Low-density lipoprotein cholesterol				Triglycerides			
Order of entry	β	R^2	P	Order of entry	β	R^2	P	Order of entry	β	R^2	P	Order of entry	β	R^2	P
Age	1.294	0.215	0.001	Sex	-5.882	0.097	0.036	Age	0.964	0.187	0.001	Age	0.680	0.059	0.064
Sex	-19.608	0.115	0.009	Age	0.067	0.009	0.477	BMI	4.802	0.149	0.006	BMI	0.410	0.000	0.889
BMI	3.945	0.037	0.071	BMI	0.162	0.001	0.822	Sex	-9.361	0.031	0.149	Sex	0.980	0.000	0.922
Total															
R^2		0.367				0.107				0.367				0.059	

^a Sex was included as a dichotomous variable: 1 = male; 0 = female.

^b Coefficients, contribution to R^2 , and P values determined after adjustment for all other variables included in the model.

measured by BMI was significantly related to HDL-C; their inclusion in the regression model did not significantly increase the amount of explained variance (Table 3). LDL-C was statistically significantly related to both estimated age and BMI, but showed only a borderline dependence on sex, although a sex difference of 9.4 mg/dl may be physiologically significant (Table 3). Although there was a tendency for a borderline association with estimated age, serum TG were not significantly related to estimated age, BMI, or sex (Table 3). Inclusion of BMI and sex did not increase the total explained variance in serum TG.

DISCUSSION

Yanomamo Indians have mean serum TC, LDL-C, and HDL-C levels below those of samples from Western industrialized populations such as the United States. They are also lower than those observed in North and South China samples (22). This is true even though serum lipids in the Yanomamo were measured without knowledge of time since the participant's last meal. Serum TC levels in Yanomamo are similar to those of some Solomon Islands samples (4). However, unlike Solomon Islanders, Kalahari Bushmen (10), and some tribal people in communities in New Guinea (8), who show no age-associated differences in TC levels, among the Yanomamo and some other traditional living populations (5, 6) age differences in cholesterol levels are observed. This suggests that higher cholesterol levels at older ages observed in cross-sectional data may not necessarily be solely a concomitant of Westernization or acculturation, since they also occur in low-cholesterol settings. However, the data on higher mean levels of serum TC with age in this cross-sectional study of the Yanomamo must be interpreted with caution given the small numbers in the estimated age groups.

LDL-C and HDL-C are also low in this sample compared with both Western and non-Western samples. However, both men and women Yanomamo have TC/HDL-C and LDL-C/HDL-C ratios that are not very different from those of U.S. women (20), and which are also similar to those observed in China (22). The serum TC/HDL-C ratio in Yanomamo men is well below that of the 50th percentile of U.S. men, while the LDL-C/HDL-C ratio is almost identical. The TC/HDL-C ratio in Yanomamo men and women approximates the value, 3.5, among Boston Marathon runners (23) and is approximately the same as the 50th percentile of U.S. women (19, 20). This finding suggests that a low-fat, low-cholesterol, high-complex carbohydrate and fiber diet in tropical forest agriculturalists may lead to low levels of both HDL-C and LDL-C. Mean triglyceride levels in Yanomamo men are much lower than the age-weighted mean among men aged 20–59 years in the LRC study sample (139 mg/dl). Conversely, in Yanomamo women TG levels exceed somewhat the age-weighted mean of non-sex hormone using women aged 20–59 years in the LRC sample (94 mg/dl) (20). This may be partly related to the measurements having been made in fasting blood samples in the LRC and random (casual) blood samples in the Yanomamo.

Cholesterol and TG levels are commonly significantly correlated with BMI in cosmopolitan societies (24); however, this association was not seen in the Yanomamo sample. Tarahumara Indians of Mexico also show no significant correlation between body weight and serum cholesterol levels (5). One possible ex-

planation may be the low amount of variation in Yanomamo BMI, another may be the small sample size. However, a significant relationship between LDL-C and BMI among the Yanomamo is shown in Table 3, suggesting that the lack of a significant relationship between BMI and serum TC may not be due to low variability in BMI. The differences and patterns of association of HDL-C and LDL-C with the independent variables examined by multiple regression suggest that these two components of cholesterol are responding to different aspects of Yanomamo physiology.

Yanomamo women had higher BMI and lipid levels than men. This has been found in at least one other isolated population (5). Such differences may be associated with a higher frequency of lactating and pregnant women in these samples. In this sample about half of the women were breastfeeding. Unfortunately, there are no data comparing women not lactating or pregnant to those who were. However, in the Tarahumara Indian sample the same levels of cholesterol were found in men and nonpregnant nonlactating women (139 mg/dl), while the levels for pregnant and lactating women were 195 mg/dl and 178 mg/dl, respectively (5). This suggests that pregnancy and lactation may lead to elevations in cholesterol levels in non-Western as well as in Western settings (25).

Several factors may be related to the low lipid levels found in the Yanomamo, including a diet low in lipids and cholesterol and high in fiber, the rarity of obesity, high levels of physical activity, and perhaps intestinal parasitism. Quantitative data to test these relationships are not presently available. The close agreement between cholesterol in the Brazilian blood samples submitted to the same laboratory and previously published values for Brazilian populations (26) suggests that the laboratory and field collection techniques were not likely to be responsible for the low lipid values in the Yanomamo sample.

In conclusion, this unacculturated Brazilian Indian tribe shows serum TC levels significantly below that of virtually all nonisolated populations in both industrialized and developing countries. In this sample, both sexes had moderately higher cholesterol levels at older ages. This suggests that modest age-related increases in cholesterol may not be exclusively related to Westernization and acculturation but may also occur in more isolated settings.

ACKNOWLEDGMENTS

We gratefully acknowledge the cooperation of the study participants, the Brazilian Air Force, and the FUNAI representatives resident on the Surucucu Plateau at the time of the fieldwork. We express appreciation to Dr. J. Stamler for his encouragement and valued input during the development of this manuscript. We also thank Professors A. Dyer, R. Stamler, Kiang Liu, and W. K. Beatty for helpful suggestions. This manuscript was written while J.J.M.C. was a visiting scholar and D.E.C. was an NHLBI postdoctoral fellow (Grant No. 5T32HLO7113-14) in the epidemiology of cardiovascular disease in the Department of Community Health and Preventive Medicine at Northwestern University Medical School. Parts of the manuscript were presented at the 28th Annual Conference on Cardiovascular Disease Epidemiology, Council on Epidemiology, American Heart Association, 1988.

REFERENCES

1. Castelli W, Kannel WB. Risk factors for cardiovascular disease: The Framingham Heart Study. In: *Forty Years of Achievement in Heart, Lung, and Blood Research*. National Institutes of Health, 1987:53-61.

2. Stamler J. Population studies. In: Levy R, Rifkind B, Denis B, Ernst N, Eds. Nutrition, Lipids, and Coronary Heart Disease. New York: Raven Press, 1979:25-88.
3. Shekelle RB, Shryock AM, Paul O, Lepper M, Stamler J, Liu S, Raynor WJ. Diet, serum cholesterol, and death from coronary heart disease—The Western Electric Study. *N Engl J Med* 1981; **304**:65-70.
4. Page LB, Damon A, Moellering RJ, Jr. Antecedents of cardiovascular disease in six Solomon Island societies. *Circulation* 1974; **49**:1132-1146.
5. Connor WE, Cerqueira MT, Connor RW, Wallace RB, Malinow R, Casdorph HR. The plasma lipids, lipoproteins and diet of the Tarahumara Indians of Mexico. *Am J Clin Nutr* 1978; **31**:1131-1142.
6. Werner GT. Serum cholesterol levels in the population of Punjab in north west India. *Am J Clin Nutr* 1978; **31**:1479-1483.
7. Neel JV, Arends T, Junqueira PC, Keitch F, Maybury-Lewis D. Studies of Xavante Indians of Brazilian Mato Grosso. *Am J Hum Genet* 1964; **16**:52-135.
8. Sinnet PF, Shyte HM. Epidemiological studies in a total highland population, Tukisenta, New Guinea. Cardiovascular disease and relevant clinical, electrocardiographic, radiological and biochemical findings. *J Chronic Dis* 1973; **26**:265-290.
9. Mendez JC, Tejada C, Flores M. Serum lipid levels among rural Guatemalan Indians. *Am J Clin Nutr* 1962; **10**:403-409.
10. Truswell AS. Serum-lipids in Bushmen. *Lancet* 1968; **2**:684.
11. Oliver WJ, Cohen EL, Neel JV. Blood pressure, sodium intake and sodium related hormones in the Yanomamo Indians, a "no-salt" culture. *Circulation* 1975; **52**:146-151.
12. Mancilha-Carvalho JJ. Estudo da pressao arterial de Indios Yanomami. Tese de Doutorado, Rio de Janeiro, Brazil, 1985.
13. Intersalt Cooperative Research Group. Intersalt: An international study of electrolyte excretion and blood pressure. Results for 24 hour urinary sodium and potassium excretion. *Br Med J* 1988; **297**:319-328.
14. Mancilha-Carvalho JJ, Baruzzi RG, Howard PF, Poulter N, Alpers MP, Franco LJ, Marcopito LF, Spooner VJ, Dyer AR, Elliott P, Stamler J, Stamler R. Blood pressure in four remote populations in the INTERSALT study. *Hypertension* 1989; **14**:238-246.
15. Chagnon NA. Yanomamo: The Fierce People. New York: Holt, Rinehart & Winston, 1968.
16. Allain CC, Lucy SP, Cicely CGC, Richmond W, Paul CF. Enzymatic determination of total cholesterol. *Clin Chem* 1974; **20**:470-474.
17. Sugiura M, Oikawa T, Hirano K, et al. A simple colorimetric method for determination of serum triglycerides with lipoprotein lipase and glycerol dehydrogenase. *Clin Chim Acta* 1977; **81**:125-130.
18. Lopes-Virela MF, Stone P, Ellis S, Colwell JA. Cholesterol determination in high-density lipoproteins separated by three different methods. *Clin Chem* 1974; **23**:882-884.
19. National Center for Health Statistics. Total Serum Cholesterol Levels of Adults 20-74 Years of Age, United States, 1976-1980. DHHS Publication No. (PHS) 86-1686, 1986.
20. The Lipid Research Clinics Population Studies Data Book, Vol. I, The Prevalence Study. Lipid Metabolism Branch, Division of Heart and Vascular Diseases, National Heart, Lung, and Blood Institute. NIH Vascular Diseases, National Heart, Lung, and Blood Institute. NIH Publication No. 80-1527 July 1980.
21. National Center for Health Statistics. Anthropometric Reference Data and Prevalence of Overweight, United States, 1976-80. DHHS Publication No. (PHS) 87-1688, 1987.
22. Tao SC, Huang ZD, Tsai RS, Wu XG, Zhou BF, Yu JS, Li YH, Rao XX, Zhang K, Cen RC, Friedewald DB, Stamler J, Warnick TJ, Williams D. Dietary patterns, serum lipids, urinary electrolytes, and blood pressure: Middle-aged male and female workers and farmers in North and South China. Abstracts of the 10th World Congress of Cardiology, Washington, D.C., September 14-19, 1986:131.

23. Castelli WP. Epidemiology of coronary heart disease: The Framingham Study. *Am J Med* 1984; 76:4-12.
24. Alexander JK. Obesity and coronary heart disease. In: Connor WE and Bristow JD, Eds. *Coronary Heart Disease: Prevention, Complications and Treatment*. Philadelphia: Lippincott, 1985:111-123.
25. Van Stiphout WA, Hofman A, de Bruijn AM. Serum Lipids in young women before, during, and after pregnancy. *Am J Epidemiol* 1987; 126:922-928.
26. Carneiro O. Níveis de lipídeos sanguíneos em diferentes populações brasileiras. *Arq Bras Cardiol* 1979; 32:361-365.