Factors Influencing Serum Cholesterol Levels of Central American Children

II. The Effect of Gross Dietary Changes

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School children of low income families in Guatemala have been found to have much lower serum cholesterol levels than those from upper income groups.[1] Nevertheless, in all socioeconomic strata average serum cholesterol levels at birth are closely similar and very low compared to those of school children.[2] Since serum cholesterol differences among socioeconomic groups are marked by the time children have reached school age, it would appear that environmental factors are primarily responsible.

In previous experiments[3] the low serum cholesterol levels of rural children were not influenced by the simple addition of animal protein or of three different types of fat to the habitual diets. In the present study, in order to investigate the effect of more extensive dietary changes on their low serum cholesterol levels, children from families of low socioeconomic status were given diets similar to those consumed among upper socioeconomic groups in Guatemala.

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MATERIAL AND METHODS

Trials were carried out in a small orphanage in Guatemala City (HNP) and in two villages (SMC and MMA) in the highlands of Guatemala. The orphanage children were of either mestizo or Mayan Indian origin while the village children were primarily Mayan Indian. The first trial included, twenty-six children in HNP (twenty-two boys and four girls), averaging eight years of age, 50 pounds of weight and 114 cm. of height. All were given adequate diets which differed primarily in the kind of fat used; during three consecutive four-week periods cottonseed oil, hydrogenated cottonseed oil and lard served in turn as the main source of dietary fat.

The second trial was carried out in the small rural village of SMC in which eighteen children (ten boys and eight girls), averaging six years of age, 36 pounds of weight and 97 cm. of height, were given for a period of eight weeks a diet similar to those of the previous trial. This eight-week study differed in that mixed fat was employed throughout to simulate the fat ordinarily used by high income families.

The third and fourth trials were carried out in the rural village of MMA. In the third trial, twelve children (seven boys and five girls), averaging four years of age, 30 pounds and 90 cm. of height were given the test diet for four weeks. This diet was high in calories from carbohydrate and included a substantial increase in fat intake so that it resembled that of low income urban Guatemalans. In the fourth trial, another twelve children

TABLE I

Diet and Serum Cholesterol Levels in Guatemalan Children in a Poor Orphanage (HNP)

A. *Experimental Diets*

Data	Calories	Protein (gm.)		Carbohydrate (gm.)	Fat (gm.)	Fatty Acids (gm.)*		
		Animal	Vegetable			SAFA	MUFA	PUFA
Initial intake	1,082	9.1	28.8	204.0	15.1	5.8	5.5	2.8
Per cent calories		14.0		75.4	12.6	4.8	4.6	2.3
4 weeks cottonseed oil	2,027	34.5	34.0	356.0	40.6	10.3	11.6	15.1
Per cent calories		13.5		70.3	18.0	4.6	5.2	6.7
4 weeks hydrogenated cottonseed oil	2,043	38.5	32.5	331.0	51.2	13.2	29.2	5.1
Per cent calories		13.9		64.8	22.6	5.8	12.9	2.2
4 weeks lard	1,968	36.8	29.0	298.0	59.4	22.2	25.0	8.2
Per cent calories		13.4		60.6	27.2	10.2	11.4	3.8

B. *Serum Cholesterol Levels*

Data	Initial	4 Weeks Cottonseed Oil	4 Weeks Hydrogenated Cottonseed Oil	4 Weeks Lard
No. of children	24	26	26	24
Serum cholesterol (mg./100 ml.)	119	133	147	152
Standard deviation	22	22	24	26

* In this and the following tables SAFA = saturated fatty acids; MUFA = monounsaturated fatty acids; PUFA = polyunsaturated fatty acids.

(eight boys and four girls), averaging five years of age, 33 pounds and 96 cm. of height, were given a diet for four weeks which contributed calories from fat in proportion similar to that consumed by the upper income urban Guatemalan families.

Throughout all these studies, requirements for minerals and vitamins were adequately met. In each trial dietary surveys were made at the beginning of the experiment and successively during each experimental period by technics previously described.[4] The nutritive value of the diets was calculated using the food composition table prepared by INCAP.[5] For the estimation of the dietary fatty acid intakes, the tables of Hardinge and Crooks[6] and Hayes and Rose[7] were used. All meals were carefully supervised.

Fasting blood samples were obtained by finger tip puncture at the beginning and end of each four-week period in all trials and four weeks after resuming the original diet in trial two. Serum cholesterol was measured by the method of Abell et al.[8] In the analysis of the results the t test for paired comparisons was employed.

DIETARY CHANGES AND SERUM CHOLESTEROL RESULTS

Trial One

Table I shows the daily intake during the trial in group HNP. Total calories, animal and total protein were all greatly increased. The percentage of calories derived from protein, however, was maintained constant throughout the experiment at about 14 per cent. Although carbohydrate intake was increased in amount, the percentage of calories derived from carbohydrate was decreased. Fat intake was greatly increased in net amounts and the resulting percentages of calories derived from fat were 13 per cent in the initial diet, and 18, 23 and 27 per cent, respectively, in the experimental periods. As also shown

TABLE II

Diet and Serum Cholesterol Levels in Guatemalan Children in Rural Village (SMC)

A. *Experimental Diets*

Data	Calories	Protein (gm.)		Carbohydrate (gm.)	Fat (gm.)	Fatty Acids (gm.)		
		Animal	Vegetable			SAFA	MUFA	PUFA
Initial intake	1,032	7.8	22.7	206.0	11.0	2.5	4.1	2.9
Per cent calories		11.8		79.8	9.6	2.2	3.6	2.5
Intake during the study	1,568	39.5	16.8	212.0	57.2	23.1	22.5	7.7
Per cent calories		14.4		54.1	32.8	13.3	12.9	4.4

B. *Serum Cholesterol Levels*

Data	Initial	Treatment		4 Weeks After Resuming Original Diet
		4th Week	8th Week	
No. of children	18	18	18	12
Serum cholesterol (mg./100 ml.)	115	130	129	110
Standard deviation	18	13	18	18

in this table, the saturated, monounsaturated and polyunsaturated fatty acids in the diets were all greatly increased.

The corresponding serum cholesterol results are also shown in Table I. The initial values averaged 119 mg.; after four weeks of the diet containing cottonseed oil, the serum cholesterol levels increased significantly to 133 mg. Changing the source of dietary fat to hydrogenated cottonseed oil caused a highly significant elevation of cholesterol levels to 147 mg. In the last period, when lard was used, an average serum cholesterol level of 152 mg. was observed.

Trial Two

Table II shows the daily dietary intake during the trial carried out in village SMC. Calories, animal and total protein were all greatly increased in absolute amounts. The percentage of calories derived from total protein intake was not significantly increased, and that derived from carbohydrate decreased. The amount of fat was greatly increased and this resulted in an increase from 10 to 33 in the per cent of calories derived from fat. The saturated, monounsaturated and polyunsaturated fatty acids in the diet were all greatly increased.

The resulting serum cholesterol changes during this experiment are also shown in Table II. In the first four-week period, serum cholesterol changed significantly from 115 to 130 mg., but showed no further increase at the end of the eighth week. Four weeks after returning to their habitual diet, the children's serum cholesterol levels returned to 110 mg., a decrease which was significant at the 5 per cent level.

Trials Three and Four

Table III shows the daily dietary intake during the two experiments in village MMA. Caloric intake was greatly increased in trial three and slightly in trial four. Animal protein intake was maintained constant in the third trial and greatly increased in the fourth, although the calories derived from total protein were maintained fairly constant in both. In trial three, carbohydrate intake increased, but the percentage of calories derived from carbohydrate varied only from 78 to 73 per cent. In trial four, carbohydrate intake was reduced in net amount, and percentage of calories from this source lowered from 78 to 54 per cent. Fat was increased in amounts which gave an initial percentage of calories

TABLE III

Diet and Serum Cholesterol Levels in Guatemalan Children in Rural Village (MMA)

A. *Experimental Diets*

Data	Calories	Protein (gm.)		Carbohydrate (gm.)	Fat (gm.)	Fatty Acids (gm.)		
		Animal	Vegetable			SAFA	MUFA	PUFA
Initial intake	1,130	9.0	23.4	221.0	16.6	5.4	7.0	3.4
Per cent calories		11.5		78.2	13.2	4.3	5.6	2.7
First trial	1,736*	9.3	28.6	317.0	37.9	14.2	15.1	5.8
Per cent calories		8.7		73.0	19.6	7.4	7.8	3.0
Second trial	1,197†	24.2	15.8	161.0	44.8	16.2	19.4	5.9
Per cent calories		13.4		53.8	33.7	12.2	14.6	4.4

B. *Serum Cholesterol Levels*

Data	First Trial		Second Trial	
	Initial	Final	Initial	Final
No. of children	12	12	12	12
Serum cholesterol (mg./100 ml.)	146	152	141	142
Standard deviation	24	22	20	20

* Includes estimated house consumption.

† All the meals given at the clinic.

derived from fat of 13.2 per cent and a final value of 19.6 in the third experiment, and 33.7 in the fourth. The saturated, monounsaturated and polyunsaturated fatty acid intakes were increased in both trials.

The resulting serum cholesterol levels during these two studies are also shown in Table III. The values of 146 and 152 mg. per 100 ml. at the beginning and end in the third trial, and 141 and 142 in the fourth, do not represent a significant change. The MMA population differed, however, in that initial serum cholesterol levels were higher than in the previous two trials and were similar to those commonly found among low income families in Guatemala City.[1]

COMMENTS

The influence of dietary changes on serum cholesterol levels of man has been extensively reviewed.[9–11] Although school age children from different socioeconomic groups in Guatemala have strikingly different levels of serum cholesterol,[1] there is evidence that their serum cholesterol levels are difficult to change by dietary manipulation of fat or protein alone.[3]

The present studies show that dietary changes which include not only fat, but other nutrients as well, can elevate the low cholesterol levels of the children of low income Guatemalan families. However, the increase observed in one rural village (SMC), although significant, was only one-third of the difference between low income rural and upper income urban children found in previous studies.[1] Furthermore, in the other village (MMA) in which initial cholesterol levels were already at the level of those of poor urban children, the results were negative.

Although the children under study were of predominantly Mayan Indian origin, their failure to respond to dietary changes cannot be attributed to unique racial characteristics.[12–14] Under given conditions, each subject seems to have a characteristic serum cholesterol level and pattern of variation. In the present trials serum cholesterol concentration changed promptly and noticeably in response to the alterations in diet in some

subjects; in others, the cholesterol levels responded only slowly or not at all.

Many authors have demonstrated that all of the serum cholesterol response as a result of dietary change occurs within the first few weeks.[15–18] A possible exception is a recent abstract by Lee et al.[19] in which they state that Koreans with initially low serum cholesterol and lipid phosphorus levels showed an increase in these levels "within one month" when they were given a high fat diet and that "most of them reached almost as high levels as those of American soldiers of similar age in twelve to eighteen months." In this study serum cholesterol values showed no tendency to increase further beyond the fourth week on an experimental diet. Since the increase observed in four weeks, as a result of the dietary changes, fell far short of compensating for the differences previously encountered between upper and lower socioeconomic groups it appears that other environmental factors, independent of diet as such, must have an important influence on serum cholesterol levels among different socioeconomic groups in Guatemala. These factors are still unknown.

SUMMARY

Twenty-six orphanage children in Guatemala City consuming daily 15 gm. of fat and 38 gm. of protein (36 and 24 per cent animal) were given, during successive four-week periods, adequate diets averaging 37 gm. of animal protein with 41 gm. of fat (18 per cent of calories) predominantly from cottonseed oil, 51 gm. (23 per cent of calories) mainly from hydrogenated cottonseed oil and 59 gm. (27 per cent of calories) primarily from lard. Cholesterol levels increased from 119 (s = 22) to 133 (s = 22), 147 (s = 24) and 152 (s = 26) mg. per 100 ml., respectively.

In a rural Guatemalan highland village eighteen children with cholesterol levels of 115 (s = 18) were consuming daily 11 gm. of fat and 30 gm. of protein (37 and 25 per cent animal). When dietary fat was increased with lard to 57 gm. (33 per cent of calories), and animal protein to 40 gm., cholesterol levels increased significantly to 130 (s = 13) mg. per 100 ml. in four weeks with no further change in eight weeks. Four weeks after resuming the original diet, cholesterol levels were 110 (s = 18) mg. per 100 ml.

It is concluded from these two experiments that dietary changes can elevate the low cholesterol levels of children of low income families, although not sufficiently to account for differences between upper and lower socioeconomic groups in Guatemala. In a similar village in which cholesterol levels of twenty-four children were higher initially (143, s = 29 mg. per 100 ml.) increasing fat with lard from 17 to 45 gm. (34 per cent of calories) with 24 gm. animal protein, did not change cholesterol values. The results of all four trials suggest that factors other than those studied must be important in producing the markedly lower serum cholesterol values in lower as compared with upper socioeconomic groups in Guatemala.

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