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REPRINTS AND REFLECTIONS

Serum-cholesterol, diet, and coronary heart-disease in Africans and Asians in Uganda*

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In the African population of Uganda coronary heart disease is almost non-existent. This statement is confirmed by adequate necropsy evidence[1]. In the Asian community, on the other hand, coronary heart disease is a major problem. During the three years 1956–58 the Kampala health department registered 102 male and 45 female deaths over 30 years of age among Asians and of these 48 (44 male and 4 females) were certified as due to coronary heart disease (''myocardial infarction'', ''coronary thrombosis''). Though the errors inherent in certification must be borne in mind, it is noteworthy that 43% of male deaths and 9% female deaths over 30 years of age were attributed to coronary heart disease.

While the significance of a high-serum-cholesterol level in the pathogenesis of coronary atherosclerosis cannot yet be taken as proven, it is supported by much indirect evidence.

In a survey of a multiracial community in Cape Town Bronte-Stewart *et al.*[2] have shown that wide differences in the incidence of coronary heart disease in different races may be associated with a parallel difference in the mean serum-cholesterol levels. Moreover the report of a prospective study[3], in which blood-lipid measurements were made in healthy men who were then observed for two years, establishes clearly that elevation of blood-lipids precedes clinical coronary disease and that mean serum-cholesterol concentrations appear to have a high predictive value for populations; although this cannot be applied to the clinical prediction of coronary heart-disease in the individual.

In view of the radically different incidences of coronary heart disease in the two communities in Kampala and their marked differences in social, economic, and dietary backgrounds, we decided to measure serum-cholesterol concentrations in African and Asian males at three age-levels – viz., 12 years, 20 years, and over 40 years.

Socio-economic Background

Kampala is the largest town in the Uganda Protectorate with some 50,000 inhabitants (25,000 Africans, 20,000 Asians, and 5,000 Europeans). It lies on a group of hills about 4000ft. above sea level, and the temperature varies from 65 to 80°F by day with little seasonal variation. The rainfall is about 50 in. a year and the relative humidity is 60–80%.

African

The Africans live mostly in the peripheral areas of Kampala where they are predominantly agricultural small holders growing most of their own staple foods and cash crops such as cotton and coffee.

The Baganda are the original inhabitants of the area and most have a small farm on the outskirts of the town; they form the middle and upper classes in local African society, but the majority are simple peasants. The immigrant peoples from Ruanda-Urundi and the Western Province tend to be employed in unskilled and menial work and are at the lower end of the socioeconomic scale. The people attending Mulago Hospital outpatient department generally belong to the less economically successful sections of the Baganda and to the immigrant groups from other parts of the Protectorate and Ruana-Urundi.

The dietary habits of all groups depend partly on their purchasing-power and partly on traditional customs. In general two meals are taken daily – midday and late evening – and food distribution appears to favour the males. Where the man is at work all day, and in all the poorer groups, a single evening meal is taken. The staple foods, green plantain and sweet potatoes, are steamed in banana leaves; cassava, yams, maize, and millet are also staple commodities in particular of the non-Baganda groups, while pumpkins, tomatoes, and green leafy vegetables are taken

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by all. The adequacy of protein in the diet depends almost entirely on the extent to which pulses, groundnuts, and cereals are used. Most meals are served with a sauce made of groundnuts, beans, and a mixture of vegetables, and occasionally meat or fish, and these are fried in very small amounts of fat. The difference between the diets of the moderately well-off and the rich seems to reside in the quantity and quality of the sauces rather than in the quantities of the staple food. When the Baganda can afford to do so they eat considerably more fat than is usually recorded, and eat it mainly in their sauces[4]. In the typical adult attending Mulago Hospital the daily fat intake is 16–20 g., while well-to-do families on housing estates take up to 40 g. daily with a total daily intake of about 2000 calories. Even in middle-class urban families meat is eaten only once or twice a week, and in the labourer class perhaps only once a month.

Asian

The Asian community in Kampala is derived mainly from immigration from the north and west of India, augmented by natural increase over the past fifty years. The Asians provide most of the skilled labour and business enterprise and are a major source of professional skills. This community is on the whole economically prosperous as compared with the Africans, and, while the range of financial status is wide, there are few families who cannot afford to eat reasonably well. Kampala has twice as many Hindus as Muslims, and these religious differences are closely associated with differences in diet and alcohol intake, the Hindus being by tradition vegetarians and taking no alcohol. They are in fact lacto-ovo-vegetarians, and eggs are eaten in small quantities in most families, especially by the men. The Muslim diet differs in that meat, fish, and poultry are taken and eggs are more freely used.

The basic foods are polished rice, ''dhal'' (lentils), wheat flour (for making ''chapattis'' [handmade unleavened breads] and ''pooris'' [unleavened bread fried in oil]), green vegetables and herbs, and other vegetables and fruits. Fats and oils are always used in the preparation of foods, and cottonseed oil and ''ghee'' are mainly employed, together with smaller quantities of butter and groundnut oil. The ''ghee'' (clarified butter) available is either a ''superfine'' form, made from pure dairy products, or one made from vegetable fats. Both types are widely used in Kampala, the dairy product somewhat more commonly, while a few better-off families make their own ghee in large amounts from Kenya butter. As ghee is relatively expensive the proportion of cottonseed oil to ghee used may be greatly increased in the poorer families. The cottonseed oil is made locally and is used for frying vegetables and breads, while ghee is used on chapattis, in boiled rice, and for preparing vegetables and sweetmeats. In this particular survey the average estimated quantities of fats taken per person weekly are: 1 lb (454 g) cottonseed oil; ½ – ¾ lb. (230-340 g) ghee; ¼ lb. (114 g) butter; 6–8 pints milk; and 1 oz (30 g) cheese. It is evident that fats and oils provide a large proportion of the total caloric intake.

Selection of Subjects

The selection and matching of comparable groups at various ages in the African and Asian communities presented many problems.

Within the Asian group religious and sectarian differences are associated with differences in diet, while in the African community the rapidly changing social and economic patterns of a developing society make it almost impossible to represent a steady progression along the ''normal'' pattern of a particular society. In their childhood and youth those in the over-40 group have certainly experienced a nutritional background far less favourable than that which obtains in school children and students of today. These latter groups in turn will contribute largely to the new middle and professional classes with a nutritional standard far above that found in the present over-40 group.

Africans

(a) *12 year group* – 96 children were selected from two boarding schools near Kampala; most were Baganda and few were from really poor families. The average age was 11.8.

(b) *20 year group* – New students entering Makerere College, who had spent three to six months at home on local diets, were examined and bled within three weeks of arriving at College, and 101 unselected sera were used. The students came from all three East African territories and a wide variety of tribes. The average age was 20.3.

(c) *Over 40 group* – 120 men were selected from outpatients attending Mulago Hospital for minor complaints. There were 61 Baganda, 22 Ruanda, and 37 from other tribes. The average age was about 50. All appeared to be in good health and none had been admitted to hospital or referred to consultant clinics. If any bias in selection existed it was towards excluding any who looked thin or malnourished.

Asians

(a) *12 year group* – 120 children were selected from two Kampala schools; most came from one Muslim school and were non-vegetarian. The average age was 12.

(b) *20 year group* – 104 students were bled from five Kampala schools. Two-thirds were non-vegetarian, and the average age was 19.

(c) *Over 40 group* – 141 men were selected by general practitioners in Kampala from persons attending

their surgeries for minor complaints. 11 subjects known to have diabetes mellitus or coronary heart-disease were excluded. Of the remaining 130 subjects, 94 were vegetarian and 36 non-vegetarian, a bias introduced by the larger number of Hindu doctors in general practice. The average age was 49.

Methods Used

Most specimens were collected early in the morning. In the Asian over-40 group specimens were usually collected in the evening, about four or five hours after the midday meal and before the evening meal.

A light tourniquet was applied, and venous blood was collected using a hypodermic needle size 0 (length 41.5 mm), to which was attached a length of translucent plastic tubing. When clotting had occurred the clot was loosened from the walls of the tube and the tube centrifuged. Serum was separated and stored at minus 10°C until used; all testing was completed within ten days of collection. The method of Sacket as described by King[5] was used to determine serum-cholesterol.

The standard error of difference between means (S.E.D.) and the difference between the means (D.) was calculated; where D./S.E.D. was greater than 2, the series were considered significantly different[6].

Findings

The mean serum-cholesterol levels and standard deviation in 354 Asians and 317 African males in the three age-groups selected for study are summarised in table 1.

The slight difference in mean value between the 12-year and 20-year Asians groups is not statistically significant, but there is a substantial difference in mean value between these levels and those seen in the over-40 group. The Asian results at 20 and over 40 years are very similar to those found in American men in Minnesota by Keys and Keys[7].

The mean serum-cholesterol levels in the 12-year and 20-year African groups are almost identical, despite the fact that the former group represents predominantly one local tribe while the latter is composed of tribes from all over East Africa. In the adult African group the mean level falls to 144 mg. per 100 ml,; and, as these subjects were unselected, the possibility of there being a chance predominance of one or other socioeconomic group was considered. The subjects were grouped by tribes, there being 61 Baganda, 22 Ruanda, and 37 from other tribes with mean serum-cholesterol concentrations of 152, 124, and 144 mg. per 100 ml. respectively. Even if the Baganda alone were considered, as representing the highest socioeconomic group of the three, there would be no rise in mean concentration with age, such as is seen in those communities susceptible to coronary heart-disease[7]. The mean levels when grouped by tribes suggest a definite correlation with the socioeconomic position in the community.

Table I Mean Serum-Cholesterol Concentrations in African and Asian Males, Kampala, Uganda

	Serum-cholesterol (mg. per 100 ml.)(mean & S.D.)	
Age (yr.)	**African**	**Asian**
12	(96) 166 ± 40	(120) 206 ± 46
20	(101) 164 ± 28	(104) 218 ± 49
40	(120) 145 ± 43	(130) 248 ± 52

Numbers in parentheses are numbers of subjects in each group.

As pure vegetarians have been shown to have considerably lower serum-cholesterol levels than non-vegetarians[8], we analysed the results to determine whether the vegetarians and non-vegetarians in the Asian community displayed differences (table 2). In point of fact, many who professed pure vegetarianism were found to be lacto-ovo-vegetarians, and many took meat on occasion. Whatever the dietary group, food was prepared with the same fats and oils – i.e., cottonseed oil and ghee.

Discussion

The mean serum-cholesterol levels of Africans and Asians differed considerably at all the ages studied. Thus any factor or factors responsible for this difference must be present and effective at all three ages, and in the reasons for the interracial difference may be found the factors responsible for the differing racial susceptibility to coronary heart-disease. Climatic and geographic environmental factors are the same in the two groups, and Bronte-Stewart *et al.*[2] have emphasised the considerable overlap from race to race despite interracial differences in mean values.

Physical activity, as suggested by Mann *et al.*[9] cannot be held responsible for the difference in the mean serum-cholesterol levels of young Africans and Asians – school children and students. Moreover, Keys *et al.*[10] think that differences in physical exertion cannot explain the large differences found when groups of people with different dietary habits are studied. Though work entailing physical activity may be protective against coronary heart-disease[11], it cannot *by itself* account for the differences in mean cholesterol levels seen in Western countries and the so-called primitive areas.

In South Africa Bersohn and Wayburne[12] have demonstrated that African and European babies at birth have the same mean serum-cholesterol levels, despite significant differences in the mean levels in the African and European mothers. Sperry[13] showed that in the first three to four days of life the total cholesterol content of the plasma increases – by an

Table II Mean Serum-Cholesterol Concentrations in Asian Vegetarians and Non-Vegetarians in Kampala, Uganda

Age (yr.)	Serum-cholesterol (mg. per 100 ml.) (mean & S.D.)	
	Vegetarian	Non-vegetarian
12-year and 20-year groups	(47) 209 ± 50	(177) 209 ± 47
Over-40 groups	(93) 236 ± 46	(37) 274 ± 52

Numbers in parentheses are numbers of subjects in each group.

average of 76% in 15 subjects – but from the age of 4 to 25 days there was neither increase nor decrease. From the 2nd month to the 13th year the average cholesterol level in children, calculated for each year of age, does not change appreciably and is almost the same as that found in healthy adults aged 19–43[14]. Studies in New York[15] confirm that the serum-cholesterol levels in males remain constant from 2 to 19 years, after which there is a significant but gradual increase to the mid-30 s. It seems likely, therefore, that for each community with its own specific nutritional background the characteristic ''young adult'' level is reached in the first few years of life, possibly because of the changeover to adult types of food. Our own findings in Kampala agree with this.

Various workers have differed somewhat in their reports on cholesterol levels from the mid-30 s to the 6th decade. Some have found a gradual rise with age[16,17,18]. On the other hand, Adlersberg *et al.*[15,] and Oliver and Boyd[19] in Scotland showed no progressive rise in the total cholesterol with age after 33, and a study by Keys[20] on men in Naples with a low fat intake showed that a plateau was reached in the mid-30 s. Thus a rise in serum-cholesterol does not necessarily accompany ageing.

Walker and Arvidsson[21] demonstrated no significant rise with age in the South African urban Bantu, while Keys *et al.*[22], in studies in Japan on men with an intake of less than 10% of total calories from fat, found only a moderate rise with increasing age. In South Africa Bronte-Steward *et al.*[2] reported a mean serum level of 166 mg. per 100 ml. in African men over 40, and, as in Uganda, this group experienced little or no coronary heart-disease. The implications of their findings is that the customary dietary habits of communities may be reflected in their mean serum-cholesterol levels and that increases in cholesterol level run strikingly parallel to increases in consumption of animal fats and a rise in income. This correlation between mean serum-cholesterol levels and socioeconomic standards has been demonstrated in West Africans[23], Johannesburg Bantu[24], and Israelis[25,26].

The African adults in this Kampala study, on a diet to which fat contributes some 10-15% of total calories, have a mean serum-cholesterol level roughly the same as that seen in the two younger age-groups. The Asian over-40 group, however, showed the progressive rise with age seen in other population groups with a high intake of fat. Keys and Keys[7] maintain that in all areas where mean serum-cholesterol levels increase with age the diets have been shown to be relatively high in fat, which provides about 35 to 40% of the total calories. The Kampala Asian community, with a fat intake estimated at some 30–45% of total calories, provides further evidence that a rise of serum-cholesterol with age is associated with abundance of fat. Some of this fat is taken as unsaturated cottonseed oil, which might be expected to prevent a rise in serum-cholesterol. But our results show that the mere taking of unsaturated as well as saturated fat, without regard to the relative quantities, cannot achieve the results obtained under experimental conditions.

Our findings (Table II) are the same as those noted by Hardinge and Stare[8] in their nutritional studies on vegetarians. In young people there is presumably some physiological mechanism whereby, within certain limits of a fat intake, serum-cholesterol levels are maintained at or below about 200 mg. per 100 ml.; and with ageing or a decline in physical activity this mechanism may no longer cope with a heavy intake of fat. The higher cholesterol levels in the Kampala Asian non-vegetarian adults thus reflects their high intake of saturated fat.

The concept of an ''ideal'' level of serum-cholesterol has been raised – a concept which assumes an ætiological relation between the serum-cholesterol concentration and atherosclerosis. Bloomberg *et al.*[24] regard the ideal value as 170–180 mg. per 100 ml., because they consider the level of 150 mg. per 100 ml.[18] is that found in primitive communities with a background of malnutrition. Our figures in African schoolboys and university students would support their contention that the ideal level is about 170 mg. per 100 ml., for neither of these two groups could be said to be malnourished, though their diets may be considered unsatisfactory as regards animal protein. The lower mean serum-cholesterol levels in the African over-40 group in Kampala may be an indication of relative malnutrition in this group, and certainly the tribal levels obtained support this view.

These observations on serum-cholesterol levels in different parts of the world are consistent with the hypothesis that the level of blood-lipids is artificially raised in ''successful'' modern civilisations[27] and that this appears to be an essential condition for coronary heart-disease to become endemic in a people. While a rise of blood-lipids does not cause thrombosis, it undoubtedly predisposes to it.

Summary

A study was made of the dietary background and serum-cholesterol levels in African and Asian males aged 12 years, 20 years, and over 40 years in Kampala, Uganda. These two racial groups differ markedly in their liability to coronary heart-disease.

At all three ages Africans and Asians show a considerable difference in the mean level of serum-cholesterol. This corresponds to their different consumption of fat.

The results of this survey support the view that a rise in serum-cholesterol level is not a necessary accompaniment of ageing.

If an ætiological relationship does exist between coronary heart-disease and the serum cholesterol concentration, a level of 170 mg. per 100 ml. is suggested as ''ideal''.

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Commentary: Personal reflection on 'Serum-cholesterol, diet and coronary heart-disease in Africans and Asians in Uganda'*

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This article and the setting in which the study was carried out reflect very closely my social and political background, my medical training and the way in