Serum Cholesterol Levels in School Children from Three Socio-Economic Groups

By NEVIN S. SCRIMSHAW, PH.D., M.D.,* ALAN BALSAM, B.A.,† AND GUILLERMO ARROYAVE, PH.D.‡

THE SERUM cholesterol levels of rural low-income adults in both Guatemala[1] and Costa Rica[2] have been shown to be significantly lower than middle and upper income persons in urban areas of the United States and Guatemala matched for age and sex. Reports of a comparable nature based on work in Italy,[3] Spain,[4] South Africa,[5–8] and Japan[9] as well as studies with experimental human diets[3,10–16] have given similar evidence of the role of environmental factors in determining the mean cholesterol levels of population groups. In these studies the factor receiving greatest attention has been the difference in habitual diets,[9,13] particularly the relative amounts of protein of animal origin, and fat.[7,8,17]

Serum cholesterol levels appeared to be low in children at birth[7,18,19] and at this time, to be independent of the diet, race, and cholesterol level of the mother.[5] They have been reported to rise during the first two years of life to levels within the adult range.[18–20] During childhood and adolescence, most observers have found no consistent variations with either age or sex.[16,21–25] In view of the marked differences in serum cholesterol levels among adults in different socio-economic groups in Guatemala, it was of great interest to determine whether school children show the differences in serum cholesterol levels which characterize their parents.

This report presents the total serum cholesterol levels of 288 Guatemalan school children selected from three distinct economic and occupational groups of differing dietary habits.

MATERIAL

Economic and Social Status

Boys and girls 7 to 12 years of age were selected at random from the following three types of Guatemalan primary schools:

Group I: Urban Private School—the fathers of these children were mainly business and professional men in Guatemala City. Only children having at least one Guatemalan parent were included. Many of the parents in this group had been examined previously.[1]

Group II: Urban Public School—the fathers of the children in this group worked as mailmen, policemen, truck and bus drivers, and at other unskilled and semiskilled labor. They lived in a relatively poor district of Guatemala City.

Group III: Rural Public School—the fathers of most of these children worked as agricultural laborers on nearby farms and coffee plantations or on their own small plots of land. They lived in and around the rural village of San Miguel Dueñas, Department of Guatemala, and their parents were representative of the other rural Guatemala adults studied previously.[1]

Dietary Habits

No precise dietary information was available for most of the school children studied, but the diets of the parents of these children, or of adults of comparable socio-economic groups were analyzed in detail and have been summarized in Table I. The total calories,

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* Regional Adviser in Nutrition, Pan American Sanitary Bureau, Regional Office for the Americas of the World Health Organization, and Director, INCAP.

† Medical student Fellow of the National Foundation for Infantile Paralysis and the Williams-Waterman Fund of the Research Corporation.

‡ Chief, Division of Clinical Biochemistry, INCAP.

TABLE I

Dietary Estimates for the Study Groups

Group No.		Calories	Protein, g/day			Fat, g/day			% Calories from fat
			Animal	Vegetable	Total	Animal	Vegetable	Total	
I	Urban upper-income	2,462	39	30	69	46	56	102	37
II	Urban lower-income	1,585	10	37	47	13	14	27	15
III	Rural lower-income	2,283	6	61	67	9	14	23	8

percentage of calories from fat, and the proportions of animal and vegetable protein are indicated for each of the three groups. The technics employed by INCAP for collecting and calculating the dietary data have been previously cited.[1]

The dietary pattern of Group I was based on seven-day diet histories obtained in November 1954, from 15 mothers of children[26] in the private school included in the present study.

Similar dietary information for Group II has been calculated from the diet histories of 15 families in the nearby town of Amatitlán.[27] Their diets correspond closely to those of the four- and five-year-old pre-school children recently studied in a poor district of Guatemala City.[28]

Dietary information for Group III has been published previously.[1] The figures in Table I are averages for four villages in the immediate vicinity of San Miguel Dueñas.[29–32]

METHODS

Eight boys and eight girls were selected at random from each age group from seven through twelve, in three different schools. Children obviously ill with an acute or chronic disease were excluded. At least 0.5 ml of blood was extracted from the fingertip. The serum was separated and frozen within eight hours of collection of the blood and analyzed within ten days.

Total serum cholesterol was determined by the method of Abell *et al.*,[33] with the modification that all quantities of samples and reagents were reduced by one-half so that sufficient serum (0.26 ml) could be obtained from fingertip-blood samples. The significance of the

TABLE II

Height and Weight and Skin-Fold Thickness of Guatemalan School Children*
(8 Children per Group)

Boys

Age (years)	Urban upper-income						Urban lower-income						Rural lower-income					
	Height		Weight		Skin-fold		Height		Weight		Skin-fold		Height		Weight		Skin-fold	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
7	126.0	4.1	26.8	5.3	7.0	3.2	113.4	3.5	20.2	2.5	6.7	2.0	112.2	6.5	20.4	2.5	5.5	1.1
8	127.1	4.2	26.6	4.2	6.8	1.1	116.5	6 0	21.4	2.4	6.4	1.2	113.8	3.8	21.1	1.7	6.8	1.7
9	133.7	3.8	32.3	7.7	8.5	1.8	123.3	4.7	23.4	2.9	6.3	1.7	118.5	8.8	22.2	2.8	4.4	1.3
10	135.9	3.7	31.7	4.6	10.2	3.6	124.6	7.6	25.6	3.8	5.8	1.2	124.6	5.9	24.5	3.2	6.0	2 4
11	139.4	4.0	33.5	3.3	7.9	2.9	129.0	7.4	26.8	4.5	5.4	1.1	127.8	6.5	26.4	2.9	6.5	2.9
12	148.8	3.5	43.0	4.5	10.9	3.9	135.6	4.6	31.4	3.4	6.8	0.7	132.6	6.2	28.1	4.0	4.9	0.9

Girls

7	120.4	5.9	23.7	3.6	8.1	2.6	113.0	5.5	19.3	2.2	6.7	1.4	111.1	5.3	20.6	2.8	6.5	2.0
8	126.2	6.9	26.8	4.1	8.8	1.3	117.1	6.2	21.3	3.4	7.4	1.7	113.8	4.5	19.8	2.0	6.4	1.7
9	130.4	4.0	32.0	3.8	10.1	2.2	122.0	5.5	22.4	3.2	5.8	0.9	120.8	4.9	21.7	1.8	5.8	0.9
10	135.8	5.3	36.0	4.3	12.2	1.9	127.9	10.0	24.5	3.8	6.6	2.0	125.9	5.3	25.8	5.0	6.6	3.2
11	142.3	5.0	38.0	6.2	11.0	3.9	131.2	3.2	28.4	3.3	6.7	3.4	134.1	8.5	30.8	5.6	8.0	3.3
12	155.8	7.1	46.0	9.0	9.3	3.7	137.3	3.2	30.8	2.5	7.5	2.0	131.6	6.7	29.7	3.2	6.9	2.1

* Height in cm, weight in kg, and skin-fold thickness in mm.

S. D. = standard deviation.

differences among the cholesterol values obtained was determined by the *t*-test.

Height, weight, and general nutritional status were determined at the time the blood samples were taken.* Measurements of the thickness of the skin-fold of the posterior surface of the upper arm were made according to the recommendations of Brožek *et al.*[34]

RESULTS

The values obtained for height, weight, and skin-fold thickness are shown in Table II. These values indicate that the upper-income urban children were taller, heavier, and had more subcutaneous fat than either the urban or rural lower-income groups. The differences between the latter two groups were not statistically significant although the urban children showed slightly higher values for all three measurements.

The lower-income children, both urban and rural, had frequent follicular hyperkeratosis and mild tongue changes suggestive of nutritional deficiency. The serum cholesterol results obtained are summarized in Table III. The average cholesterol values were significantly different ($P < 0.01$) among each of the three school groups for both boys and girls. There was no consistent tendency for the values to increase with age during the period studied. Moreover, the cholesterol differences between boys and girls were not significant for either the upper-income urban or the lower-income rural groups. However, in the urban public school group the average sex difference in cholesterol was significant at the 5 per cent level.

DISCUSSION

The data clearly demonstrate that the environmental factor or factors responsible for the differences in serum cholesterol between upper-income and lower-income adults in Guatemala also affect the serum cholesterol levels of children of school age. In view of these results, and the finding that regardless of the status of the mother serum cholesterol levels are low at birth and rise rapidly during the first few days,[18–20] it is possible that still younger children would show this difference.

It is of special interest that the relatively small dietary and other differences between the lower-income urban and rural groups should be reflected in significant differences in serum total cholesterol. Apparently, the mechanism responsible for maintaining serum cholesterol levels is sensitive to relatively small changes in the environment; whether or not these are dietary cannot be concluded from the present

* These samples were collected jointly with Mr. Roger A. Feldman for a parallel study of serum pseudocholinesterase levels. The collection of blood samples in Group I was made possible through the kind cooperation of Mr. Robert B. McVean, Director of the *Colegio Americano de Guatemala*.

TABLE III

Serum Cholesterol Levels of Guatemalan School Children*

(8 Children per Group)

Age (years)	Boys						Girls					
	Urban upper-income		Urban lower-income		Rural lower-income		Urban upper-income		Urban lower-income		Rural lower-income	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
7	205.9	19.7	139.7	25.7	118.5	19.2	192.1	25.2	154.0	26.6	121.4	12.1
8	173.6	22.6	129.6	22.2	107.5	23.4	172.8	30.0	157.3	31.7	108.6	23.2
9	180.2	29.8	142.2	35.1	115.1	35.3	184.9	33.1	160.7	33.2	126.7	33.0
10	181.1	24.0	135.2	16.0	135.8	17.4	196.2	36.7	149.2	38.5	140.9	27.1
11	201.9	31.2	149.3	38.1	122.5	18.4	194.5	25.0	153.5	29.2	129.4	19.0
12	180.5	21.5	162.0	27.8	127.3	22.4	185.2	31.0	161.4	23.4	139.1	13.2
Total	187.2	26.8	143.0	28.9	121.1	24.0	187.6	29.9	156.0	29.5	127.7	24.0

* Expressed in mg/100 ml.

data. However, children should be suitable experimental subjects for determining the specific factors responsible for the observed differences in cholesterol among socio-economic groups.

It should be noted that the children with relatively low serum levels of cholesterol belong to the same socio-economic groups in which the severity of atherosclerosis and frequency of myocardial infarction are relatively low.[35]

Except for the work of Strong *et al.*[36] relatively little attention has hitherto been paid to atherogenesis in children, but the present findings suggest that such studies may prove useful. In view of its potential importance in relation to the development of atherosclerosis, these investigations should also include determinations of serum cholesterol.

SUMMARY

Total serum cholesterol was determined in eight boys and eight girls selected at random for each age from seven through twelve in schools with children from the following three population groups: urban upper-income business and professional families, urban lower-income families living in a poor district of Guatemala City, and lower-income families in a rural village. The former consumed about 69 g of protein per day and received 37 per cent of their calories from fat as compared with 47 g and 15 per cent for the urban lower-income and 67 g of protein and 8 per cent of fat calories for the rural group. The amount of animal protein consumed by the three groups was 39, 10, and 6 g respectively. The urban children tended to be heavier and taller; their skin-folds over the mid-triceps area were thicker. The serum cholesterol levels showed no age differences within groups. The average cholesterol values for boys were: urban upper-income, 187.2 mg/100 ml (Standard Deviation: 26.8); urban lower-income, 143.0 mg/100 ml (S.D. 28.9) and rural lower-income, 121.1 mg/100 ml (S.D. 24.0). The corresponding values for girls were: 187.6 (S.D. 29.9); 156.0 (S.D. 29.5) and 127.7 mg/100 ml (S.D. 24.0). All of the serum cholesterol differences among the groups were statistically significant.

REFERENCES

1. Mann, G. V., Muñoz, J. A., and Scrimshaw, N. S.: The serum lipoprotein and cholesterol concentrations of Central and North Americans with different dietary habits. *Am. J. Med.* 19: 25, 1955.
2. Scrimshaw, N. S., Trulson, M., Tejada, C., Hegsted, D. M., and Stare, F. J.: Serum lipoprotein and cholesterol concentrations of rural Costa Ricans compared with Guatemalan and U. S. populations. *Circulation* (in press).
3. Keys, A., Fidanza, F., Scardi, V., and Bergami, G.: The trend of serum-cholesterol levels with age. *Lancet* 2: 209, 1952.
4. Keys, A., Vivanco, F., Miñon, J. L. R., Keys, M. H., and Castro Mendoza, H.: Studies on the diet, body fatness and serum cholesterol in Madrid, Spain. *Metabolism* 3: 195, 1954.
5. Walker, A. R. P., and Arvidsson, U. B.: Fat intake, serum cholesterol concentration, and atherosclerosis in the South African Bantu. Part I. Low fat intake and the age trend of serum cholesterol concentration in the South African Bantu. *J. Clin. Investigation* 33: 1358, 1954.
6. Brock, J. F., and Bronte-Stewart, B.: Arteriosclerosis in African populations, in *Arteriosclerosis*, edited by A. Keys, p. 102, Symposium, Minnesota Heart Association and the University of Minnesota, 1955.
7. Bersohn, I., and Wayburne, S.: Serum cholesterol concentration in new-born African and European infants and their mothers. Am. J. Clin. Nutrition 4: 117, 1956.
8. Bronte-Stewart, B., Antonis, A., Eales, L., and Brock, J. F.: Effects of feeding different fats on serum-cholesterol level. *Lancet* 1: 521, 1956.
9. Keys, A.: Mode of life and the prevalence of coronary heart disease, in *Arteriosclerosis*, (edited by A. Keys), Symposium, Minnesota Heart Association and the University of Minnesota, 1955, p. 28.
10. Bruch, H.: Obesity in childhood. II. Basal metabolism and serum cholesterol of obese children. *Am. J. Dis. Child.* 58: 1001, 1939.
11. Hildreth, E. A., Mellinkoff, S. M., Blair, G. W., and Hildreth, D. M.: An experimental study of practical diets to reduce the serum cholesterol. *J. Clin. Investigation* 30: 649, 1951.
12. Groen, J., Tjiong, B. K., Kamminga, C. E., and Willebrands, A. F.: The influence of nutrition, individuality and some other factors, including various forms of stress, on the serum cholesterol; an experiment of nine months duration in 60 human volunteers. *Voeding* 13: 556, 1952.
13. Keys, A.: The cholesterol problem. *Voeding* 13: 539, 1952.
14. Keys, A.: Human atherosclerosis and the diet. *Circulation* 5: 115, 1952.

15. Byers, S. O., Friedman, M., and Rosenman, R. H.: Review: On the regulation of blood cholesterol. *Metabolism* 1: 479, 1952.
16. Kinsell, L. W., Partridge, J., Boling, L., Margen, S., and Michaels, G.: Dietary modification of serum cholesterol and phospholipid levels. *J. Clin. Endrocrinol.* 12: 909, 1952.
17. Sinclair, H. M.: Deficiency of essential fatty acids and atherosclerosis, etc. (Letter to the Editor.) *Lancet* 1: 381, 1956.
18. Rafstedt, S.: *Studies on Serum Lipids and Lipoproteins in Infancy and Childhood.* Berlingska Boktryckeriet, Lund, 1955.
19. Sperry, W. M.: Cholesterol of the blood plasma in the neonatal period. *Am. J. Dis. Child.* 51: 84, 1936.
20. Senn, M., and McNamara, H.: The lipids of the blood plasma in the neonatal period. *Am. J. Dis. Child.* 53: 445, 1937.
21. Hodges, R. G., Sperry, W. M., and Andersen, D. H.: Serum cholesterol values for infants and children. *Am. J. Dis. Child.* 65: 858, 1943.
22. Thomas, E. M.: Total and fractional blood lipid levels in diseases of childhood. *Am. J. Dis. Child.* 74: 563, 1947.
23. Kornerup, V.: Concentrations of cholesterol, total fat and phospholipid in serum of normal man. *Arch. Int. Med.* 85: 398, 1950.
24. Wambert, E.: *Studier Over Alimentaer Lipaemi Hos Børn, Med Saerligt Hinblik pa Forholdene ved Kroniske Fordøjelseslidelser.* Dansk Videnskabs Forlag, Copenhagen, 1954.
25. Schaffer, L. E., and Adlersberg, D.: Genetic and epidemiologic studies in cholesterol metabolism: Contributions of a pre-paid medical care program. *Am. J. Pub. Health* 46: 966, 1956.
26. Flores, M., Cruz, E., and Meneses, B.: Estudios de hábitos dietéticos en poblaciones de Guatemala. VIII. En un grupo de mujeres pertenecientes a un alto nivel económico. *Revista del Colegio Medico de Guatemala* 7: 99, 1956.
27. Flores, M., Garcia, B., and Cruz, E.: Estudio dietético individual de pre-escolares. I. Area de Demostractión de Amatitlán (in preparation).
28. Flores, M., Garcia, B., and Saenz, C.: Estudio dietético individual de pre-escolares. II. Barrio "San Antonio," Ciudad de Guatemala (in preparation).
29. Flores, M., and Reh, E.: Estudios de hábitos dietéticos en poblaciones de Guatemala. I. Magdalena Milpas Altas. *Suplemento No. 2 del Boletín de la Oficina Sanitaria Panamericana*, p. 90, Publicaciones Científicas del Instituto de Nutrición de Centro América y Panamá, 1955.
30. Flores, M., and Reh, E.: Estudios de hábitos dietéticos en poblaciones de Guatemala. II. Santo Domingo Xenacoj. *Suplemento No. 2 del Boletín de la Oficina Sanitaria Panamericana*, p. 129, Publicaciones Científicas del Instituto de Nutrición de Centro América y Panamá, 1955.
31. Flores, M., and Reh, E.: Estudios de hábitos dietéticos en poblaciones de Guatemala. III. San Antonio Aguas Calientes y su aldea, San Andrés Ceballos. *Suplemento No. 2 del Boletín de la Oficina Sanitaria Panamericana*, p. 149, Publicaciones Científicas del Instituto de Nutricion de Centro América y Panamá, 1955.
32. Flores, E., and Reh, E.: Estudios de habitos dietéticos en poblaciones de Guatemala. IV. Santa Maria Cauqué. *Suplemento No. 2 del Poletin de la Oficiana Sanitaria Panamericana*, p. 163, Publicaciones Científicas del Instituto de Nutrición de Centro América y Panamá, 1955.
33. Abell, L. L., Levy, B. B., Brodie, B. B., and Kendall, F. E.: A simplified method for the estimation of total cholesterol in serum and demonstration of its specificity. *J. Biol. Chem.* 195: 357, 1952.
34. Brožek, J., and Keys, A.: The evaluation of leanness-fatness in man: Norms and interrelationships. *Brit. J. Nutrition* 5: 194, 1951.
35. Tejada, C., and Gore, I.: Comparison of atherosclerosis in Guatemala City and New Orleans. *Am. J. Pathology* (in press).
36. Strong, J. P., McGill, H. C., Jr., Griffin, O. R., and Holman, R. L.: Natural history of aortic atherosclerosis, ages 1 to 40. *Fed. Proc.* 15: 533, 1956.