

Family Diet Pattern for Lowering the Serum Cholesterol Level

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THERE is a wealth of data showing that, under carefully controlled conditions, the ingestion of diets high in polyunsaturated fatty acids can produce significant lowering of the blood cholesterol level.¹ A number of approaches have been utilized in attempts to increase the dietary level of polyunsaturated fatty acids: (1) the feeding of emulsified synthetic diets containing 40 per cent of the calories as corn oil, (2) supplementation of the usual diet with fats rich in polyunsaturated fatty acids, and (3) the substitution of a large proportion of the usual food fats by fats high in polyunsaturated fatty acids. However, the first and second approaches are not practical from an outpatient or family standpoint since they are highly restrictive, require special foods, or are not very palatable.²⁻⁸ In addition, the second approach has been shown to be relatively ineffective in lowering the blood cholesterol level because it does not lead to a high enough percentage of polyunsaturated fatty acids in the total dietary fat.^{9,10} The most promising appears to be the third approach in which fats high in polyunsaturated fatty acids are substituted for a large proportion of the usual dietary fat which is rich in saturated and monounsaturated fatty acids. To date, studies involving these approaches have been made on subjects with ischemic

heart disease, both in the hospital and living at home, or on normal subjects in institutions.

The substitution diets that have been tested in the home have generally been too restrictive and limited in choice for general acceptance. Tobian and Tuna⁹ observed a significant reduction in the serum cholesterol level over a short-term period twelve days in eighteen patients living at home who were fed corn oil orally (1 to 1.5 ounces) coupled with a diet low in butter, margarine and hydrogenated fats. Pilkington and others¹¹ reported on the effect of practical diets for lowering the serum lipid levels in patients with ischemic heart disease and noted significant reductions in the blood cholesterol level. However, the recommended diet excluded all meat, margarine and butter for the first six months of the dietary period. In the present report data are presented on a family diet pattern high in polyunsaturated fatty acids which has produced a significant lowering of the blood cholesterol level over a ten week period. No marked changes in the family cooking or dietary habits were found necessary.

METHODS AND MATERIALS

Dietary Pattern

Basic considerations in devising a practical dietary pattern for lowering the serum cholesterol level were the average fat intake of the population and the linoleic acid content of the common food fats. In order to assess the latter factor, the fatty acid composition of local food fats purchased at a supermarket were determined by gas-liquid chromatography. The results are shown in Table I.

Of the five "corn oil margarines" examined only one (brand A) was found to have a proportion of linoleic acid close to that of corn oil. That product§

§ Emdee® Margarine.

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TABLE I
Fatty Acid Composition of Some Common Food Fats as Determined by Gas-Liquid Chromatography

Food Fat†	Fatty Acid Composition as Per Cent Total Fatty Acids*								
	Short Chain C6-6:14	Palmitic	Stearic	Oleic	Linoleic	Linolenic	Saturated‡	Mono-unsaturated‡	Poly-unsaturated
Corn oil margarine									
A.....	6.8	13.2	8.5	24.6	45.7	1.2	28.5	24.6	46.9
B.....	Trace	13.1	6.5	50.8	28.9	0.7	19.6	50.8	29.6
C.....	Trace	14.3	6.7	62.7	16.1	0.2	21.0	62.7	16.3
D.....	0.2	12.9	6.7	61.6	18.3	0.3	19.8	61.6	18.6
E.....	0.6	14.1	6.7	51.7	26.4	0.5	21.4	51.7	26.9
Margarine									
A.....	0.8	13.8	7.9	60.9	16.4	0.2	22.5	60.9	16.6
B.....	0.2	14.8	7.7	57.5	19.2	0.6	22.7	57.5	19.8
C.....	0.6	16.3	6.8	58.4	17.0	0.9	23.7	58.4	17.9
D.....	1.4	15.8	6.8	58.7	16.8	0.5	24.0	58.7	17.3
E.....	0.6	16.0	8.5	52.4	21.3	1.2	25.1	52.4	22.5
F.....	0.2	16.7	8.8	51.8	22.1	0.4	25.7	51.8	22.5
G.....	0.2	15.0	7.6	61.7	14.7	0.8	22.8	61.7	15.5
H.....	0.3	16.7	8.7	59.7	14.4	0.2	25.7	59.7	14.6
I.....	0.2	16.4	6.8	59.3	16.7	0.6	23.4	59.3	17.3
J.....	0.2	15.6	8.9	59.3	15.3	0.7	24.7	59.3	16.0
Butter.....	14.4	35.1	11.1	24.2	1.5	1.0	69.1	28.0	2.9
Lard.....	1.6	26.2	13.3	45.3	10.2	0.2	41.1	48.2	10.7
Hardened vegetable fat									
A.....	0.4	15.8	13.3	58.4	11.9	0.2	29.5	58.4	12.1
B.....	0.2	15.1	11.2	53.7	19.1	0.7	26.5	53.7	19.8
Vegetable oils									
Corn oil.....	Trace	12.4	1.7	27.7	57.4	0.8	14.1	27.7	58.2
Peanut oil.....	Trace	13.0	2.6	46.5	32.5	1.1	19.9	46.5	33.6
Cottonseed oil.....	1.0	27.6	2.3	17.6	50.6	0.3	31.5	17.6	50.9
Olive oil.....	Trace	14.6	1.9	72.6	9.3	0.8	16.5	73.4	10.1

* The percentages for the unsaturated fatty acids in the partially hydrogenated margarines and vegetable fats include the total of both cis and the trans isomers.¹⁹

† Represents the average of four analyses; duplicate analyses carried out on two packages of the food fat. Variation in fatty acid composition between packages was within limit of error of the method or 5 per cent. All food fats were purchased at a local supermarket, with the exception of corn oil margarine A.

‡ Several of the food fats contained small amounts of palmitoleic and long chain fatty acids.

contained 45.7 per cent linoleic acid and was selected for use in this study. The remaining corn oil margarines were considerably lower in linoleic acid content than brand A, some of them were as low or even lower than regular margarines. In addition, several of the regular margarines, and in particular brands G and F, had a greater proportion (22.5 per cent) of polyunsaturated fatty acids than two of the corn oil margarines. Butter had an exceedingly small amount of linoleic acid (1.5 per cent). Lard and partially hydrogenated vegetable fats had levels of linoleic acid ranging from 10 to 19 per cent. All vegetable oils, with the exception of olive oil, were rich in linoleic acid. The levels of polyunsaturated fatty acids in those oils ranged from 32.5 per cent to 57.4 per cent. Corn oil (57.4 per cent) was selected as the cooking fat for this study. The data in Table I are in general agreement with values reported by the Agricultural Research Service,¹² except for the corn oil margarines for which values were not available.

The usual American diet contains 40 per cent of its total calories as fat; 100 to 125 gm. of fat are consumed per day. Boyer and others¹³ have shown that a diet containing at least 22 per cent of the fat calories as linoleic acid is effective in reducing the blood cholesterol level. The available data¹⁴ indicate that in the usual American diet linoleic acid constitutes 9 to 11 per cent of the fat calories and that 75 to 85 per cent of the dietary fat is of animal origin. In order to increase the linoleic acid level to 22 per cent of fat calories it is necessary to substitute 40 to 50 per cent of the usual dietary fat with fats rich in polyunsaturated fatty acids (approximately 50 per cent linoleic acid). Preliminary calculations suggested that the substitution of ordinary corn oil and Emdee margarine for hydrogenated fats, butter and other margarines in the diet would produce the necessary degree of substitution.

The diet pattern as developed is divided into two parts: one deals with the household preparation of food and the other with some minor changes

TABLE II
Influence of Dietary Regimens on the Serum Cholesterol Level of Healthy Subjects
with Normal Serum Cholesterol Levels

Subject No.	Sex	Age (yr.)	Control Period*	Total Serum Cholesterol (mg. %)									
				High Linoleic Acid Diet					High Animal Fat Diet				
				2 wk.	4 wk.	6 wk.	8 wk.	10 wk.	2 wk.	4 wk.	6 wk.	8 wk.	10 wk.
1	M	34	242 ± 11	294	236	217	221	218	197	199	242	258	306
2	F	23	240 ± 24	206	184	215	194	205	199	230	227	242	247
3	F	39	214 ± 10	207	194	209	186	185	205	224	219	213	244
4	M	39	203 ± 7	175	200	205	174	180	176	176	208	209	210
5	M	37	201 ± 16	184	168	177	183	197	197	...	188	213	195
6	M	26	223 ± 9	200	180	206	203	209	202	209	202	187	239
7	M	33	239 ± 13	186	185	...	193	170	250	...	271	279	279
8	F	33	154 ± 6	139	128	136	134	136	145	176	148	184	160
9	F	34	175 ± 9	165	157	165	150	162	172	184	188	166	213
10	M	37	228 ± 24	204	195	202	214	195	228	268	256	237	268
Average		34	212 ± 29	196 ± 40	183 ± 29	192 ± 27	185 ± 27	186 ± 26	197 ± 29	208 ± 31	215 ± 36	219 ± 35	236 ± 43

* Each value during control period represents average (\pm S.D.) of five fasting serum cholesterol values determined on weekly blood samples.

in eating habits. The subjects were instructed to use only the two fats supplied them, notably corn oil and the corn oil margarine, and to eliminate all other cooking fats from their household such as butter, other margarines, lard and hydrogenated vegetable fats. The margarine was to be used as a table spread, for seasoning vegetables and wherever a solid fat was desired or required in food preparation. The corn oil was to be used for salad dressings, frying, baking and wherever oil was desired or required in food preparation.

The dietary changes were as follows: pork or pork products were allowed only once a week; other meats were not restricted. However, all visible fat was to be trimmed from the meat. Cheese and milk products were allowed twice a week and skimmed milk as often as desired. There was no restriction on the use of small amounts of whole milk when desired, such as for coffee. Meat drippings were not to be used for cooking or gravy. No commercial pastries were allowed; however pastries, prepared with corn oil or corn oil margarine, were to be consumed at least twice a week. Salads, made with corn oil dressing, were to be consumed regularly (three or four times a week).

All subjects were instructed to follow this dietary pattern as closely as possible when eating meals outside the home. Interviews with the subjects on this dietary regimen, and some of them had been on it for one year, indicated that it was readily accepted by the family and required no adjustment or marked change in the family dietary habits. Individual

dietary records of the first group of subjects described subsequently showed that each subject ingested approximately 48 gm. per day of corn oil (including that in the corn oil margarine) or 40 or 50 per cent of the total fat intake. Thus, each subject consumed approximately 24 gm. of linoleic acid per day from these two sources plus the linoleic acid from the other dietary fat; this latter amount would be approximately 5 to 7 gm. per day. Therefore, the total intake of linoleic acid was estimated to be approximately 30 gm. per day or 25 per cent of the fat calories. This increase in dietary linoleic acid was at the expense of saturated and monounsaturated fatty acids.

Subjects

Two groups of subjects (employees) were used for testing the effectiveness of this dietary regimen. In the first group of ten subjects serum cholesterol levels were in the approximate range of 150 to 250 mg. per cent. Fasting blood samples were obtained from each of the subjects at weekly intervals for five weeks while on their usual diet. They were then given the diet high in linoleic acid and blood samples obtained every two weeks for ten weeks. At the end of that period the diet was changed to one rich in animal fat. The subjects were supplied with butter, lard and a hydrogenated vegetable fat for household food preparation and were instructed to omit all vegetable oils and margarines from their diet. This dietary period lasted for another ten weeks.

TABLE III

Influence of a High Linoleic Acid Dietary Regimen on the Serum Cholesterol Level of Clinically Healthy Subjects with High Serum Cholesterol Levels

Subject No.	Sex	Age (yr.)	Total Serum Cholesterol (mg. %)					
			Control Period*	2 wk.	4 wk.	6 wk.	8 wk.	10 wk.
1	M	34	278 ± 14	258	218	240	226	220
2	M	43	262 ± 18	225	221	203	220	197
3	M	30	268 ± 9	249	233	204	206	218
4	M	51	315 ± 16	292	299	260	258	254
5†	M	35	367 ± 20	304	338	341	316	300
6	M	51	335 ± 45	297	304	276	270	214
7	M	55	273 ± 14	223	214	221	209	214
8	M	46	285 ± 10	297	227	244	244	209
9	M	41	245 ± 18	255	216	195	202	207
10	M	37	272 ± 28	229	225	257	247	207
11	M	36	350 ± 24	310	267	297	291	278
12	M	47	259 ± 9	249	232	235	237	208
13	M	45	267 ± 11	270	258	256	229	...
14	F	54	397 ± 24	318	308	326	310	308
15	F	39	281 ± 24	247	216	247	218	219
16	M	45	264 ± 15	227	199	219	208	207
17	M	46	271 ± 15	228	233	219	...	239
Average		43	293 ± 43	263 ± 34	248 ± 41	249 ± 42	243 ± 37	231 ± 35

* Each value during control period represents average (\pm S.D.) of four fasting serum cholesterol values determined on weekly blood samples.

† This subject had a proved acute myocardial infarction approximately two years prior to this study.

In the second group, consisting of sixteen clinically healthy subjects and one subject with ischemic heart disease, serum cholesterol levels were in the approximate range of 250 to 400 mg. per cent. Blood samples were obtained at weekly intervals for four weeks prior to the subjects being placed on the dietary regimen. Thereafter, the blood samples were obtained every two weeks for ten weeks.

Methods

The total serum cholesterol was determined by the method of Sperry and Webb.¹⁵ The fatty acid composition of the food fats was determined by gas-liquid chromatography as previously described.¹⁶ Statistical analysis was carried out by the *t* test and $P < 0.05$ was considered to be significant and $P < 0.01$ highly significant.

RESULTS

Table II shows the influence of the dietary pattern on the serum cholesterol level in the first group of subjects. The average age of the subjects was thirty-four years. The group

consisted of four women and six men. The serum cholesterol levels during the control period averaged 212 mg. per cent. At the end of eight and ten weeks there were consistent significant declines in the total serum cholesterol level. The average drop at the end of ten weeks was 26 mg. per cent (12.3 per cent). Some subjects showed greater responses to the high linoleic acid diet than others. One subject (No. 7) had a drop of 28.9 per cent, whereas another (No. 5) had no drop at all.

Following ingestion of the diet high in linoleic acid the subjects were immediately switched to the diet high in animal fat. At the end of ten weeks on the animal fat diet the increase in the total serum cholesterol level of the group was marked when compared to the last value obtained with the subjects on the linoleic acid diet. The average increase was 50 mg. per cent (26.9 per cent). The responses were much greater in some subjects than in others. In contrast to the dietary pe-

riod during which the diet was high in linoleic acid and the serum cholesterol level in seven of ten subjects was below 200 mg. per cent, in all but two of the subjects on the animal fat diet the serum cholesterol level was above 200 mg. per cent and in one had increased to a level above 300 mg. per cent. The subjects did not show any weight changes while they were on these dietary regimens. Their average weight before the diet was 143 pounds; after ten weeks on the diet high in linoleic acid diet, 144 pounds; and after ten weeks on the diet high in animal fat 143 pounds.

Table III shows the influence of the dietary regimen high in linoleic acid on the serum cholesterol level of clinically healthy subjects with elevated blood cholesterol levels. The group consisted of fifteen men and two women with an average age of forty-three years. The average blood cholesterol level during the control period was 293 mg. per cent. At the end of the first two-week period on the dietary regimen there was a significant decline of 30 mg. per cent (10.2 per cent) in the serum cholesterol level. There was an additional drop in the level at the end of four weeks and at that time the change was highly significant. At the end of ten weeks the average blood cholesterol level of the group had declined to 231 mg. per cent or a drop of 62 mg. per cent (21.2 per cent). Of the seventeen subjects, the cholesterol level ranged above 250 mg. per cent in only four, but even in those subjects the declines in their blood cholesterol level were highly significant. The response of the subjects to the dietary regimen was varied e.g., at the end of ten weeks one subject (No. 6) showed a decline of 121 mg. per cent (36.1 per cent). It is also significant that in every subject in the group, regardless of his initial level, there was a significant decline after ten weeks. There was no evidence of any weight changes; the initial and final average weight was 176 pounds.

COMMENTS

It has become abundantly clear that the polyunsaturated fatty acid content of dietary food fats is an important factor in regulating the serum cholesterol level in man. Recent

reports have called attention to the desirability for raising the level of polyunsaturated fatty acids in the dietary fat of the American population.^{17,18} However, whether such manipulation of the diet and resultant lowering of serum cholesterol will be beneficial in the prevention of ischemic heart disease and vascular disorders in the periphery remains to be proved. This can only be determined by long-term comparative studies of populations on diet patterns comparable to the one described in this report and populations on diets high in animal fat.

Our data confirm and extend the observations of Boyer and others¹³ who showed that comparable substitution diets are effective in institutions. The results of the present study demonstrate that it is practical to substitute up to a half of the usual dietary fat with fats rich in linoleic acid and that this manipulation of the family diet pattern will effectively lower the serum cholesterol level. It is also shown that changing to a diet rich in animal fats from one rich in vegetable fat produces a significant elevation in the serum cholesterol level.

The diet did not involve any major change in food preparation in the home and some of the subjects who have been adhering to this diet for more than a year have experienced no difficulty. Of interest is the fact that the subjects did not gain or lose weight. This indicates that there was no appreciable increase in their caloric or fat intake while on the diet.

An important aspect of this diet was that it was readily accepted by the children of the family. This is of particular significance since such diets, if they are beneficial in reducing the incidence of atherosclerosis, should probably be started at an early age in the general population. Another factor was that the subjects of the study did not have any known previous history of ischemic heart disease (with the one exception) and therefore did not have any psychological drive to adhere to such a dietary regimen.

While the diet pattern is largely of a free-choice nature and nonrestrictive, it is likely that rigid adherence to the few dietary rules is necessary. Correlation of interviews and the



analytical data during the experiment suggested that minor deviations from the diet pattern rendered the diet somewhat less effective in lowering the serum cholesterol level.

SUMMARY

A family diet pattern is described which is effective in lowering the serum cholesterol level of clinically healthy subjects with either normal or elevated serum cholesterol levels. This diet pattern is largely of a free-choice nature, nonrestrictive, and necessitates a minimal amount of change in the dietary habits of the family. It consists of substitution of up to one-half the normal dietary fat with two fats rich in linoleic acid (corn oil and a corn oil margarine).

The diet does not produce any change in body weight. In a group of clinically healthy subjects with elevated serum cholesterol levels (293 mg. per cent) the diet was found to be highly effective in lowering the serum cholesterol level to 231 mg. per cent (21 per cent) after ten weeks. In a group of healthy subjects with serum cholesterol levels averaging 212 mg. per cent there was a significant decline to 186 mg. per cent (12 per cent) in the serum cholesterol level after ten weeks. When the latter group of subjects was placed on a diet high in animal fat the increase in the blood cholesterol level was 27 per cent over the level obtained during the previous dietary period.

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