

# Serum Cholesterol Concentration in New-Born African and European Infants and their Mothers

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THAT serum cholesterol concentrations are lower in the African than the European is being borne out by increasing evidence.<sup>1-4</sup> Thus, at this center, we have found the mean cholesterol level in 70 healthy South African European subjects of both sexes (age group 21-30 years) to be 215 mg, per 100 ml, while a group of 89 African nurses of similar age had a mean cholesterol level of 174 mg per 100 ml. A group of 45 male Bechuana Africans (age 21-35 years) had a mean cholesterol level of 156 mg per 100 ml.<sup>5</sup> These figures closely resemble those of Walker and Arvidsson<sup>4</sup> on similar groups of subjects. We found no statistical differences between mean values of comparable age groups of the sexes. The question arises: Are lower cholesterol levels characteristic of the African and apparent at birth, or are mean values in the new-born the same for both racial groups?

In a previous publication, we demonstrated that serum proteins and certain liver function tests in the umbilical cord bloods of European and Bantu infants showed no statistical differences, whereas the mothers of the two racial groups showed marked differences.<sup>6</sup> Since data on serum cholesterol were also determined at the same time, and in view of the present interest in the role of serum cholesterol concentration in atherogenesis, we have thought it worth while to present and discuss our results.

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## SUBJECTS AND METHODS

### Subjects

The subjects, 37 European and 51 African mothers, were patients at Queen Victoria Hospital for Women (149 beds) and Baragwanath Non-European Hospital, Johannesburg (1350 beds). Age ranges and mean ages of European and African mothers were 18-42 (mean 25) and 18-40 (mean 26) years, respectively (Table I). All mothers were healthy

TABLE I  
Age Distribution of African and European Mothers

Years	African	European
16-20	5	8
21-25	21	14
26-30	17	9
31-35	5	4
36-40	3	1
41-45	..	1
Total	51	37

and showed no signs of undernourishment. Where ante- or post-partum hemorrhage, toxemia, hypertension, edema, diabetes, or premature labor were featured, the mothers, as well as their infants, were excluded from this study. Furthermore, infants with a birth weight below 5½ lb, together with their mothers, were also excluded. The blood from the infants was drawn from the placental end of the umbilical cord, after division, immediately after pulsation had ceased. The mothers' blood was obtained from the cubital vein with the minimum of stasis and was collected before or after labor, but always within 24 hours of parturition and usually within 12 hours.

### Methods

Serum cholesterol determinations were carried out as described by Kaye<sup>7</sup> with minor modifications. Results obtained by this method were compared with Sperry and Webb's modification of the Schoenheimer and Sperry technique.<sup>8</sup> Our mean results for total and free cholesterol were 5 per cent and 4 per cent higher, respectively, than those obtained using the latter technique.

### RESULTS

The results are summarized in Tables II-IV. Table II summarizes the results of total cholesterol levels. The serum cholesterol concentration was 71.3 mg per 100 ml in the African new-born infant and 75.3 mg per 100 ml in the European infant, there being no statistical differences between the two racial groups. The mean cholesterol concentration was 189.8 mg per 100 ml in the African mother and 258.5 mg per 100 ml in the European mother, a very highly significantly lower value in the African ( $P = 0.000001$ ).

Table III summarizes the concentrations of free and esterified cholesterol and, here too, the African and European infants showed no statistical differences; but highly significant differences were found in the maternal groups. The ratios of cholesterol esters to total cholesterol are summarized in Table IV. No differences in the ratio were found between the European or African groups. The ratios obtained in both the infants and the adults were within the range of normality (70-75 per cent).<sup>9</sup>

### DISCUSSION

This investigation shows that the mean cholesterol level in the African adult is significantly lower than that of a similar group of European subjects, whereas no significant difference exists between the cholesterol levels of African and European new-born infants. Furthermore, it is clear that the ratio of cholesterol esters to total cholesterol does not differ in the new-born and adult subjects of both racial groups. Regarding the latter findings, it is interesting to note that in

TABLE II

A Comparison of the Total Serum Cholesterol Levels of African and European Infants and Their Mothers

	Infants		Mothers	
	African	European	African	European
<i>mg/100 ml</i>				
31-50	6	6	--	--
51-70	21	15	1	--
71-90	15	12	--	--
91-110	5	9	2	--
111-130	3	2	1	--
131-150	--	--	3	1
151-170	--	--	9	--
171-190	--	--	15	4
191-210	--	--	5	2
211-230	--	--	7	1
231-250	--	--	5	6
251-270	--	--	--	7
271-290	--	--	1	8
291-310	--	--	--	4
311-330	--	--	1	2
331-350	--	--	1	--
351-370	--	--	--	1
371-390	--	--	--	1
Total	50	44	51	37
Means	71.30	75.27	189.81	258.47
S.D.	19.29	21.05	49.79	50.13
D <sub>m</sub> /S.E.d.		0.95		6.36
"P"		0.34		0.000001
Significance of "P"		Not significant		Very highly significant

Sperry's investigation,<sup>9</sup> the ratio of esterified to total cholesterol is lower in infants (41-72 per cent) than in adults (70-75 per cent); he considered that the mechanism whereby the proportions of total and free cholesterol in the adults is maintained within narrow limits is not yet fully established in the neonatal period. In addition, Boyd,<sup>10</sup> in an analysis of 29 samples of plasma in the new-born, showed that the ratio of esterified to total cholesterol was 59 per cent (mean total cholesterol 34 mg, cholesterol esters 20 mg, free cholesterol 14 mg per 100 ml) as against a mean of 71 per cent in adults. In the plasma of one infant, there were no cholesterol esters. This author stated that there was a greater variation in the infant than in the adult, and among the possible causes for the lowered percentage of esterified cholesterol in infants were listed the state of nutrition of the new-born child, the effects of

TABLE III

A Comparison of the Free Cholesterol and Cholesterol Esters of African and European Infants and their Mothers

	Free cholesterol				Cholesterol esters			
	Infants		Mothers		Infants		Mothers	
	African	European	African	European	African	European	African	European
mg %								
1-20	26	24	—	—	—	—	—	—
21-40	23	20	14	5	12	9	—	—
41-60	1	—	26	5	25	15	1	—
61-80	—	—	11	20	10	17	2	—
81-100	—	—	—	3	3	3	2	—
101-120	—	—	—	3	—	—	7	1
121-140	—	—	—	1	—	—	13	2
141-160	—	—	—	—	—	—	14	6
161-180	—	—	—	—	—	—	6	6
181-200	—	—	—	—	—	—	3	6
201-220	—	—	—	—	—	—	1	8
221-240	—	—	—	—	—	—	—	2
241-260	—	—	—	—	—	—	1	5
261-280	—	—	—	—	—	—	1	1
Total	50	44	51	37	50	44	51	37
Means	20.1	19.818	48.833	67.392	52.10	56.636	142.167	191.17
S.D.	7.54	8.090	12.629	22.03	12.42	17.47	38.53	23.08
D <sub>m</sub> /S.E.d.		0.186		4.6		1.43		7.431
"P"		0.8		0.0001		0.15		0.0000001
Significance of "P"		No		Highly		No		Very highly

TABLE IV

Serum Cholesterol Ratio. A Comparison of the Ratio of Cholesterol Esters to Total Cholesterol in African and European Infants and Their Mothers

	Infants		Mothers	
	African	European	African	European
Mean total cholesterol, mg per 100 ml	71.3	75.27	189.81	258.47
Mean cholesterol esters, mg per 100 ml	52.1	56.63	142.16	191.17
Ratio of esterified to total cholesterol, %	73	75	75	74

anesthesia and analgesics given during labor, whether labor was easy or difficult, and the possibility of fasting of the mother during labor having influenced the lipid content of the newborn. Our findings, therefore, of no significant difference in the percentage of esterified cholesterol to total cholesterol between infants and adults of both racial groups stands in marked contrast to the data of the workers cited. At present, we have no satisfactory explanation.

The reason for the serum cholesterol level of the African adult being lower than that of the European is open to speculation; probably no single factor is responsible, but rather a combination of factors, some recognized and others still unknown. Among the possible reasons are differences in race, in the nature of the diet consumed and the relevant pattern of metabolism thereby imposed, in the incidence of hepatocellular disease and imbalance of sex hormones. These aspects will now be briefly considered.

*Racial Differences*

There is no evidence that serum lipids are influenced by race.<sup>11</sup> Moreover, as Beyers and associate workers maintain, food habits of various races are probably far more responsible for differences in cholesterol concentration than intrinsic racial peculiarities.<sup>12</sup> Our finding that at birth there is no difference in cholesterol concentration in European and African groups strongly supports the view expressed by various

investigators<sup>4,11,12</sup> that the racial factor is not relevant to the problem.

### Diet

The diet of the African differs in many respects from that of the European. Thus, as has been recently pointed out, although the African probably does not suffer severely from calorie deficiency, the average diet consumed is low in animal protein and in certain vitamins and mineral salts, but is high in carbohydrate intake and crude fiber. The fat intake is low, usually less than 20 per cent of the total calories being provided by dietary fat.<sup>4,13</sup> In contrast, the proportion of calories supplied by fat in local European diets is probably 35–40 per cent.<sup>14</sup> Keys and associates, who have carried out exhaustive studies in this field, consider that, although the serum cholesterol level is subject to a complex regulation which is affected by many factors, the clearest of these is the diet, and the major dietary factor is the fat/calorie ratio.<sup>15–19</sup> In other words, the higher the fat intake the higher the serum cholesterol concentration and vice versa. Although Walker and Arvidsson have demonstrated a correlation between fat intake and serum cholesterol concentration in the African,<sup>4</sup> it is quite obvious, as these workers maintain, that fat intake is unlikely to be the only or even the most important influencing factor. There is now ample evidence, for example, that the true Eskimo, although subsisting on a high fat diet, does not show elevated cholesterol levels, and apparently the incidence of severe atherosclerosis is not high.<sup>20–23</sup> Moreover, although Keys and co-workers do not consider the distinction of animal versus vegetable fat to be of peculiar importance,<sup>15–19</sup> it is becoming increasingly apparent that “pure” vegetarians consuming a high vegetable fat intake are marked by cholesterol levels lower than those of omnivorous eaters.<sup>24–25</sup> At the present stage of knowledge, we agree with Walker<sup>13</sup> that it would be premature to single out one feature of the Bantu diet, namely, low fat intake, as being wholly or even mainly responsible for the low serum cholesterol levels observed.

An explanation to be considered for the rela-

tively low level of serum cholesterol found in the African is the possibility that maize, being the staple food of the African, and constituting a high proportion of his diet, may contain a substance, in the nature of an antimetabolite, interfering or competing with the absorption of cholesterol from the bowel in a manner similar to that previously shown to occur in respect of certain vegetable fats<sup>26,27</sup> and of sitosterol. This hypothesis warrants further study.

Furthermore, it is well to realize that our knowledge of the metabolism and fate of cholesterol, whether ingested or synthesized, is far from complete. We know very little of the factors which influence the rate of cholesterol synthesis, its absorption and re-absorption, destruction by intestinal microflora, or excretion in the feces. Certainly it is conceivable that the processes are not the same for different types of diets. In addition, the effect of the superimposition of malnutrition and of undernutrition on any particular type of diet also requires consideration. The vast gaps in our information underline the caution that must be exercised in crediting any particular dietary constituent with undue etiological significance in atherogenesis.

### Liver Disease

In an investigation still in progress, we have found that approximately 60 per cent of the adult Bantu population examined show biochemical evidence of liver derangement, believed to be due to the effects of chronic malnutrition.<sup>30</sup> Byers *et al.*<sup>12</sup> considered that the liver is the only organ supplying significant amounts of endogenously-derived cholesterol to the plasma. On account of our observation that more than half of the Bantu population show evidence of abnormal liver function, the question arises as to whether a lowered rate of cholesterol synthesis due to chronic liver disease may not be responsible for the lowered cholesterol concentration found in the African. In this respect Walker and Arvidsson,<sup>4</sup> investigating a group of Bechuana and Basuto Africans, 67 per cent of whom showed marked biochemical evidence of liver damage, found no significant difference in mean serum cholesterol



in those showing abnormal liver function tests compared with those who showed slight or no evidence of liver disease. They reported a similar situation occurring in a Bantu group on a partially European diet. In liver disease, hypocholesterolemia is only found in the presence of severe hepatic damage, and even in acute hepatitis and portal cirrhosis it is uncommon to find low cholesterol concentrations. However, in mild to moderate degrees of liver damage, although the total cholesterol concentration is not usually low, the degree of esterification of cholesterol is usually disturbed at an early stage, and is indicative of hepatocellular damage.<sup>31</sup> In the present investigation, however, we found no reduction in the percentage of esterified cholesterol, and this, despite the high incidence of liver disturbances in the Bantu mother.<sup>6</sup> Thus, it would appear unlikely that liver damage in the African directly affects their metabolism of cholesterol, but at the same time, the implication of hormonal imbalance due to a malfunctioning liver must be considered as a possible contributory factor.

#### *Sex Hormones*

The liver exerts an important influence on hormonal metabolism in maintaining the delicate balance between estrogens and androgens. In chronic liver disease, disturbance of sex hormone balance is encountered. Thus, menstrual disturbances occur in the female, and gynecomastia, testicular atrophy, loss of pectoral and axillary hair, loss of libido, impotence and sterility are observed in the male. Gynecomastia and testicular atrophy are more common in Africans than in Europeans, and Gillman and Gillman<sup>32</sup> have alluded to the correlation between gynecomastia and atrophy of the testis, on the one hand, and liver damage, on the other. These authors, however, state that they were unable to correlate the presence or absence of gynecomastia with the extent or severity of the pathologic changes in the liver. The incidence of gynecomastia in their series was only one sixth that of moderate or severe liver damage. It is known that in chronic liver damage, increased estrogen blood levels are found, as well as decreased androgen

levels, which in turn may be due to testicular atrophy.<sup>33</sup> Eilert<sup>34</sup> has shown that increased estrogen levels depress plasma cholesterol; and Boyle<sup>35</sup> has reported reduction in all serum lipids, including cholesterol, in humans during long-term administration of estrogens. Thus, alterations in the balance between the male and female sex hormones, arising from chronic liver disease, may well be involved in the observed difference between the cholesterol levels in African and European subjects.

Much further work is required before the lowered cholesterol concentration in the African can be adequately explained. The question of reaction to stress in the African, the effects of nutritional disturbances on the thyroid, adrenal, and other endocrine glands, and the role of the steroid hormones in cholesterol metabolism, all still require much further investigation before a definite answer can be given to the problem. The cholesterol problem, moreover, seems to be very intimately related to the present high increasing incidence of atherosclerosis and coronary heart disease. In the Africans we have ideal material for a study of this whole subject, since we have a racial group (living side by side with the European population) in whom severe coronary disease is almost non-existent and who normally have low serum cholesterol values.

#### SUMMARY

Serum was collected from 51 African and 37 European mothers and their infants and determinations were made of total and esterified cholesterol concentration. It was found that: (1) mean cholesterol concentrations of infants from both groups were identical; (2) mean cholesterol concentrations in the African mothers were significantly lower than among the European mothers; and (3) no significant difference was found in the percentage of esterified serum cholesterol in the infant and maternal groups from both races.

The possible parts played by race, diet, liver disease, and sex hormones, in producing low serum cholesterol concentrations in African adults, are discussed.



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## REFERENCES

- STONE, W.: The blood chemistry of normal Southern Rhodesian natives. *Tr. Roy. Soc. Trop. Med. & Hyg.* 30: 165, 1936.
- SQUIRES, B. T.: Observations on the blood chemistry of the Bechuanas. *S. Afr. J. Med. Sc.* 6: 53, 1941.
- VAN OYE, E., and CHARLES, P.: Contribution à l'étude de la fonction hépatique chez le noir Africain. vi. La cholestérolémie. *Ann. Soc. belge de méd. trop.* 32: 297, 1952.
- WALKER, A. R. P., and ARVIDSSON, U. D.: Fat intake, serum cholesterol concentration, and atherosclerosis in the South African Bantu. I. Low fat intake and the age trend of serum cholesterol concentration in the South African Bantu. *J. Clin. Investigation* 33: 1358, 1954.
- BERSOHN, I., and WAYBURNE, S.: Unpublished data.
- BERSOHN, I., WAYBURNE, S., HIRSCH, H., and SUSSMAN, C. D.: A comparison of the serum protein, "liver function tests," and serological tests for syphilis in the new-born African and European infants and their mothers. *S. Afr. J. Clin. Sc.* 5: 35, 1954.
- KAYE, I. A.: Determination of total and free cholesterol in blood serum. *J. Lab. & Clin. Med.* 25: 996, 1940.
- SPERRY, W. M., and WEBB, M.: Revision of the Schoenheimer-Sperry method for cholesterol determination. *J. Biol. Chem.* 187: 97, 1950.
- SPERRY, W. M.: Cholesterol of the blood plasma in the neonatal period. *Am. J. Dis. Child.* 51: 84, 1936.
- BOYD, E. M.: Lipid composition of blood in new-born infants. *Am. J. Dis. Child.* 52: 1319, 1936.
- PETERS, J. P., and VAN SLYKE, D. D.: *Quantitative Clinical Chemistry: Interpretations.* Williams & Wilkins Co., Baltimore, 1946.
- BYERS, S. O., FREIDMAN, M., and ROSENMAN, R. H.: Review on the regulation of blood cholesterol. *Metabolism* 1: 479, 1952.
- WALKER, A. R. P.: Diet and atherosclerosis. *Lancet* 1: 565, 1955.
- Report on Inquiry into Expenditure of European Families in Certain Urban Areas, 1936,* Government Printer, Pretoria, 1937.
- KEYS, A.: The cholesterol problem. *Voeding* 13: 539, 1952.
- KEYS, A., VIVANCO, F., MIÑON, R. J. L., KEYS, M. H., and MENDOZA, H. C.: Studies on the diet, body fatness and serum cholesterol in Madrid, Spain. *Metabolism* 3: 195, 1954.
- KEYS, A.: The diet and degenerative heart disease. *Proc. 42nd Annual Meeting of the Medical Section of the Am. Life Convention,* 1954.
- HILDRETH, E. A., MELLINKOFF, S. M., BLAIR, G. W., and HILDRETH, D. M.: The effect of vegetable fat ingestion on human serum cholesterol concentration. *Circulation* 3: 641, 1951.
- KEYS, A.: Human atherosclerosis and the diet. *Circulation* 5: 115, 1952.
- CORCORAN, A. C., and RABINOWITCH, I. M.: A study of the blood lipoids and blood proteins in Canadian Eastern Arctic Eskimos. *Biochem. J.* 31: 343, 1937.
- ALEXANDER, F. A.: Medical survey of the Aleutian islands. *New England J. Med.* 240: 1035, 1949.
- SINCLAIR, R. G., BROWN, G. M., and CRONK, L. B.: Serum lipids of Eskimos. Effect of high fat diet (pemmican) and fasting. *Fed. Proc.* 8: 251, 1949.
- SINCLAIR, H. M.: The diet of Canadian Indians and Eskimos. *Proc. Nutrition Soc.* 12: 69, 1953.
- GROEN, J., TJIONG, B. K., KAMMINGA, C. E., and WILLEBRANDS, A. F.: The influence of nutrition, individuality and some other factors, including various forms of stress, on the serum cholesterol; an experiment of nine months duration in 60 normal human volunteers. *Voeding* 13: 556, 1952.
- DONATH, W. F., FISCHER, I. A., MUELEN VAN EYSBERGEN, H. C., and DE WIJN, J. F.: Voorlopige mededelingen omtrent een onderzoek naar de voedingstroestand van personen, die zich uitsluitend met plantaardige middelen voeden. Gezondheid, voeding en veganisme. *Voeding* 14: 153, 1953.
- KINSELL, L. W., COCHRANE, G. C., SMYRI, S., FUKAYAMA, G., and COELHO, M.: Further experience with high vegetable fat diet in patients with extensive diabetic vascular disease. *Circulation* 10: 593, 1954 (Abstract).

27. BEVERIDGE, J. M. R., CONNELL, W. F., MAYER, G., FIRSTBROOK, J. B., and DE WOLFE, M.: The effects of certain vegetable and animal fats on plasma lipids of humans. *Circulation* 10: 593, 1954 (Abstract).
28. JOYNER, C. R., and KUO, P. T.: The serum cholesterol level and lipoprotein pattern following administration of plant sterols. *Circulation* 10: 589, 1954 (Abstract).
29. BEST, M. M., DUNCAN, C. H., WATHEN, J. D., VAN LOON, E. J., and SHIPLEY, R. E.: Effects of prolonged administration of sitosterol on serum lipids. *Circulation* 10: 590, 1954 (Abstract).
30. BERSOHN, I., and HIGGINSON, J.: Unpublished data (1954).
31. EPSTEIN, F. Z.: The cholesterol partition of the blood plasma in parenchymatous disease of the liver. *Arch. Int. Med.* 47: 82, 1931.
32. GILLMAN, J., and GILLMAN, T.: *Perspectives in Human Malnutrition*, Grune and Stratton, New York, 1951.
33. GLASS, S. J., EDMONDSON, H. A., and SOLL, S. N.: Sex hormone changes associated with liver disease. *Endocrinology* 27: 749, 1940.
34. EILERT, M. L.: The effects of estrogens upon the partition of the serum lipids in female patients. *Proc. Am. Soc. Study Arteriosclerosis, Am. Heart J.* 38: 472, 1949.
35. BOYLE, E.: Effects of long-term estrogen and heparin administration on serum lipoprotein levels in hypercholesterolemic humans. *Circulation* 10: 587, 1954 (Abstract).

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### *Climate + Intake = Temperament (?)*

"Huge white bodies, cool-blooded, with fierce blue eyes, reddish flaxen hair; ravenous stomachs, filled with meat and cheese, heated by strong drinks; of a cold temperament, slow to love, home-stayers, prone to brutal drunkenness: these are to this day the features which descent and climate preserve in the race. . . . There is no living, in these lands, without abundance of solid food; bad weather keeps people at home; strong drinks are necessary to cheer them; the senses become blunted, the muscles are braced, the will vigorous."

—H. A. Taine. *History of English Literature: The Saxons*, 1863.

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### *The Strenuous Pleasures of Barbarians—and Others*

"If the carnivorous, warlike, drinking savage, proof against the climate, still shows beneath the conventions of our modern society and the softness of our modern polish, imagine what he must have been when, landing with his band upon a wasted or desert country, and becoming for the first time a settler, he saw extending to the horizon the common pastures of the border country, and the great primitive forests which furnished stags for the chase and acorns for his pigs. The ancient histories tell us that they had a great and coarse appetite. Even at the time of the Conquest the custom of drinking to excess was a common vice with men of the highest rank, and they passed in this way whole days and nights without intermission. Henry of Huntingdon, in the twelfth century, lamenting the ancient hospitality, says that the Norman kings provided only one meal a day, while the Saxon kings used to provide four. . . . To shout, to drink, to gesticulate, to feel their veins heated and swollen with wine, to hear and see around them riotous orgies, this was the first need of the Barbarians. The heavy human brute gluts himself with sensations and with noise."

—H. A. Taine. *History of English Literature: The Saxons*, 1863.