Fatty acid composition of the plasma lipids in Greenland Eskimos[1,2]

J. Dyerberg,[3] M.D., Ph.D., H. O. Bang,[4] M.D., Ph.D. and N. Hjørne[5]

ABSTRACT Gas-liquid chromatography analyses have been carried out to investigate the composition of esterified fatty acids in the plasma lipids in 130 Greenland Eskimos, compared with those of 32 Greenland Eskimos living in Denmark and of 31 Caucasian Danes in Denmark. While the Eskimos living in Denmark did not differ substantially from other persons living in Denmark and, from what is found in other studies in Western communities, the Greenland Eskimos showed a completely different pattern. They demonstrated a much higher proportion of palmitic, palmitoleic, and timnodonic acids, while they had a markedly lower concentration of linoleic acid. The total concentration of polyunsaturated fatty acids was lower in Greenland Eskimos than in the other groups. These findings are discussed in the light of the generally accepted opinion of the beneficial effect on plasma lipid levels and on the morbidity of coronary atherosclerosis of a high dietary intake of polyunsaturated fatty acids. As plasma lipid and lipoprotein levels in Greeland Eskimos in a previous study were found markedly lower than those found in Western populations, and as coronary atherosclerosis seems to occur far less commonly among Eskimos in Greenland than among peoples in industrialized countries, it was found difficult to combine these observations with the results from the present study. If dietary differences are the main reason for the differences in plasma lipid concentrations, the results from the present study point more toward qualitative than toward quantitative differences in respect of fatty acid composition of the food. *Am. J. Clin. Nutr.* 28: 958-966, 1975.

An intimate relationship between the occurrence of coronary atherosclerosis and the plasma lipid level has been demonstrated for cholesterol as well as for triglycerides. This relationship is especially obvious in certain ethnic groups where there is a combination of a low incidence of coronary atherosclerosis and a low concentration of plasma lipids (1-3).

The Greenland Eskimos are no exception from this rule. Coronary atherosclerosis is almost unknown among these people when living in their original cultural environment. In an investigation of their plasma lipids we were able to demonstrate significantly lower plasma concentrations of cholesterol, triglycerides, β-lipoproteins, and pre-β-lipoproteins, as compared to a Danish reference population (4, 5). This difference could not be demonstrated if Eskimos living in Denmark were compared to other Danish citizens living in Denmark. The results from these studies are briefly summarized in Table 1.

Much interest has been focused on the influence of dietary habits, especially the intake of saturated and unsaturated fats, on the plasma lipids, and secondarily on the morbidity of ischemic heart disease. A high intake of saturated fat relative to a low proportion of polyunsaturated fat has been claimed as one of the main reasons for the growing incidence of coronary atherosclerosis in industrialized communities.

Even if the pattern of esterified fatty acids is characteristic for each plasma lipid class, this pattern can be modified by prolonged alterations in the composition of the fatty acids of the diet (6). In this way the fatty acid pattern in the plasma lipids to some degree reflects the dietary intake of these components.

The differences in dietary habits between

[1] From Dept. of Clinical Chemistry, Aalborg Hospital North, 9000 Aalborg, Denmark.

[2] The study was supported by grants from the Danish Association for the Prevention of Heart Diseases. "Aalborg Municipality's Medical Research Fund," "The Medical Research Fund for the County of North Jutland," and private sources.

[3] Chief chemist. [4] Chief chemist. [5] Pharmacist.

Eskimos living in Greenland and inhabitants of Western communities (e.g., Danes) are principally in the consumption of meat. In Eskimos the meat is the main source of calories, giving rise to a high intake of proteins, and a relatively low intake of carbohydrates. As the meat originates from animals living in the sea, the composition of the dietary fats is characterized by their maritime origin. In the daily Eskimo food in Greenland the relative amount of protein calories is approximately two and a half times that of the daily Danish food, whereas the relative amount of carbohydrates is only two-thirds (Table 2).

One of the main reasons for the low plasma concentration of triglycerides and cholesterol in Eskimos could be their highly specialized dietary habits. From this hypothesis it was found of interest to investigate if the pattern of esterified fatty acids in plasma differed from that found in Western populations. In the present paper the results from such an investigation are given.

Material and methods

The study comprises 130 West Greenland Eskimos: 61 males and 69 females, all over 30 years of age, mean age 51.8 years, range 30–83 years, and examined in the autumn of 1970 (4, 5). The results were compared with two groups of persons, namely 32 Eskimos, 7 males and 25 females, mean age 38.3 years, range 27–51 years, living in Denmark, also included in the previous studies, and of 31 Caucasian Danes, 20 males and 11 females, mean age 50.6 years, range 23–69 years, in whom the fatty acid pattern had also been investigated in a previous study (7). All blood samples were drawn after 10–12 hours of complete fasting. None of the persons were overweight.[6] The plasma lipids from the Eskimos were kept frozen at −20 C, extracted from plasma, and stored under nitrogen until the analyses were carried out. The plasma lipids were separated in three fractions: cholesterol esters, triglycerides (including unesterified cholesterol and free fatty acids), and phospholipids, by silica gel column chromatography (8). After methylation of the fatty acids (9) the fatty acid mixtures were analyzed by gas–liquid chromatography using a Beckman GCM gas chromatograph, equipped with a 2-m glass column of 3-mm internal diameter. Supporting medium was chromosorb W AW mesh 80–100, and stationary phase 10% w/w diethylene glycol succinate. Analyses were carried out at an injection temperature of 250 C, a column temperature of 180 C, and a column flow of 30 ml/min of nitrogen. A hydrogen flame ionization detector was used at a temperature of 250 C. The signal was analyzed by a disc integrator and compared with those of assays on mixtures of fatty acids supplied by Nu-Check Prep, Elysian, Minnesota, U.S.A.

TABLE 1
Mean values for plasma lipid and lipoprotein concentrations in Greenland Eskimos, Eskimos living in Denmark and Caucasian Danes in Denmark

	Greenland Eskimos	Greenland Eskimos living in Denmark	Danes
Total lipids, g/liter	5.93	7.32	6.55
Cholesterol, mmol/liter	5.58	7.30	6.77
Triglycerides, mmol/liter	0.43	1.12	0.98
Phospholipids, mmol/liter	2.92	3.18	2.91
Chylomicrons, g/liter	0.27	0.24	0.15
β-Lipoproteins, g/liter	4.27	5.00	4.58
Pre-β-lipoproteins, g/liter	0.44	1.10	1.05
α-Lipoproteins, g/liter	3.64	4.24	3.64

Randon sample (5).

TABLE 2
Composition of the Eskimo diet and average Danish food

	Eskimos[a]	Danes[b]
Carbohydrate,[c] calorie percent	37	49
Protein, calorie percent	26	11
Fat, calorie percent	37	40
Cholesterol, mg/1,000 kcal	245	139
Saturated fatty acids, percent of total	34	53
Polyunsaturated fatty acids, percent of total	10	13
Essential fatty acids (18:2 + 20:4) percent of total	4.8	10.0
P/S Ratio	0.29	0.25

[a] Detailed food analyses will be published in near future. [b] Results from The Danish Statistical Dept. of Public Health. [c] Including alcohol.

Statistics

In statistical comparisons of medians the Mann-Whitney rank-sum test was used, in that Gaussian distributed rank-sums were assumed.

Results

The results from the three groups of individuals—Eskimos, Eskimos living in Denmark, and Danes—are tabulated in detail in Tables 3–5, along with the statistical comparisons.

[6] i.e., The Danes had a body weight that differed less than 15% from the ideal body weight (Natvig, H. Landsforeningen for kosthold og helse. Oslo: Kristiansen & Wøjen, 1959). The Eskimos were by clinical inspection of "normal weight," but as no epidemiological examination of "ideal weight" in Greenlandic Eskimos exists, no comparison to tabulated weight data could be performed.

TABLE 3
Fatty acid composition of cholesterol esters

Component		G 129[b]	CG 32[b]	R 29[b]	Z-test[c] G/CG	G/R	CG/R
12:0[a]	M[d]	0.0	0.0	0.0			
	x	0.03	0.00	0.00			
13:0	M	0.0	0.0	0.0			
	x	0.01	0.00	0.00			
14:0	M	1.3	0.0	0.4	***	***	
	x	1.22	0.56	0.43			
14:1	M	0.0	0.0	0.0			
	x	0.00	0.07	0.04			
15:0	M	0.0	0.0	0.0			
	x	0.01	0.06	0.00			
16:0	M	18.9	12.2	11.7	***	***	
	x	19.27	12.98	12.41			
16:1	M	9.0	4.2	3.8	***	***	
	x	9.23	4.37	4.06			
17:0	M	0.0	0.0	0.0			
	x	0.00	0.06	0.04			
17:1	M	0.0	0.0	0.2		***	***
	x	0.00	0.00	0.20			
18:0	M	0.0	1.1	0.8			
	x	1.05	1.50	0.96			
18:1	M	25.0	19.6	20.6	***	**	
	x	25.34	20.56	22.78			
18:2	M	20.3	54.8	48.2	***	***	**
	x	20.35	52.78	47.81			
18:3	M	0.0	0.0	0.5	**	***	
	x	0.02	0.56	0.47			
19:0	M	0.0	0.0	0.0			
	x	0.03	0.00	0.00			
20:0	M	0.0	0.0	0.5		***	***
	x	0.06	0.00	0.50			
20:1	M	0.0	0.0	0.0			
	x	0.05	0.18	0.00			
20:2	M	0.0	0.0	0.0			
	x	0.01	0.00	0.00			
20:3	M	3.7	3.2	0.0		***	***
	x	3.37	3.07	0.61			
20:4	M	0.0	0.0	4.4		***	***
	x	1.02	0.72	4.02			
20:5	M	15.4	0.0	0.0	***	***	**
	x	15.79	1.00	0.08			
22:0	M	0.0	0.0	0.0			
	x	0.01	0.04	0.00			
22:2	M	0.0	0.0	0.0			
	x	0.02	0.00	0.00			
22:3	M	0.0	0.0	0.0			
	x	0.12	0.05	0.00			
22:4	M	0.0	0.0	0.0			
	x	0.00	0.09	0.00			
22:5	M	0.0	0.0	0.0			
	x	0.01	0.15	0.00			
22:6	M	0.0	0.0	3.3	***	***	
	x	0.96	0.38	5.55			
24:0	M	0.0	0.0	0.0			
	x	0.36	0.58	0.00			
24:1	M	0.0	0.0	0.0			
	x	0.88	0.11	0.00			
24:2	M	0.0	0.0	0.0			
	x	0.88	0.29	0.00			
26:0	M	0.0	0.0	0.0			
	x	0.00	0.04	0.00			

Relative values, percent. [a] Fatty acids are indicated by the number of carbon atoms in the molecule, followed by a ":" and a figure indicating numbers of double bonds. [b] Person groups are indicated as follows: G = Greenland Eskimos living in Greenland. CG = Control group of Greenland Eskimos living in Denmark. R = Reference group of Caucasian Danes. Every signature is followed by a number indicating the total number in the group. Due to occurrence of samples lost in the analytical procedure, the number is not coincident in all lipid groups. [c] Statistical comparisons of rank sums with Z-test. The outfall of the test is indicated by asterisks. $*P \leq 0.05$, $**P \leq 0.01$ $***P \leq 0.001$. [d] M = median. x = mean.

Sex differences

A rather extensive pattern of significant sex differences was observed. These differences were especially obvious in the Greenland Eskimo group, in which the greater sample size allowed rather small numerical differences to be realized as not due to chance. As the differences generally were of a magnitude of less than 1–2%, it was found justified to ignore them and to pool the results from both sexes. This was further justified as the statistical comparisons were performed with a distribution free test, except for the assumption of Gaussian distributed rank sums.

Differences between person groups

As for the sex differences, extensive significant differences were observed between the person groups. However, many of these differences were of a rather small magnitude, and consequently, they will not be referred to in the text.

Comparisons between Greenland Eskimos living in Denmark and the Danish reference group

As shown in Tables 3–5 and in the more concentrated Tables 6–8 in which the results are compared with those from other studies, the two person groups exposed a parallel distribution of esterified fatty acids in all three plasma lipid classes. Differences of a certain magnitude were found in *cholesterol esters* for linoleic acid (18:2) and eicosatrienoic acid (20:3) with larger amounts in Eskimos, and for arachidonic acid (20:4) and docosahexaenoic acid (22:6), in which the differences were reversed. In the fatty acids of the *triglyceride fraction* the same difference was found for linoleic acid (18:2), with the reverse in palmitic acid (16:0). In *phospholipids* a rather great difference was found for arachidonic acid (20:4) with larger amounts in the reference group. The same difference, but to a lesser extent was found for docosahexaenoic acid (22:6), compensated by smaller amounts of palmitic (16:0), oleic (18:1), and linoleic acid (18:2). The three last mentioned differences, however, were not statistically significant. In *conclusion:* gener-

TABLE 4
Fatty acid composition of triglycerides, including free fatty acids

Component		G 128	CG 32	R30	Z-test G/CG	Z-test G/R	Z-test CG/R	Component		G 128	CG 32	R 30	Z-test G/CG	Z-test G/R	Z-test CG/R
12:0	M	0.0	0.0	0.0				20:1	M	3.6	0.0	0.0	***		
	x	0.18	0.04	0.00					x	3.35	0.20	0.00			
14:0	M	2.1	1.8	1.4	**	***	**	20:2	M	0.0	0.0	0.0			
	x	2.13	1.86	1.51					x	0.02	0.09	0.00			
14:1	M	0.0	0.0	0.2		***	***	20:3	M	1.7	0.0	0.0	*	***	
	x	0.04	0.0	0.21					x	1.70	1.03	0.27			
15:0	M	0.0	0.0	0.0				20:4	M	0.0	0.0	0.0	*		*
	x	0.01	0.00	0.00					x	0.60	0.83	0.20			
16:0	M	24.7	26.3	28.7		***	***	20:5	M	4.0	0.0	0.0	***	***	
	x	25.07	25.72	28.79					x	4.21	1.52	0.00			
16:1	M	9.3	5.6	5.3				22:0	M	0.0	0.0	0.0	***	***	
	x	9.47	6.04	5.18					x	1.09	0.09	0.02			
16:2	M	0.0	0.0	0.0				22:1	M	0.0	0.0	0.0			
	x	0.05	0.00	0.00					x	0.01	0.00	0.00			
17:0	M	0.0	0.0	0.6		***	***	22:2	M	0.0	0.0	0.0			
	x	0.01	0.00	0.64					x	0.01	0.13	0.00			
17:1	M	0.0	0.0	0.4		***	***	22:3	M	0.0	0.0	0.0			
	x	0.00	0.06	0.43					x	0.24	0.00	0.00			
17:2	M	0.0	0.0	0.0				22:4	M	0.0	0.0	0.0			
	x	0.04	0.00	0.00					x	0.15	0.00	0.00			
18:0	M	6.7	6.0	5.6	*			22:5	M	0.0	0.0	0.0			
	x	5.89	4.57	5.84					x	0.28	0.30	0.00			
18:1	M	35.1	38.0	38.3	**	***		22:6	M	2.0	0.0	0.0	***		**
	x	35.05	38.57	40.07					x	2.35	0.38	3.34			
18:2	M	5.7	16.0	12.0	***	***	***	24:0	M	0.0	0.0	0.0			
	x	6.19	17.30	12.53					x	0.64	0.13	0.00			
18:3	M	0.0	0.0	0.8	*	***	**	24:1	M	0.0	0.0	0.0			
	x	0.08	0.54	0.83					x	0.15	0.00	0.00			
18:4	M	0.0	0.0	0.0				24:2	M	0.0	0.0	0.0			
	x	0.07	0.27	0.00					x	0.55	0.29	0.00			
20:0	M	0.0	0.0	0.0											
	x	0.49	0.00	0.14											

See footnote to Table 3.

TABLE 5
Fatty acid composition of phospholipids

Component		G 129	CG 32	R31	Z-test G/CG	Z-test G/R	Z-test CG/R	Component		G 129	CG 32	R 31	Z-test G/CG	Z-test G/R	Z-test CG/R
12:0	M	0.0	0.0	0.0				20:1	M	2.8	0.0	0.0	***	***	
	x	0.01	0.00	0.00					x	2.73	0.10	0.00			
14:0	M	0.0	0.0	0.2		***	***	20:2	M	0.0	0.0	0.0	*		
	x	0.08	0.08	0.18					x	0.00	0.50	0.00			
14:1	M	0.0	0.0	0.0		***	**	20:3	M	2.2	3.9	1.6	**		**
	x	0.00	0.00	0.08					x	2.30	3.75	1.96			
16:0	M	33.4	32.6	30.9		**		20:4	M	0.0	0.0	8.2		***	***
	x	34.87	34.30	30.56					x	0.81	1.27	7.99			
16:1	M	2.5	1.1	0.6	***	***		20:5	M	6.1	0.0	0.0	***	***	
	x	2.68	1.49	0.77					x	7.11	0.74	0.16			
17:0	M	0.0	0.0	0.4		***	***	22:0	M	0.0	0.0	0.0		*	
	x	0.00	0.00	0.47					x	0.69	0.57	0.00			
17:1	M	0.0	0.0	0.0		***	**	22:3	M	0.0	0.0	0.0			
	x	0.00	0.00	0.16					x	0.01	0.07	0.00			
17:2	M	0.0	0.0	0.0				22:4	M	0.0	0.0	0.0			
	x	0.01	0.00	0.00					x	0.04	0.13	0.00			
18:0	M	18.8	16.3	16.8	***	**		22:5	M	0.0	0.0	0.0			
	x	19.56	16.29	17.21					x	0.16	0.00	0.00			
18:1	M	15.7	16.1	14.9				22:6	M	3.4	0.0	3.0	***		***
	x	15.94	16.08	15.39					x	3.92	1.01	3.04			
18:2	M	5.7	23.3	21.3	***	***		24:0	M	0.0	0.0	0.0		***	
	x	6.58	22.55	20.95					x	2.12	0.99	0.00			
18:3	M	0.0	0.0	0.5		***	***	24:1	M	0.0	0.0	0.0			
	x	0.00	0.00	0.50					x	0.13	0.00	0.00			
18:4	M	0.0	0.0	0.0				24:2	M	0.0	0.0	0.0			
	x	0.00	0.05	0.00					x	0.04	0.00	0.00			
20:0	M	0.0	0.0	0.0											
	x	0.26	0.08	0.01											

See footnote to Table 3.

ally rather small differences in the pattern of esterified fatty acids in plasma lipids were observed when comparing Eskimos living in Denmark with a Danish reference group. This is especially obvious when compared with the differences found between Eskimos living in Greenland and the two other groups, summarized below.

Comparisons of Eskimos living in Greenland with Eskimos living in Denmark and with the Danish reference group

Very marked differences were observed when Eskimos in Greenland were compared with persons living in Denmark. These differences were, due to the small differences between the two groups living in Denmark, generally the same, whether the Eskimos in Greenland were compared with Eskimos living in Denmark or with the Danish reference group. In the following the most pronounced differences will be summarized, while the minor differences in spite of their statistical significance will not be referred to in the text.

Cholesterol esters. Significantly larger proportion of palmitic (16:0), palmitoleic (16:1), oleic (18:1), and eicosapentaenoic acid (20:5), with markedly smaller proportion of linoleic acid (18:2) in the Eskimos residing in Greenland.

Triglycerides. Significantly larger proportion of palmitoleic (16:1), eicosaenoic (20:1),

TABLE 6
Fatty acid composition of cholesterol esters compared with the results from other studies

	12:0–15:0	16:0	16:1	16:2–17:2	18:0	18:1	18:2	18:3	18:4–20:2	20:3	20:4	20:5	22:0–26:0
Own investigations:													
Greenland Eskimos	1.3	19.3	9.2	0.0	1.1	25.3	20.3	0.0	0.2	3.4	1.0	15.8	3.2
Danish Eskimos	0.7	13.0	4.4	0.1	1.5	20.6	52.8	0.6	0.2	3.1	0.7	1.0	1.7
Danes (7)	0.4	12.4	4.1	0.2	1.0	22.8	47.8	0.5	0.5	0.6	4.0	0.1	5.6
Hallgren, Stenhagen, Svanborg and Svennerholm (11)	2.0	11.0	4.8	1.1	0.8	23.2	46.2	2.1			5.9	1.8	0.6
Schrade, Biegler and Böhle (12)	1.0	11.9	7.2		2.8	19.7	46.7			1.1	4.5	1.4	1.9
Lindgren, Nichols and Wills (13)	3.0	10.0	3.2	1.1	1.2	17.8	55.3	⊢— 2.1 —⊣			5.6	⊢0.6⊣	
Swell, Schools and Treadwell (10)	1.7	15.6	3.7	1.6	2.4	21.8	47.5	0.5	0.3	0.4	5.9		
Freeman, Lindgren and Nichols (14)	4.4	10.4	3.4	1.7	1.3	18.8	50.4	⊢— 3.0 —⊣			6.1	⊢0.6⊣	
Kirkeby, Ingvaldsen and Bjerkedal (15)		9.2	3.3		1.0	19.6	54.9				4.9	1.8	

Values in percent of total.

TABLE 7
Fatty acid composition of triglycerides, compared with the results from other studies

	12:0–15:0	16:0	16:1	16:2–17:2	18:0	18:1	18:2	18:3	18:4–20:2	20:3	20:4	20:5	22:0–26:0
Own investigations:													
Greenland Eskimos	2.4	25.1	9.5	0.1	5.9	35.1	6.2	0.1	3.9	1.7	0.6	4.2	5.5
Danish Eskimos	1.9	25.7	6.0	0.1	4.6	38.6	17.3	0.5	0.6	1.0	0.8	1.5	1.3
Danes (7)	1.7	28.8	5.2	1.1	5.8	40.1	12.5	0.8	0.1	0.3	0.2	0.0	3.4
Hallgren, Stenhagen, Swanborg and Svennerholm (11)	3.9	24.9	6.2	1.8	4.0	41.4	10.9		1.4		0.8	0.6	1.7
Schrade, Biegler and Böhle (12)	1.6	28.4	7.7		4.0	36.2	12.0			1.0	2.7	1.3	1.9
Lindgren, Nichols and Wills (13)	3.5	29.8	3.7	1.1	4.6	39.1	15.7	⊢— 1.2 —⊣			1.3		
Swell, Schools and Treadwell (10)	3.6	31.2	3.1		6.8	41.1	13.0	0.4			0.8		
Freemann, Lindgren and Nichols (14)	4.2	27.9	3.9	1.1	4.4	40.7	14.8	⊢— 1.8 —⊣			1.2		
Kirkeby, Ingvaldsen and Bjerkedal (15)	2.2	22.1	5.2		5.5	39.6	14.5	1.2			1.1		1.1

Values in percent of total.

TABLE 8
Fatty acid composition of phospholipids, compared with the results from other studies

	12:0 15:0	16:0	16:1	16:2 17:2	18:0	18:1	18:2	18:3	18:4 20:2	20:3	20:4	20:5	22:0 26:0
Own investigations:													
Greenland Eskimos	0.1	34.9	2.7	0.0	19.6	15.9	6.6	0.0	3.0	2.3	0.8	7.0	7.1
Danish Eskimos	0.1	34.3	1.5	0.0	16.3	16.1	22.6	0.0	0.7	3.8	1.3	0.7	2.8
Danes (7)	0.3	30.6	0.7	0.6	17.2	15.4	21.0	0.5	0.0	2.0	8.0	0.2	3.0
Hallgren, Stenhagen, Svanborg and Svennerholm (11)	1.1	⊢—27.7—⊣		1.6	11.9	14.3	20.4			2.4	8.8	1.8	6.0
Schrade, Biegler and Böhle (12)	0.6	30.9	3.6		12.3	15.0	21.0			1.1	8.4	2.2	2.9
Lindgren, Nichols and Wills (13)	2.0	33.2	1.1	0.9	14.3	11.9	21.9	⊢——3.3——⊣		9.3	⊢—2.0—⊣		
Swell, Schools and Treadwell (10)	2.3	32.6	2.0	0.6	13.5	17.8	18.2	0.3	0.5	1.1	6.6	⊢—4.5—⊣	
Freemann, Lindgren and Nichols (14)	3.3	30.5	1.3	1.0	13.9	12.1	20.7	⊢——4.3——⊣		9.9	⊢—3.0—⊣		
Phillips and Dodge (16)		26.0		0.6	13.5	11.4	19.7	⊢——7.1——⊣		10.7	0.7	9.4	
Kirkeby, Ingvaldsen and Bjerkedal (15)		24.7	1.7		13.5	12.3	22.4			2.4	6.4	2.6	6.1

Values in percent of total.

and eicosapentaenoic acid (20:5), with smaller proportion of oleic (18:1) and linoleic acid (18:2).

Phospholipids. Somewhat larger proportion of palmitic (16:0) and stearic acid (18:0), and markedly larger proportion of eicosaenoic (20:1) and eicosaepentaenoic acid (20:5) with very much smaller proportions of linoleic acid (18:2), and moderately smaller amounts of arachidonic acid (20:4).

Discussion

As mentioned in the introduction it has been shown that prolonged dietary alterations in the fatty acid composition of the food leads to changes in the composition of the fatty acid pattern in the plasma lipids. The three major lipid groups, cholesterol esters, triglycerides and phospholipids, are not altered in the same manner, keeping their own characteristics (6). Eskimos living in Denmark adapt the pattern of plasma lipid concentrations as shown in a previous study (4) as well as the distribution of esterified fatty acids which is summarized in Tables 6–8. As also shown in these tables this pattern does not differ substantially from that of other populations in Western communities, probably due to similarities in dietary habits.

The esterified fatty acid pattern in the plasma lipids of Eskimos living in Greenland differed dramatically from that of the two other reference populations. Most markedly this was found for linoleic acid, the proportion of which in Eskimos was only one-third to one-half of that in the other groups. Another notable difference was in the occurrence of eicosapentaenoic acid (timnodonic acid). This acid, of which only very small amounts are normally found in Western populations, was one of the major components of the esterified fatty acids in plasma in Eskimos, consisting of up to 16% of the total.

As also stressed in the beginning of this paper, it is very tempting to correlate the documented observations to the low plasma lipid and lipoprotein concentrations in Eskimos and to the low incidence of atherosclerotic heart disease among these peoples.

Coming to this point, it is very difficult to combine the generally accepted concept of the advantage of a high intake of polyunsaturated fatty acids in prevention of ische-

TABLE 9
Distribution of esterified fatty acids in the plasma lipids expressed as saturated, monoenes, and polyunsaturated

Fatty acids	Cholesterol esters			Triglycerides			Phospholipids			Total		
	G	CG	R	G	CG	R	G	CG	R	G	CG	R
Saturated	22	16	14	36	32	37	58	52	49	39	33	33
Monoenes	36	25	27	45	45	46	21	18	17	34	29	30
Polyunsaturated	42	59	59	19	23	17	21	30	34	27	37	37

Values in percent of total. Abbreviations: G = Greenland Eskimos; CG = Control group of Greenland Eskimos living in Denmark; R = Danish reference group

mic heart disease with the present results. The discrepancy is that a generally higher proportion of polyunsaturated fatty acids was *not* found in the plasma lipids of Greenlandic Eskimos. In fact, when combining the fatty acids into only three groups: saturated, monoenes, and polyunsaturated as shown in Table 9, the saturated group was found to be higher and the polyunsaturated lower in the Greenlandic Eskimos, while no *marked* difference was found in the monoenes. This is true as well in the cholesterol esters and in the phospholipids as in total, while the fatty acids of the triglycerides compiled in this manner did not differ between the three groups. In this connection it must be held in mind that it is not the absolute concentrations that are dealt with, but amounts, not directly convertible to absolute values due to differences in the concentrations of plasma lipids between the groups.

In a study of the composition of Eskimo food (to be published) the present observations were confirmed, in that a lower proportion of polyunsaturated fatty acids were found as compared to that of average Danish food (Table 2).

The difficulties in combining these observations could be overcome by indicating other explanatory reasons than dietary, for the differences in plasma lipid and lipoprotein concentrations *and* coronary atherosclerosis when comparing Greenland Eskimos with Western populations. However, the evidence of an intimate relationship between these observations is so strong, and the implications pointing at dietary differences to be the cause of the differences in plasma lipid concentrations so convincing, that they cannot be neglected. This is especially obvious when remembering the differences between Eskimos living in Greenland and in Denmark.

When still accepting dietary differences as one of the major variables in the chain of causality, our observations indicate strongly a focusing on qualitative rather than on quantitative differences in the diet.

One of the most remarkable differences is the high amount of certain long-chained fatty acids in the Greenland Eskimos, not occurring to that extent in the other groups. This is valid especially for timnodonic acid (20:5), richly represented in the Eskimo maritime food and in their plasma lipids.

Only extensive dietary studies, which are in progress in our laboratory, combined with primary prevention studies starting with animals, may give answers to the questions arising from the present studies. We feel strongly that the last word in the problem: dietary habits—especially related to the intake of polyunsaturated fatty acids—plasma lipid and lipoprotein concentrations, and coronary atherosclerosis has not yet been spoken.

Grateful appreciation is rendered to Mrs. J. Ellitsgåard, Mrs. J. Heimburger, and Mrs. J. Borg for their technical assistance.

References

1. McGandy, R. B., D. M. Hegsted and F. J. Stare. Dietary fats, carbohydrates and atherosclerotic vascular disease. New Engl. J. Med. 277: 417, 1967.
2. Keys, A. Current status of research on the epidemiology of coronary heart disease. Japan Circulation J. 32: 1669, 1968.
3. Keys, A. The diet and the problem of coronary heart disease. Minerva Med. 61: 173, 1970.
4. Bang, H. O., J. Dyerberg and A. B. Nielsen. Plasma lipid and lipoprotein pattern in Greenlandic west-coast Eskimos. Lancet 1: 1143, 1971.
5. Bang, H. O., and J. Dyerberg. Plasma lipids and lipoproteins in Greenlandic west-coast Eskimos. Acta Med. Scand. 192: 85, 1972.
6. Ahrens, E., W. Insull, J. Hirsch, W. Stoffel, M. Peterson, J. Farquar, T. Miller and H.

THOMASSON. The effect on human serum lipids of a dietary fat, highly unsaturated, but poor in essential fatty acids. Lancet 1: 115, 1959.
7. BANG, H. O., E. H. THAYSEN AND J. THYGESEN. The plasma lipids and their fatty acid pattern in myocardial infarction. Acta Med. Scand. 184: 241, 1968.
8. OLIVECRONA, T. The metabolism of 1-C^{14}-palmitic acid in the rat. Acta Physiol. Scand. 54: 295, 1962.
9. JESTING, E., AND H. O. BANG. Gas liquid chromatography applied as a control for methylation processes. Danish Med. Bull. 8: 169, 1961.
10. SWELL, L., P. E. SCHOOLS AND C. R. TREADWELL. Correlation of diet and serum cholesterol level with serum lipid fatty acid composition. Proc. Soc. Exptl. Biol. Med. 109: 682, 1962.
11. HALLGREN, B., S. STENHAGEN, A. SVANBORG AND L. SVENNERHOLM. Gas chromatographic analyses of the fatty acid composition of the plasma lipids in normal and diabetic subjects. J. Clin. Invest. 39: 1424, 1960.
12. SCHRADE, W., R. BIEGLER AND E. BÖHLE. Fatty acid distribution in the lipid fractions of healthy persons of different age, patients with atherosclerosis and patients with idiopatic hyperlipidaemia. J. Atherosclerosis Res. 1: 47, 1961.
13. LINDGREN, F. T., A. V. NICHOLS AND R. D. WILLS. Fatty acid distribution in serum lipids and serum lipoproteins. Am. J. Clin. Nutr. 9: 13, 1961.
14. FREEMANN, N. K., F. T. LINDGREN AND A. V. NICHOLS. The chemistry of serum lipoproteins. In: Progress in the Chemistry of Fats and Other Lipids, edited by R. T. Holmann, W. O. Lundberg and T. Malkin. New York: Macmillan, 1963, p. 216.
15. KIRKEBY K., P. INGVALDSEN AND I. BJERKEDAL. Fatty acid composition of serum lipids in men with myocardial infarction. Acta Med. Scand. 192: 513, 1972.
16. PHILLIPS, G. B., AND J. T. DODGE. Composition of phospholipids and of phospholipid fatty acids of human plasma. J. Lipid Res. 8: 676, 1967.