Long-Term, Low Fat, Low Protein Diets and Their Effect on Normal Trappist Subjects

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THE purpose of this report is to present data on the effect of long-term diets, low in calories, cholesterol, animal fat and protein, on the serum cholesterol levels of normal male subjects, of similar racial and environmental backgrounds, residing in the United States.

This study was initiated to test the hypothesis that serum cholesterol levels in persons with a lower than usual intake of animal protein, fat and cholesterol will be below those of the general population.

STUDY GROUP, MEDICAL EVALUATION AND DIET

The subjects were thirty-nine Trappist monks between nineteen and eighty-two years of age. The age range of the population in the community studied is usually between forty and forty-five years. One subject was excluded from our study because he had diabetes; four others were excluded because complete data could not be obtained from them. Three subjects had been in the religious order for less than two months (Fig. 1) and are included in the report only for later evaluation.[1] Thirty-six subjects, except under exceptional circumstances, had adhered to a strict diet and daily routine for from one to forty-nine years. The daily routine of all the subjects was regulated to include eight hours of physical labor, eight hours of prayerful activities and seven hours and fifteen minutes of sleep. A thorough medical evaluation, including history and physical examination, a resting 12 lead electrocardiogram taken with the subject at rest, a 14 by 17 inch chest roentgenogram, urinalysis, hematocrit determination, blood smear evaluation and chemical determinations of blood urea nitrogen, fasting blood sugar and serum proteins, was carried out on all subjects. The results were within normal limits.

Diets in all Trappist monasteries are similar and an analysis of these diets has appeared in the literature.[2–4] The diet consists mainly of vegetables, fruits, breads, cereals, skim milk, coffee and vegetable oil. Variations of diet from monastery to monastery depend upon the regional availability of specific foods. With the exception of bread and beverages, portions served in these monasteries are not generous. Vegetable oil (corn or cotton seed) was allowed *ad libitum* as a salad dressing in the monastery in which this study was made. Those who used it consumed up to 3 ounces per week. Skim milk was used as a beverage and as an ingredient in the bread which was the mainstay of the diet. Meat and fish were excluded from the diet. When the subjects were ill, convalescent or advanced in age, they were allowed to eat eggs. Cheese was available in minimal quantities on special occasions throughout six months of the year and three times a week during the remainder of the year. Ice cream was served rarely. Butter, whole milk and eggs occasionally were used in the preparation of some foods, e.g., bread and spaghetti.

Standard tables of food values were used to estimate nutritional data.[5,6] It was estimated that the subjects ingested 500 gm. carbohydrate, 25 gm. animal fat and up to 20 gm. animal protein daily. Animal protein was derived from the previously mentioned dairy products and the eggs used in cooking. Intake of vegetable protein was estimated to be 50 gm. a day per person. Total caloric intake on this diet was estimated to be between 2,000 and 3,500 calories daily per person. This wide difference in calories depended on the variation in individual intake of bread, skim milk and vegetables. The average caloric intake was considered to be particularly low for the quantity of physical labor each subject performed.

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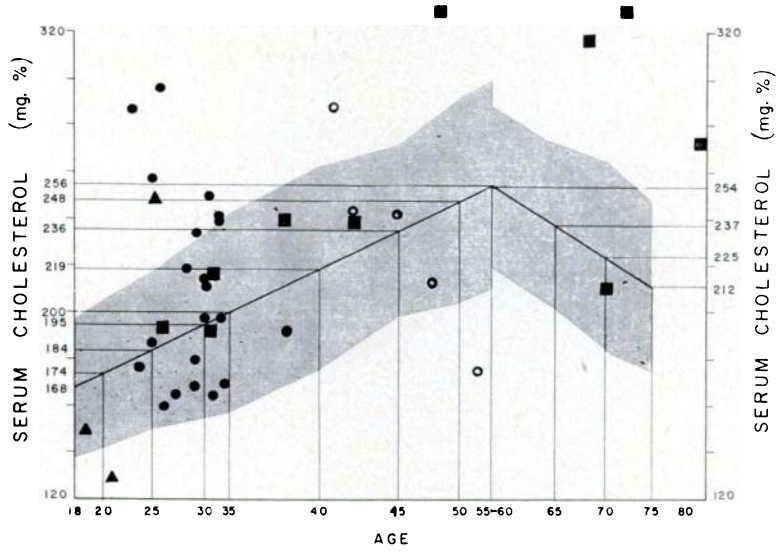

FIG. 1. Serum cholesterol values of monks plotted on published normal data.[10] Triangles = subjects who had been in the religious order for less than two months. Closed circles = subjects aged twenty-three to thirty-eight years. Open circles = subjects aged forty-one to fifty-three years. Squares = subjects aged twenty-six to eighty-two years who had been allowed two eggs daily for one to two years prior to the study.

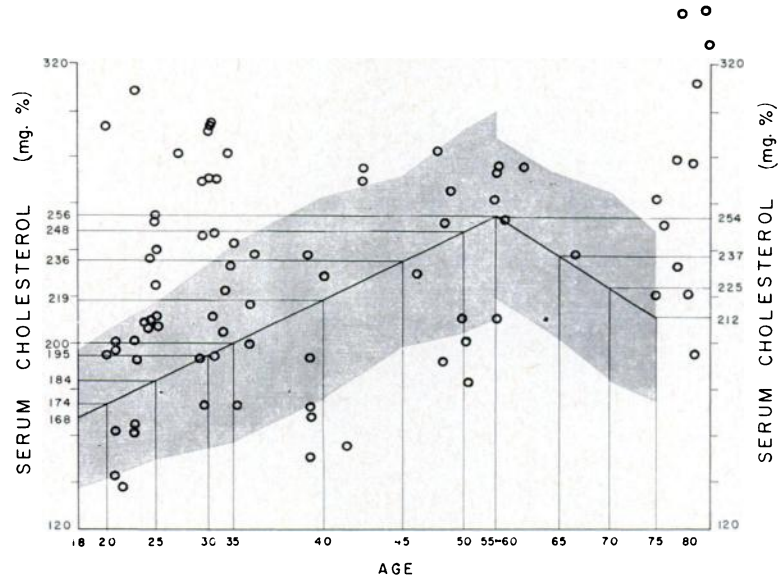

FIG. 2. Serum cholesterol values from control subjects plotted on published normal cholesterol data.[10]

LABORATORY METHODS

Serum total cholesterol and its esters were determined by the method of Sperry and Webb.[7] The standard deviation for replicate cholesterol determinations in the laboratory was 8.8 mg. per 100 ml. Serum lipoproteins were evaluated by the determination of cholesterol in the alpha and beta fractions according to the technic of Langan et al.[8]

The total protein of the serum was determined by the Biuret method.[9] Serum lipid values from control "normal" subjects were obtained during the general period of this study. This group was comprised of medical students, hospital staff members and persons undergoing pre-employment medical examinations. Each subject gave a history and underwent a physical examination, blood count,

urinalysis and chest roentgenogram. All subjects were on unrestricted diets.

Employing similar laboratory methods, Keys et al. have reported age-corrected values of serum cholesterol in normal subjects.[10] We have used his data for graphic comparison with our findings because of the large size of his samples. Serum cholesterol in milligrams per 100 milliliters expected for a specific age is shown on the vertical axis of Figures 1 and 2. The progressive increment in serum cholesterol anticipated with age is shown by the thick diagonal line that reaches its summit at about age sixty, after which serum cholesterol values decline. The age of the subjects is shown on the horizontal axis. Age is not shown linearly because serum cholesterol values, although they increase with age, do not necessarily do so in linear fashion.

For purposes of comparison and discussion, we have chosen arbitrarily as normal serum cholesterol values, those that fall within plus or minus 1 standard deviation of Keys' mean values for specific age. The shaded portions of the graphs show that range.

TABLE I

Summary of Clinical and Laboratory Data from the Monastery Population

Case No.	Age (yr.)	Time in Monastery (yr.)	Serum Total Cholesterol (mg./100 ml.)	Ester Cholesterol (%)	Beta Lipoprotein Cholesterol (%)	Serum Protein Electrophoresis (%)					Serum Total (gm./100 ml.)
						Albumin	$Alpha_1$	$Alpha_2$	Beta	Gamma	
1	19	2/12	154	77.8	81.1	52.2	3.6	7.5	15.3	21.4	8.37
2	21	2/12	128	68.8	74.5	67.0	3.4	7.4	7.9	14.4	7.92
3	25	2/12	248	72.5	85.6	62.4	3.8	9.5	10.0	14.3	7.36
4	23	2	202	78.6	81.2	60.6	3.4	5.9	12.1	18.0	7.35
5	24	5	177	75.6	81.4	49.7	3.4	9.6	16.8	20.5	7.87
6	25	7	188	76.5	69.5	48.4	4.3	11.6	16.2	19.5	7.29
7	25	5	258	65.7	87.5	55.6	3.3	6.3	13.0	21.8	7.05
8	26	1	297	79.2	88.5	42.6	3.7	11.8	16.5	25.4	8.32
9	26	1	160	76.4	75.0	54.5	3.4	8.5	11.9	21.7	7.75
10	27	2	165	75.9	89.4	60.6	4.3	7.3	12.9	14.8	7.62
11	28	2	219	74.0	81.4	52.0	3.5	4.7	14.5	25.3	8.50
12	29	4	169	60.4	80.1	59.0	3.4	8.1	13.4	16.1	7.92
13	29	2	180	75.1	84.2	53.9	6.0	9.1	16.3	14.7	7.24
14	29	8	235	75.8	73.8	55.0	3.4	9.0	16.3	16.3	7.20
15	30	8	213	78.5	66.9	51.8	3.6	9.5	12.6	22.5	7.24
16	30	8	217	76.3	75.7	61.0	3.3	6.1	12.3	17.3	7.96
17	30	2	279	72.8	85.2	51.2	5.4	9.9	16.9	16.6	7.29
18	31	3	250	66.6	79.1	57.8	4.0	7.6	11.7	18.6	7.90
19	32	4	163	74.8	81.4	48.9	3.2	9.4	13.6	24.9	7.05
20	32	9	239	72.6	77.2	68.1	3.7	7.0	10.3	11.0	7.05
21	32	8	241	76.8	83.5	66.6	2.7	4.9	11.9	14.0	7.20
22	33	7	197	69.1	84.7	57.6	3.2	6.5	13.3	19.4	7.96
23	34	11	169	78.1	76.7	51.6	4.1	8.9	14.6	20.8	6.57
24	38	9	193	67.5	77.2	64.6	3.5	5.7	10.4	15.9	7.74
25	41	2	288	70.5	76.0	65.5	3.1	6.5	11.6	13.5	7.43
26	42	23	244	78.0	78.1	54.0	3.0	9.1	13.0	20.9	7.60
27	45	5	243	60.3	82.1	63.1	3.5	7.7	9.2	16.5	7.33
28	48	29	211	73.4	81.1	54.6	5.0	7.8	13.5	19.1	7.48
29	53	24	175	72.3	97.5	52.1	3.7	7.7	15.4	21.2	7.07
30	26	9	194	81.5	67.5	63.6	3.6	6.5	11.7	14.6	6.57
31	31	8	217	55.0	76.4	53.1	3.2	7.4	14.1	22.2	6.77
32	31	12	192	81.7	57.0	53.5	4.1	5.3	12.9	24.1	7.85
33	38	12	240	79.9	74.8	55.0	4.5	8.1	15.8	16.6	7.75
34	42	12	238	75.5	88.8	51.3	4.5	10.4	18.0	15.8	7.62
35	48	23	333	71.4	80.4	63.7	2.4	6.2	11.3	16.5	7.20
36	68	35	317	72.1	78.9	64.0	3.9	9.3	10.7	12.1	7.15
37	70	21	212	71.9	85.5	44.7	3.7	10.6	16.5	24.5	6.95
38	72	35	330	75.5	90.0	63.5	3.0	8.1	10.1	15.5	8.57
39	82	49	273	74.7	80.0	51.0	3.8	9.5	17.1	18.6	7.05

RESULTS

Detailed laboratory data from each of the subjects are given in Table I, and cholesterol values are plotted in Figure 1. The entire group of thirty-nine subjects was subdivided according to age differences and minor variations in diet.

The largest subdivision included twenty-one subjects between the ages of twenty-three and thirty-eight (Fig. 1). The average age was twenty-nine. All but one, a Canadian, were born and lived in the Middle Atlantic and New England States. All twenty-one subjects had been on a strict diet for over one year and up to eleven years, with an average of five years. None of these subjects had serum cholesterol values below the range expected for his age, although the values of six exceeded the mean by more than 1 standard deviation. The mean serum cholesterol value of this group of twenty-one subjects was 214 mg. per 100 ml. According to Keys, the expected mean serum cholesterol value at an average age of twenty-nine is 194 mg. per 100 ml.

Five subjects between the ages of forty-one and fifty-three had been on a strict dietary regimen for three to twenty-nine years (Fig. 1). They were considered separately from the previous group because they exceeded forty years in age. One of these subjects, who at the age of fifty-three had been on the strict diet for twenty-four years, had a mean serum cholesterol value 1 standard deviation below that expected for his age; the values of the others were above or within the expected range.

Ten subjects between the ages of twenty-six and eighty-two years (Fig. 1) had followed strict diets for at least eight years, but for one to two years prior to this period they had been allowed two eggs daily in addition to the otherwise unchanged diet. In the subjects under sixty, this was because of previous exposure to tuberculosis; in those over sixty, all monks in this monastery routinely receive the same dietary supplement. None of these ten subjects had a serum cholesterol value below the range expected for his age although four subjects had values above the expected range.

In general, the subjects who had been on a strict diet for longer periods were older than those who had been on strict diets for shorter periods. The relationship between increasing serum cholesterol values and increasing age is suggested in Figure 1. The length of time each person had been on the strict diet did not appear to have any correlation to serum cholesterol values below those expected for a given age.

The mean serum cholesterol levels of twelve subjects exceeded the mean expected for their age by 1 standard deviation. Nine were between twenty-three and forty-eight years of age, and the remaining three were over sixty. Those over sixty had been on strict diets for at least twenty years but had been allowed two eggs daily since the age of sixty. Of the remainder, one had been on a strict diet for less than one year and the others for an average of five years.

This group of twelve subjects whose mean serum cholesterol values exceeded the mean for their specific age by 1 standard deviation was compared with the remainder of the subjects

TABLE II

Comparison of Characteristics of Monks with Serum Cholesterol Levels Exceeding and Within Normal Range

Characteristics	No.	Twelve Subjects with Increased Serum Cholesterol Levels (%)	Twenty-Seven Subjects with Normal Cholesterol Values (%)
Positive family history of coronary artery disease	10	42	19
Higher than normal weight*	10	33	22
Lower than normal weight*	19	50	49
Ad libitum oil intake	21	75	45
Eggs eaten	9	33	19
Subjective evaluation of increased stress in the monastery in contrast to outside world	10	8	33

* According to Metropolitan Life Insurance Standard Weight Tables for height, age and sex.

in reference to characteristics of interest in the epidemiology of the coronary artery disease (Table II). One of the characteristics the subjects were asked to compare was stress in their communal society as contrasted with stress prior to entrance into the community. Forty per cent of each group stated that it was approximately the same. Eight per cent of the group with higher cholesterol levels and 33 per cent of the remainder said that it was greater in the religious community.

Figure 2 shows the results of individual serum cholesterol determinations performed on eighty control subjects during the general period of this study. The serum cholesterol values of these control subjects generally conform to the expected range of age-corrected values suggested by the studies reported by Keys et al.[10]

The mean of the cholesterol level for the control subjects as opposed to the mean of the cholesterol level for the subjects of this study was tested statistically within each decade. These cholesterol values are given to age fifty in Table III. No statistically significant difference at the 0.05 level was found between the subjects of this study on restricted diets and the control subjects on unrestricted diets (t test: $P > 0.05$). Analysis also has failed to show differences between the serum proteins and lipoprotein values of the monks and the "normal" control subjects.[11]

A statistical cross correlation of the clinical and laboratory determinations in the Trappist population was performed (Table IV). There was significance in the correlation among age, time in monastery and serum cholesterol levels and among four of the protein fractions. The lack of significant correlations between the other determinations is noteworthy but is in

TABLE III

Comparison of Serum Cholesterol Values Between Control Subjects and Trappist Subjects

Age (yr.)	Control Subjects			Trappist Subjects		
	No.	Mean Cholestrol (mg./100 ml.)	Standard Deviation	No.	Mean Cholestrol (mg./100 ml.)	Standard Deviation
20–29	27	218	43	12	218	42
30–39	22	226	45	13	210	28
40–49	7	243	55	6	260	43
All ages	56	224	...	31	223	...
Adjusted to age distribution of both groups	...	225	...	...	221	...

TABLE IV

Correlation Coefficients for Values in Table I

Data	Time in Monastery	Cholesterol	Cholesterol Ester	Beta Lipoprotein	Albumin	Alpha1	Alpha2	Beta	Gamma	Serum Total
Age	0.564*	0.512*	−0.072	0.257	−0.005	−0.051	0.181	0.046	−0.091	−0.150
Time in Monastery		0.450*	0.085	0.104	−0.013	−0.057	0.130	0.072	−0.070	−0.175
Cholesterol			−0.054	0.197	0.175	−0.160	0.077	−0.084	−0.242	0.011
Cholesterol ester				−0.222	−0.229	0.186	0.142	0.271	0.110	0.097
Beta lipoprotein					−0.096	0.044	0.166	0.188	−0.042	0.119
Albumin						−0.324†	−0.612*	−0.829*	−0.796*	−0.019
Alpha1							0.375†	0.441*	−0.103	−0.092
Alpha2								0.512*	0.166	−0.125
Beta									0.425*	−0.058
Gamma										0.145

* Values significant at 1 per cent.
† Values significant at 5 per cent.

part due to expression of certain data in terms of percentage and some in terms of milligrams per 100 milliliters. Joint interactions of these variables may be significant but were not tested. Establishment of that type of relationship may be studied but with more complex statistical-computer methods than were readily available for this study.[12]

COMMENT

At the time these studies were carried out triglyceride determinations were not available. Thus the inference that high carbohydrate diet and other factors result in elevation of serum triglyceride levels, as suggested by Albrink et al.[13] although pertinent for study in our group of subjects, cannot be discussed further at this time.

The comparison of certain characteristics of monks whose cholesterol ranges exceed or are within normal limits (Table II) should be studied further. We did not believe that the number of subjects in each category was sufficient for detailed analysis, but the results suggest the need for careful scrutiny of the itemized features. This is particularly true of stress and its effect, if any, at the time of sampling for cholesterol determinations and on the cholesterol metabolic system of each subject.

CONCLUSIONS AND SUMMARY

The subjects of this study tended to show the known association of high serum cholesterol levels with excess weight, age and a family history of coronary artery disease. As a group the subjects showed no apparent association between the low intake of animal protein, fat and cholesterol and low serum cholesterol values. The average serum cholesterol values of the entire group and of the various subdivisions according to age did not differ from those expected in the general population on unrestricted diets. The serum lipoprotein cholesterol and total protein levels similarly did not reveal significant differences between the control subjects and the groups of Trappist subjects as a whole. We conclude that in this group of subjects residing in the United States, a low intake of animal fat and protein was not associated with serum cholesterol and protein values different from those obtained from samples of the general population.

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