

## Serum cholesterol, triglycerides and heart disease of nomadic and sedentary tribesmen consuming isoenergetic diets of high and low fat content\*

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1. The effects were examined of two approximately isoenergetic diets differing widely in saturated fat content on the levels of serum cholesterol and triglycerides of nomads and non-nomads in eastern Niger. Each person was also examined for clinical and electrocardiographic evidence of heart disease.
2. No significant differences could be found between serum cholesterol and triglyceride levels of 297 Anagamba nomad men consuming 73% energy as fat and 303 Kanouri sedentary men consuming 9% energy as fat.
3. Rheumatic heart disease was common in nomads and four possible cases of ischaemic heart disease were found in sedentary men only.

Studies on the Maasai tribesmen of east Africa have revealed their remarkable lack of arteriosclerosis (Mann, Shaffer, Anderson & Sandstead, 1964) and their low levels of serum cholesterol despite their high intake of saturated fat consumed as milk and blood (Biss, Kang-Jey, Mikkelson, Lewis & Taylor, 1971). No comparative observations, however, are available on closed communities of similar ethnic background consuming isoenergetic diets with low levels of saturated fat.

A unique opportunity to study the effects of diets widely divergent in saturated fat content on two closed communities (stable, self-contained groups of people who live in relatively isolated circumstances and have little intercourse with others) arose during the Sahelian drought in eastern Niger. The exact location of the study was the village of Diffa, 130 km west of Lake Chad in the desert-savannah terrain, 13° north, 13° east. Because of the drought, a large band of Anagamba nomads who ordinarily roam this territory had moved their herds closer to the village for access to water supply and limited forage. We were able to compare the diet, physique, cardiovascular state, levels of serum cholesterol and triglycerides, and resting and stress electrocardiograms of men of this tribe with a similar number of sedentary village men of Kanouri origin, locally called Beriberi. Five members of our team provided multiple blood samples for serum cholesterol and triglycerides for comparison with these groups. The Anagamba, who speak Peul and are thought to be Fulani in origin, have distinct Nilo-Hamitic characteristics. Their source of food is almost exclusively the product of their herds in the form of milk, cheese and butter. The Kanouri have little access to milk and ordinarily eat pounded millet seed mixed with spices. The only striking differences between the two groups are their way of life, i.e. nomadic *v.* sedentary, and the main sources of their energy supply, i.e. carbohydrate in the sedentary men and saturated fat in the nomads. The Anagamba are strict nomads, wandering the desert-savannah fringe and sleeping on the ground without shelter.

\* This work was done in the Diffa department of Niger.

## METHODS

*Subjects*

All 297 males in the Anagamba tribe aged 15 years or more were examined. Age was difficult to determine, but as circumcision is practised at the fifteenth year, only circumcised men were included in the study. Also examined were 303 males aged 15 years or more of Kanouri stock living in Diffa. Eating habits and meals of both groups were observed on many occasions and found to be singularly uniform.

*Experimental procedure*

Samples of food eaten in 1 d were collected from Kanouri men on 6 separate days, weighed and their content of energy, protein, carbohydrate and fat calculated from tables in the United States Department of Agriculture Handbook No. 8. In addition a further six sets of 1 d food samples were collected, weighed and allowed to dry in the sun under muslin screens. They were then packed in plastic bags, sealed and stored until analysed chemically for the same constituents. The methods of preparation and analysis of all samples were those recommended by the Association of Official Analytical Chemists, 1975. Dairy produce was collected from the Anagamba in a similar manner and stored until analysed chemically. Milk was frozen in a deep-freeze operated by paraffin and stored for analysis.

Men were weighed on a balance scale accurate to 100 g and their height was measured to 0.5 cm with the attached measuring rod. The equipment was supplied by Detecto Scales, Brooklyn, New York 11205, USA. A general physical examination with special reference to blood pressure and cardiac findings and resting and stress electrocardiograms were performed on each man. Blood samples for serum cholesterol and triglycerides were taken after a 12 h fast with plastic disposable syringes supplied by Sherwood Medical Industries, Deland, Florida 32720, USA. Plasma was separated in a small centrifuge, Model IM 174, International Equipment Co, Needham Heights, Mass. 02194, USA, operated from a petrol-powered generator bolted to the floor of a Land Rover. Samples were initially stored in a small refrigerator operated from the generator and later frozen if necessary in a deep-freeze operated by paraffin.

For cholesterol determination 0.1 ml serum was applied to No. 1 Whatman filter paper which was then dried in the sun under muslin and packed in a plastic bag. When required for analysis the area of paper containing the sample was trimmed free of excess paper and eluted with 0.36 M ethanolic solution of potassium hydroxide made by mixing 2 ml of 33% aqueous potassium hydroxide with 31 ml of absolute ethanol, for estimation by the method of Abell, Levy, Brodie & Kendall, (1952). The frozen plasma was used for determination of triglycerides by a modification of the method of Van Handel and Zilversmit (Jagannathan, 1941).

Electrocardiograms were done with a portable machine (Hewlett Packard, Sanborn series, 1504A, Waltham, Mass. 02154, USA, powered by a battery which could be charged from the generator. Stress electrocardiograms were done by running the men around until pulse rate reached maximum or 180. Such testing cannot compare with the careful performance of a well-equipped laboratory, but it was all that could be done under the circumstances.

The ambient temperature during testing was rarely less than 46° so the stress may be more demanding than an equivalent amount of exercise in the laboratory. Laboratory studies were necessarily limited by lack of facilities.

Table 1. *Composition of diets of nomads and sedentary tribesmen of eastern Niger*

(Mean values for six samples)		
Group ...	Nomads	Sedentary tribesmen
Main component ...	Milk	Millet-Sorghum
Energy ...	4.2 (1050) MJ (kcal)/l	145 (3450) MJ(kcal)/kg
Protein (g/kg)	34	101
Carbohydrate (g/kg)	33	688
Fat (g/kg)	87	33
Energy as fat (g/kg)	730	90

## RESULTS

Both groups had similar physical characteristics, being tall and lean, although the nomads were uniformly slightly taller and heavier. No man was obese by any western standards. Although the two groups spoke different languages, it is believed that they had a common origin in Saudi Arabia which they were thought to have left in the eighth century A.D. It appears likely that their original ethnic and genetic background is similar. The sedentary Kanouri were living in the desert-savannah terrain identical to that roamed by the nomadic group and were exposed to a similar climate. The water supply for both groups was drawn from wells piercing the dried lake floor of Mega-Chad, the waters of which covered the whole of eastern Niger 7000 years ago.

It was not possible to measure energy expenditure directly but both groups appeared to maintain their weights on isoenergetic diets so it is reasonable to assume their energy output was similar. Simple observation of their activities confirmed this assumption. Neither group smoked, drank alcohol nor had more than occasional access to sucrose or processed foods and no man had hypertension. In summary, the variables between these people appeared to be limited to diet and life-style. The nomads had mean weights and heights of 1.72 m and 52.3 kg and the sedentary tribesmen 1.70 m and 51.4 kg.

No person without rheumatic heart disease had a systolic blood pressure of more than 135 mm mercury or a diastolic blood pressure of more than 80 mm Hg. There was an unusual incidence of rheumatic heart disease in nomads. The clinical findings were characteristic of well-developed rheumatic valvular disease. Thirty-four nomads had dominant mitral stenosis with lesser degrees of mitral insufficiency and aortic insufficiency while eleven nomads had dominant aortic insufficiency. There were nine sedentary tribesmen with rheumatic heart disease, predominantly mitral insufficiency and aortic insufficiency while eleven had dominant aortic insufficiency. There were nine sedentary tribesmen with rheumatic heart disease, predominantly mitral insufficiency with lesser degrees of mitral stenosis and aortic insufficiency. No other clinical heart disease was detected and no findings suggestive of endomyocardial fibrosis were found.

Exercise tests were performed only on those without clinical heart disease and with normal resting electrocardiograms. There were four positive tests, all on non-nomads who appeared to be more than 50 years of age. Each test was characterized by depression of the S-T interval of the electrocardiogram in one or more leads of  $\geq 2$  mm. On questioning, three of these men admitted to central chest distress on vigorous activity.

Table 1 records the results of chemical analysis of food samples. The remarkable finding, despite limited forage, was the high fat content of the milk from the nomad's cattle which were mainly Zebu and Lake Chad animals, the latter being characterized by massive ballooning of their horns. The saturated fat intake of the nomads was between eight and nine times that of the sedentary tribesmen.

Table 2 records the energy contribution of each dietary constituent (% total energy).

Table 2. *Energy distribution in diets of nomads (N) and sedentary tribesmen (S) of eastern Niger*

Group ...	N			S			N : S
	MJ	kcal	% total energy	MJ	kcal	% total energy	
Total energy	7.71	1841	100	7.55	1803	100	1.02
Protein	0.97	233	13	0.88	211	12	1.11
Carbohydrate	1.12	266	14	6.03	1437	79	0.19
Fat	5.62	1342	73	0.64	155	9	8.66

Table 3. *Heights (m), weights (kg), serum cholesterol and triglyceride levels (mmol/l) in nomads and sedentary tribesmen in eastern Niger*

(Mean values and standard deviations)

Group	n	Weight		Height		Serum Cholesterol		Serum Triglycerides		Energy in diet as fat (% total energy)
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	
Nomads	297	52.3	1.17	172.2	1.31	3.25	0.83	0.32	0.16	73
Sedentary tribesmen	303	51.4	0.91	170.3	1.27	3.41	0.70	0.35	0.20	9
Authors	5	—	—	—	—	3.72	0.49*	0.52	0.16*	22

\* 30 samples.

SD = standard deviation

Because of isolation, drought and famine, our own group was limited to rations of millet (*Eleusine coracana*), sorghum (*Sorghum vulgare*), rice (*Oryza sativa*) and powdered milk for 6 months, during which period the average weight loss per adult was 12.5 kg. During the study, the calculated mean energy intake of our own group was 8.17 MJ (1950 kcal) with 22% total energy as fat. There was no significant difference between serum cholesterol and triglycerides of nomads and sedentary tribesmen.

Table 3 presents values for height, weight and dietary fat (% total energy intake) for nomads, sedentary tribesmen and those for the authors. The serum cholesterol and triglycerides were respectively (mean  $\pm$  SD)  $3.25 \pm 0.83$  and  $0.32 \pm 0.16$  mmol/l for nomads and  $3.41 \pm 0.70$  and  $0.35 \pm 0.20$  mmol/l for sedentary tribesmen. The values provided for our own group cannot and are not intended to provide valid statistical comparisons with the other two but they are recorded for interest as samples of westerners living on a similar diet in the same conditions for 6 months. We could not relate the lipid levels of the two major groups to age which was impossible to determine accurately. Since the levels were uniformly low, it seemed unlikely to serve any useful purpose.

## DISCUSSION

Despite isoenergetic diets widely divergent in amounts of energy from saturated fat, there was no difference between levels of serum cholesterol and triglycerides of nomads and sedentary tribesmen. We did not measure the amount of polyunsaturated fatty acids in milk from nomads' cattle, but since the bovids of the Anagamba are free-living and browse on oil-rich plants their milk is likely to have a high content of unsaturated fatty acids. Crawford (1968, 1969) observed that levels of polyunsaturated fatty acids in tissues of free-living animals were significantly increased over those of domestic grass-fed animals and that this difference was likely to be reflected in the composition of their milk. The

breast milk of Japanese women has a higher content of polyunsaturated fatty acids than milk from American women, presumably reflecting the differences in their diet (Saito, Furuich, Kondo, Kawanishi, Nishikawa, Nakazato, Nogochi, Doi, Nogushi & Shingo, 1965).

The leanness of both groups suggested that their diets were suboptimal in energy requirements. Because of the famine their weights were probably much lower than those during times of normal food supply, but no normal standards for Anagamba and Kanouri were available for comparison. The low serum cholesterol levels of the Maasai tribesmen have been attributed to an unusually effective feed back inhibition of endogenous cholesterol biosynthesis as a biological adaptation to their high intake of saturated fat (Biss *et al.* 1971). Shaper (1972), however, conjectured that the physical leanness and low cholesterol levels of most East African nomads reflected an energy intake below subsistence levels much of the time despite high energy intake at certain seasons. It is tempting to suggest the possibility in the Anagamba nomads that their frequent demand for an output of energy at the limit of their intake leads to immediate utilization of fatty acids before they can stimulate increased synthesis of cholesterol. Recently, it had been suggested that sour milk drunk by Maasai nomads may play a role in lowering serum cholesterol (Mann & Spoerry 1974). Some, if not all, of the milk drunk by the Anagamba nomads is sour, but much of the fat is eaten as Fulani butter obtained by beating the 'cream' layer of the milk. Whether or not a small portion of 'fat' energy taken as sour milk can lower serum cholesterol levels is unknown. Although positive stress tests were found in four nomads, they are not unequivocal evidence of coronary artery disease which can only be determined reliably by coronary arteriography or autopsy. The unusually high incidence of rheumatic heart disease seen in the nomads has been observed in other areas of northern Africa including Egypt and the Sudan (Strasser & Rotta, 1973). At present, the factors responsible for this unusual frequency are unknown but the role of nutritional deficiencies needs to be explored.

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