8 Medical Research among the !Kung

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San mother on the move with her baby and her possessions

This paper reports the results of three research trips to the Dobe !Kung. The purpose of our study was to provide a medical profile of a hunting and gathering population. Particular attention was paid to three sorts of questions. First, which kinds of medical conditions were present and which were absent in the population and what effect did these have on the population's fitness? Second we were interested specifically in the problem of heart disease. We wanted to follow up the lead of previous investigators that indicated a lower incidence of degenerative heart disease among the San than has been found in other populations. And if this turned out to be the case, we wished to explore the possible causes in terms of nutritional, social (life-style), and other factors.

A third area of investigation concerned the nutritional status of the !Kung population. What clinical signs of nutritional deficiencies, if any, were present? And what was the overall adequacy of the diet in terms of the maintenance of adult health and provision for the special needs of pregnant and lactating women and growing children?

Each of the three medical research trips to the Dobe Area of northwest Botswana consisted of ten days of field work. Our first visit, in October 1967, was at the end of the dry season—the weather was dry and hot, and water and food were scarce. We worked at Dobe in a specially equipped medical tent where we examined 45 adults and 30 children (under 15 years of age).

In late April to early May 1968 we returned to the area. We first worked at /Xai/xai, where we examined 51 additional adults and 28 children. Then we moved our equipment to Dobe to reexamine 34 of the San adults and 24 of the children whom we had seen the year before. The purpose of this second visit was to see whether there were any changes in the San's medical or nutritional state after the advent of the rainy season, when food and water were more abundant.

During our first visit we spent a great deal of time taking medical histories from the San with the help of interpreters. Each person was examined individually and thoroughly, and any unusual sign was checked by the other investigator. On the last day of both visits we collected 24-hour urines from a few of the San at Dobe. Preliminary findings from these first two visits have been published in abstract (Truswell and Hansen 1968a, p. 1338; Truswell et al. 1969, p. 1157; Hansen et al. 1969, p. 1158).

The third visit was made in July 1969. On this occasion Stewart Truswell was accompanied by a cardiologist, B.M. Kennelly. The special object of this visit was to record the San's electrocardiograms

(ECGs). We took with us a Cambridge "Transrite 4" portable ECG machine, powered by fourteen torch batteries. Dr. Kennelly made clinical cardiac examinations, and we measured the ventilatory function of some of the San with Wright's peak flow meter. We also went south of the Aha hills to examine San whom we had not seen before at ≠To//gana and /Du/da.

During each visit, blood samples were taken from 29, 39, and 31 adults (mostly male) respectively. Sera were allowed to separate by clot retraction in a cool place: they were decanted into tubes containing dried merthiolate and stored in a portable gas-driven refrigerator. Serum samples in a coolbox packed with ice were brought back with us when we returned to Cape Town by jeep and airplane. The samples were analyzed in the Clinical Nutrition Unit of Cape Town University Medical School.

Since our third visit, two other medical teams have made short visits to the Dobe area (Metz, Hart, and Harpending 1971, p. 229; Joffe et al. 1971, p. 206). We will summarize their findings in this chapter. However, we are not covering the highly specialized, biochemical genetic studies that have been made by H.C. Harpending and collaborators (see Chapter 7), and will deal only with biomedical studies that have been made on the !Kung in northwestern Botswana. Reports on San in other areas—the Central Kalahari, Namibia, and Angola—will be referred to only when they shed light on our own findings.

In general we found the San to be small and delicate and graceful, with light movements. Their skin is reddish-colored, often covered with a certain amount of earth. Their hair is short, peppercorn type; noses broad; cheekbones high; eyes somewhat Mongoloid; and external ears without lobes to the pinna. The San are nearly all thin. Most have lumbar lordosis, which was often striking. Many have potbellies, and a few of the women have mild-to-moderate steatopygia. The skin becomes very wrinkled and thickened, with loss of elasticity, from about the age of 45 to 50 years (but certainly not at 25 years as was once represented in the *Reader's Digest*, Ratcliffe 1967, p. 129). This is presumably from excessive exposure to the sunlight and perhaps additionally from squatting round the fire for hours when it is cold.

Medical Conditions Present

Lumbar lordosis and potbellies, often with divarication of the rectus abdominis muscles, are very common. These seem to go to-

gether and to be less common in the few young San living with Bantu pastoralists in the area. Likewise, the most striking steatopygia we noticed was in a woman married to a Herero. We think the potbellies may result from the large amount of indigestible residue and fiber in the bush diet, whereas San living with Herero have regular supplies of milk, meat, and cereals to eat instead of bush food. Chronic bronchitis and emphysema are common and perhaps result from the San's addiction to tobacco. It is, in fact, the tradition that all visitors, whether scientists or administrators, enlist the San's cooperation by giving them handfuls of *shoro,* a strong Rhodesian tobacco that men and women smoke almost universally from about ten years of age.

Tuberculosis appeared to be fairly common. We saw a few San with actual symptoms and signs of pulmonary TB, as well as a number of positive tuberculin Tine tests. Lupus vulgaris was evident, active and healed. Tonsillitis, rheumatic fever, and mitral valve

Three generations roasting, cracking, and eating nuts

disease appeared to be relatively common. Venereal diseases are fairly common in young adults. There was gonorrhea, which responded to penicillin, and there were some positive blood tests for syphillis. Gonococcal infection, clearly a cause of infertility, may have been introduced from the Herero, in whom it is rife.

Although there are no open pools of water at Dobe for most of the year, it became clear to us at our second visit that, in the wet season, malaria is an important infection, producing fevers in children and a few adults and an increase in the percentage of spleens palpable at Dobe from 40 to 53 percent. The pan at Dobe was swarming with mosquitoes at our second visit, and *Plasmodium falciparum* and *P. vivax* have both been found there (H.C. Harpending, personal communication). There appeared to be less malaria at /Xai/xai, where intensive cattle rearing by the resident Bantu has caused the original pan to dry up.

In addition to the inevitable atrophic skin in parts of the body exposed to the sun or fire, some skin infections were seen: occasional impetigo and *witkop*. The latter scalp-fungus infection is much less common than in the southern Kalahari (Murray et al. 1957, p. 657). We also saw a variety of eye problems: purulent conjunctivitis and pingueculae are common, and we suspect that trachoma is present. Joan Hickley, an ophthalmologist, found trachoma among !Kung in the northeast corner of Namibia (Bronte-Stewart et al. 1960, p. 188). Some degree of lens opacity (cataract) is the rule in the older San.

The teeth are very interesting in that they do not show caries or fluorosis but with age become worn down to the gums; the crowns of the teeth are lost and the dentine exposed. Periodontal disease is common, but scurvy was not seen. Our findings are similar to the results of more detailed dental examinations among Central Kalahari San (Van Reenan 1966, p. 703).

In elderly San, Heberden's nodes are evident in the fingers and sometimes mild osteoarthritis elsewhere, for example, in the knees. During heart examinations we sometimes encountered extrasystoles and heard a mild aortic sclerotic murmur (see below).

Bizarre results of old injuries were noted, such as one man whose foot had been pierced by a poisoned arrow and had gone septic. He later amputated his own foot at the ankle and now walks long distances on the light crutches he made for himself. Another man had survived an unarmed fight with a leopard. He is left with a facial paralysis, weakness of the extensor tendon of his bowstring finger, and chronic osteitis of his humerus. But he *had* killed the leopard with his bare hands.

Medical Conditions Absent or Rare

Perhaps of more interest and importance are some of the diseases which were *not* encountered in this isolated group of hunter-gatherers. Obesity was not seen; as a rule there is no middle-aged spread. The one or two women who are plump have moderate steatopygia There is no high blood pressure (see below) or evidence of coronary heart disease (see below).

Of the infections, we could elicit no history or signs of trypanosomiasis. It does occur 100 miles to the east, near the Okavango. Only one man gave a history of hematuria, which suggests bilharzia, but schistosomal infestation is reported to be uncommon throughout the Ovambo and Okavango systems (Geldenhuys et al. 1967, p. 767).

Silberbauer, among others, has pointed out that the San have an unusual system of sanitation. They live about a mile from their water and defecate into the sand some distance from their camp (Silberbauer 1965). The feces, rapidly dried by the sun, are disposed of by dung bettles. Furthermore the San are not crowded and move camp several times a year.

The hunting and gathering San had no alcohol. We found no evidence of cirrhosis though soft palpable livers were common. Gynecomastia (breast development in males) is uncommon, in contrast to its high prevalence in South African Bantu men. We did not see varicose veins, hemorrhoids or hernias, other than traumatic.

Jarvis and van Heerden (1967, p. 63) were struck by the well-preserved hearing of old San. They made audiometric measurements on 10 old Hei//kom San in Namibia and found no loss of hearing. One possible explanation for this is that the San are not exposed to noise in their environment. We also noticed that signs of previous otitis media were very rare. The drums could nearly always be seen; it was surprising how little wax there was in the external auditory meati. We saw only one old perforation.

There was some mild undernutrition, but malnutrition is not evident. This aspect is discussed more fully below.

Injury from interpersonal violence is rare, and suicide does not occur, as far as we could tell. We saw no neurological disease.

Anthropometry

The mean height of 79 men (15–83 years) examined was 160.92 cm (5 ft 3.4 in) with a range from 141 to 175 cms.

The mean height of 74 women (15–75 years) was 150.14 cm

(4 ft 11 in) with a range from 139.5 to 159 cms. To take into account that people aged 15–20 may not have reached their final height and to see if younger or older adults were taller, the population analyzed in Table 8.1 is subdivided into three age groups.

Tobias (1962a, p. 801) reviewed the measurements of San stature that have been recorded from the late 19th century to the 1950s. The average height of northern San males in the early studies was 156.97 cm, and in the 1950s it had reached 159.65 cm. These values are less than the average in our survey of 160.92 cm (for ages 15 years and older).

For northern San females the corresponding values are 148.5 cm in early studies, 149.93 in the 1950s, and 150.14 cm in the present study. Tobias suggested that these secular changes were not the result of examiners' selection but could be attributed to better nutrition and generally improved environmental circumstances.

Tobias has also suggested (1970, p. 101) that adverse nutritional and other environmental circumstances have less effect on the height of females than of males: the harder the environment, the closer the female to the male height. From the early studies to the present, the difference between female and male heights expressed as a percentage of male height has moved up from 5.4 percent in the earlier studies to 6.7 percent in our present study. The modal percent sex dimorphism is 7 to 8 percent in European populations.

In the present study the younger generation of adult San are 2.3 cm (nearly one inch) taller than men over forty. Part of this difference may result from loss of vertebral and intervertebral thickness and kyphosis (spinal curvature) with increasing age (Khosla and Lowe 1968, p. 742), but the difference between the generations in the men is greater than in the women. It therefore seems likely that our data show a continuation of the secular increase in San heights.

The average weight of the 79 San males was 47.91 kg (105.6 lbs). The women's weights averaged 40.08 kg (88.38 lbs). These are unclothed weights. Most women were weighed in a light kaross or underskirt, but an average figure for the same size and weight of garment was subtracted.

Table 8.1. Mean heights in cm (and number of subjects)

	15–20 years	21–40 years	41 years and older
Men	151.38	162.75	160.43
(79)	(4)	(33)	(42)
Women	150.06	150.93	149.50
(74)	(8)	(30)	(36)

At the height of the average San, the "desirable" weight in the US for small-framed men is 53.5–57.2 kg (118–126 lbs) (Diem 1962, pp. 623–624). The corresponding desirable weights for small-framed women 150 cm tall (without shoes) are 44.9–48.5 kg (99–107 lbs). Unfortunately the desirable weights are quoted for people wearing indoor clothes, which might weigh up to 4.0 kg for men or 2.5 kg for women. But even if these are subtracted, the desirable weights remain larger than the San weights.

In Table 8.2, the weight/height ratios (metric) of the San are shown for the different decades together with ratios calculated from "average" US weights (Diem 1962). All San values were relatively low, and there was little change with age except below 20 and over 69 years. For additional comparison, the weight/height index of young US men in the Minnesota experiment (Keys et al. 1950, p. 146) was 38.8, and it fell to 29.5 in the same men after 6 months' semi-starvation with loss of 25 percent of their body weight. The average weight/height ratio of Olympic long-distance runners (5,000 and 10,000 m; Tanner 1964), despite their very thin skinfolds, works out to 34.8.

The skinfold thicknesses measured with Harpenden calipers in San over age 20 are shown in Table 8.3. All these measurements were made in 1968 after the rainy season. (Measurements were lower in October 1967). These are low values, for example, compared with the oldest age (16½ years) in the only percentile charts we have seen for skinfolds (Tanner and Whitehouse 1962, p. 446). San male triceps skinfolds are on the 10th percentile and subscapular on the 25th percentile, while the San women's measurements are on the 10th and 3rd percentiles respectively. The FAO Committee on Calorie Requirements (FAO 1957) considered that average triceps

Table 8.2. Mean weight/height ratios: 100 × weight (kg) ÷ height (cm): San compared with ratios calculated from average US weights

	Age (years)						
	15–19	20–29	30–39	40–49	50–59	60–69	70–83
SAN							
Men	24.2	30.0	30.4	31.1	28.8	30.2	24.2
Women	24.0	27.5	26.4	27.0	27.1	26.1	24.7
AVERAGE US[a]							
Men[b]	34.0	38.7	40.4	41.3	41.6	40.7	–
Women[b]	31.6	33.4	36.0	38.1	38.9	39.3	–

[a]From Diem 1962, pp. 623–624.
[b]Calculated for men in shoes (1-in heel) 5 ft 4 in and women in shoes (2-in heel) 5 ft 1 in.

skinfolds in men of less than 5.0 mm would indicate definite undernutrition.

In an attempt to obtain some simple index of the degree of steatopygia, we made three circumferential measurements in a sample of Dobe women: bust, waist, and hips. We had difficulties doing this for the reasons that most women's breasts are very dependent, their waists are not well-defined because of potbellies, and they are very modest about having their hips measured. The results (Table 8.4) show that most San women have smaller hip circumference than the British average (Thomson, personal communication, 1969), but proportionately they have more of their subcutaneous fat on their hips than on the upper parts of their bodies. The very low subscapular skinfold thicknesses in San women (Table 8.3) are another reflection of the distribution of fat.

The mean mid-arm circumference was 22.9 cm in 39 men aged 20–69 and 20.8 cm in 29 women of the same age range. Arm circumference measurements were smaller in the pretwenty and postseventy age groups. Between these two limits, arm circumference did not change with age. Standard arm circumferences (age 17) given by Jelliffe are 26.8 cm for males and 24.9 cm for females (Jelliffe 1966).

Pediatric Analyses

The children are born well spaced. Families had 0 to 4 children and larger numbers were uncommon. Childbearing is said to be easy as a rule. All children are breast-fed for a long time. The baby is carried on the mother's back in her kaross all day as she walks, works, or squats. Babies are completely covered from the sun for the first few months, and in three such infants we detected craniotabes, the first sign of rickets. Once the babies are exposed to the sun, the rickets disappears.

As they grow up the lives of the children are strikingly different from those of children who have to go to school. The San parents do not give their children formal training or lay down rules. For

Table 8.3. Skinfold thickness (mm) in adults (over 20 years); mean (and range)

	Midtriceps	Subscapular
Men (n = 37)	5.01 (3.1 to 9.0)	6.64 (4.5 to 10.1)
Women (n = 34)	9.42 (3.2 to 17.3)	6.61 (4.1 to 15.4)

example, young children are not told when they should go to sleep; they wander round between the adults at night until they are tired. Boys do not accompany their fathers on hunting expeditions until they are grown up. Children of even 10–15 years have no duties which they have to perform for the community.

Young children frequently have mild respiratory, skin and eye infections. Gastroenteritis is uncommon. We think this is because all the infants are breast-fed. We saw only one case of mild protein-calorie malnutrition. This was a baby about twelve months old who appeared to have been suffering from malaria. In seven blood samples from children taken at Dobe in 1967 the mean serum albumin was a 3.73 g per 100 ml, γ-globulin 1.52 g per 100 ml and vitamin A 90 μg per 100 ml.

Nevertheless H.C. Harpending and N. Howell have found from taking detailed family histories that there is considerable childhood mortality which is not apparent at first when one spends a short time with one or two bands of San. Pneumonia and malaria would appear to be more important causes in this community than gastro-enteritis and malnutrition, and from time to time in the past there seem to have been epidemics of smallpox and measles.

Growth

The Harvard growth curves have been used for comparative purposes. The word "standard" represents the 50th percentile of weight or height. The weight and height data of children of various age groupings are shown in Figure 8.1 and Table 8.5. Of twelve infants from birth to one year the majority (50–60 percent) are within the normal range for weight and height; the boys in this small sample appear to be somewhat bigger than the girls.

From 1 to 5 years it can be seen that most children drop below the 3rd percentile in weight and height. From 6 to 12 years this

Table 8.4. San women's dressmaker measurements (in)

	Bust (b)	Waist	Hips (h)	Ratio $\frac{h}{b}$
SAN WOMEN				
Average (of 17)	30.4	27.7	34.7	1.15
3 fattest (mean)	31.7	29.4	39.0	1.24
3 aged 15 or 16 years (mean)	29.4	26.6	31.8	1.08
BRITISH WOMEN (mean)[a]	35.2	25.2	37.5	1.06

[a]From A.M. Thomson, personal communication (1969).

tendency is aggravated, the average weight being only 63 percent of standard.

During the adolescent years, ages 13–19, weight and height remain at a low level compatible with the adult weight and height. Mean weight for height drops from 98 percent in the first year to 87 percent in the age group 6–12 years. After this there is a slight improvement.

In summary, the growth data show that San infants, while on the

Figure 8.1. Weights and heights of San boys and girls plotted in the 97th, 50th, and 3rd percentile lines for Boston children

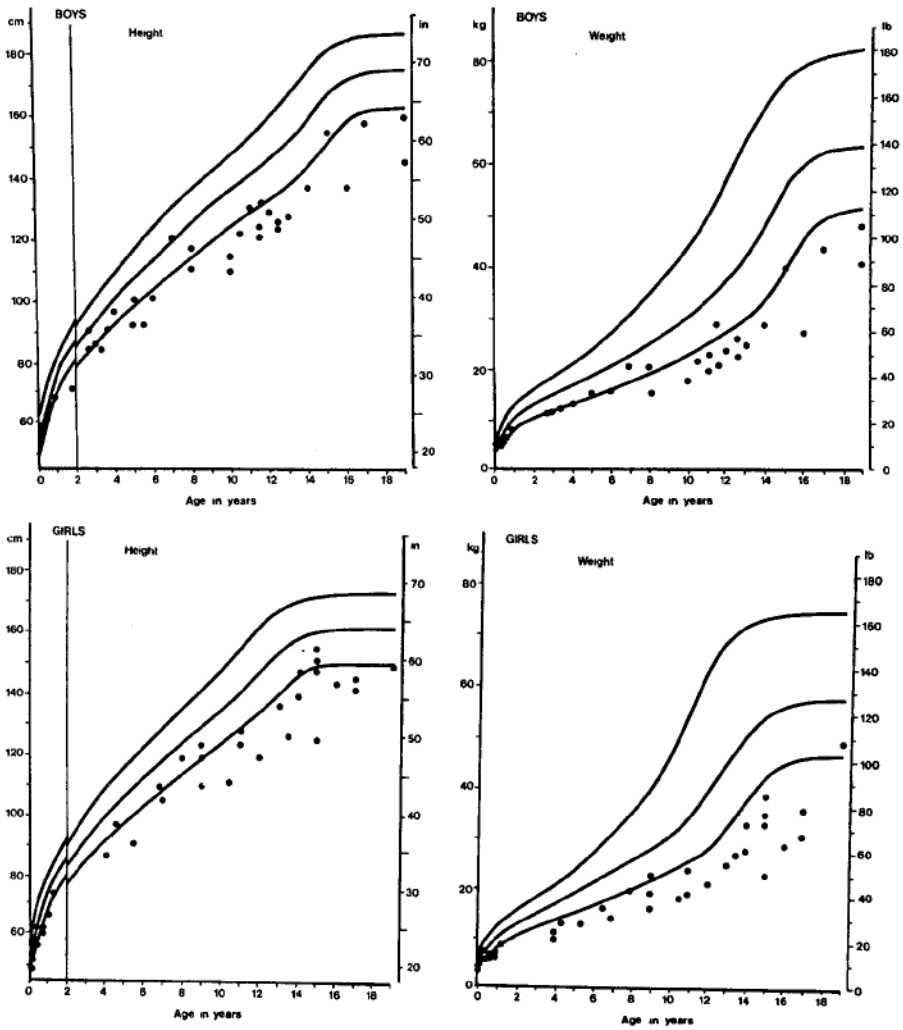


Table 8.5. Children's weights, heights, and head circumferences

Age and sex	No.	WEIGHT below 3rd percentile	Average % of standard weight	HEIGHT below 3rd percentile	Average % of standard height	Mean weight for height, % of standard[a]	Head circumference below 3rd percentile
0–1 year							
Boys	4	0	95.3 ± 6.0	1	93.8 ± 4.0	99	1/4
Girls	8	5	80.1 ± 14.0	6	90.5 ± 4.9	98	0/5
Total:	12	5 (40%)		7 (50%)		98.6	
1–5 years							
Boys	9	3	81.6 ± 6.8	7	90.7 ± 4.5	95	0/9
Girls	6	6	66.8 ± 6.9	5	89.2 ± 9.4	85	0/6
Total:	15	9 (60%)		12 (80%)		91	
6–12 years							
Boys	14	10	62.8 ± 9.9	13	86.1 ± 5.0	88	1/4
Girls	10	8	63.9 ± 11.4	6	86.9 ± 5.8	85	4/10
Total:	24	18 (75%)		19 (79%)		87	
13–19 years							
Boys	7	6	63.6 ± 10.0	6	86.4 ± 5.1	95	2/7
Girls	12	11	62.0 ± 11.6	9	89.0 ± 5.4	88	3/10
Total:	19	17 (89%)		15 (79%)		91	

[a]See Jelliffe (1966).

breast, compare favorably with western infants. However, after weaning, this growth is not maintained; and there is moderate growth retardation persisting to adult life. The low weight for height and thin skinfolds (Figure 8.2) with normal serum albumins suggest an energy (calorie) deficit throughout the growing period which could reasonably account for eventual short stature in adults. During the wet season the skinfolds increased somewhat (Figure 8.2), and growth increment over a six-month period was comparable to the Harvard average.

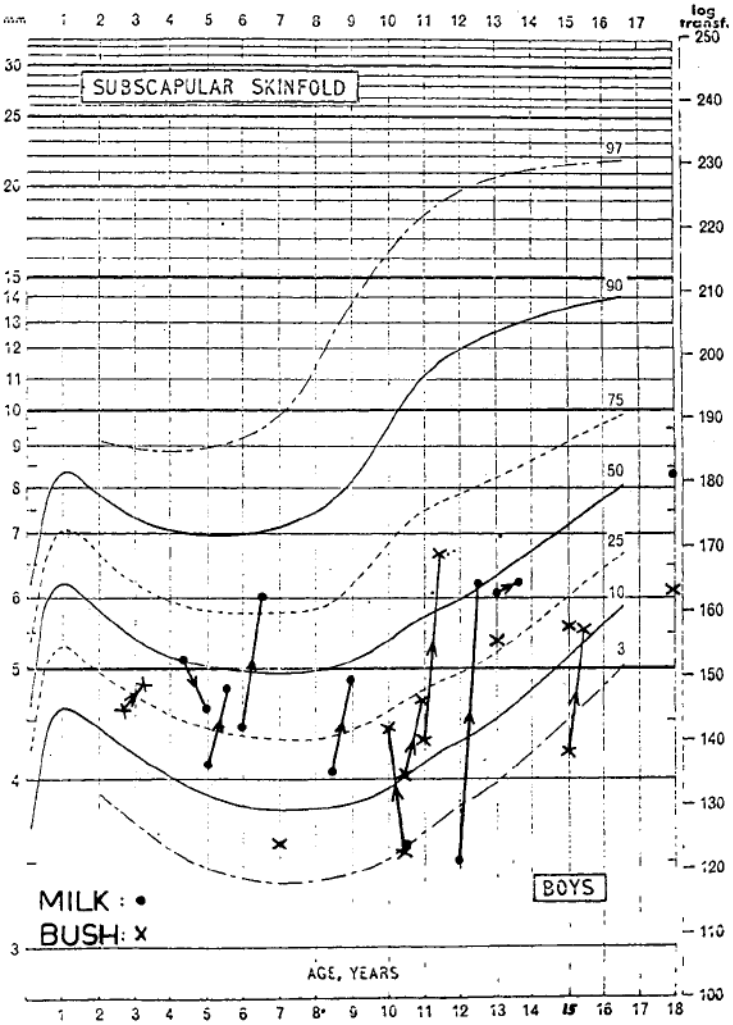
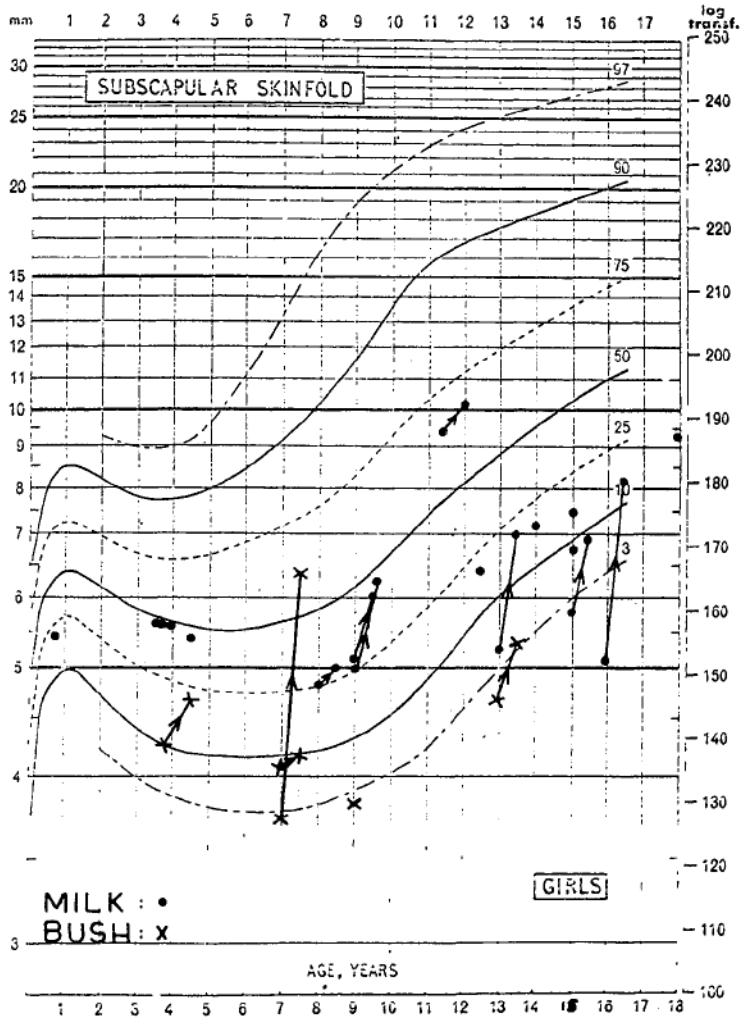


Figure 8.2. Subscapular skinfolds of San boys and girls in October 1967 (dry season) and April–May 1968 (wet season). For each child the two measurements (6 months apart) are joined by a line; the arrow indicates the direction of change from dry to wet season. The percentile lines on the charts are Tanner's for healthy British children. Note that most of the children's skinfolds are below the British 50th percentile and that skinfold thickness usually increased after the rains.



Head circumference is within the normal western range for most children but 17 percent (mostly older girls) are just below the 3rd percentile.

Puberty

Breast development starts in girls at about thirteen years; the menarche occurs late, at about fifteen years. At this stage the girls show the areolar hypertrophy of their breasts, illustrated in E.M. Thomas's book (1959).

Biochemical Measurements in Sera and 24-Hour Urines

The San's sera (Table 8.6) show slightly low albumins and increased γ-globulins; serum lipids are all very low, particularly the cholesterol. While vitamin A concentrations are above the average, carotenoids are rather low (ICNND 1963). Urates and electrolytes appear to be normal.

The 24-hour urines (Table 8.7) needed much care and explanation to obtain, and the question will naturally arise whether the collections were complete. For example, one of the subjects in 1967 took his foldable, plastic, urine-collecting containers with him when he went out hunting for the day! It will be noticed that creatinine

Table 8.6. Mean biochemical concentrations in adult sera

	SAN			
SERUM	1967	1968	1969	CONTROLS
Total proteins, g/100 ml	7.37			
Albumin (chemical), g/100 ml	3.48	3.88	3.84	4.97[a]
Albumin (electrophoresis), g/100 ml	3.73			
γ-globulin (electrophoresis), g/100 ml	2.10			
Cholesterol, mg/100 ml	119	110	128	202[a]
Triglycerides, mg/100 ml		111	91	
Phospholipids, mg/100 ml		130	159	193[a]
Carotenoids, μg/100 ml	15	26		87[a]
Vitamin A, μg/100 ml	101	53		71[a]
Urate, mg/100 ml	3.78 (males)			6.30 (males)
Sodium, mEq/L		139		152[a]
Chloride, mEq/L		100		99[a]
Potassium, mEq/L	4.26			

[a]Controls: one or two sera from the authors collected in the field. They do not therefore show the range but rather serve as a check that there was little or no loss of the substance in the San samples.

excretions (an indication of muscle mass) are lower in the San than in the controls. However, the San are smaller and weigh less than the controls. When creatinines are expressed per kg body weight, the San's come to 83 percent of the controls in 1967 and 86 percent in 1968, indicating that collection was almost complete for the group. While urinary nitrogens and potassium are the same or even higher in the San's urine than in the controls, the San excrete far less sodium, chloride, and phosphate.

Because we could not carry strong mineral acid with us in the airplane, we added iodine in 1967 and oxalic acid in 1968 to help preserve aliquots of urine while we carried them in a coolbox back to our laboratory. On both occasions the control urines were treated in exactly the same way.

Special Topics

Blood Pressures

The mean blood pressures of 152 San, measured under standard conditions with a mercury sphygmomanometer, are shown in Table 8.8. The methods are described in detail by Truswell and colleagues, 1972, page 5. The San mean blood pressures by decade are compared

Table 8.7. 24-hour urines from San adults at Dobe compared with controls collected at the same time (amounts excreted per day)

	SAN		CONTROLS[b]	
	1967	1968	1967	1968
Number of subjects	6	4[a]	2	3
Volume (ml)	873	1342	890	1367
Specific gravity	1.017	1.013	1.022	1.017
Creatinine (g)	0.84	0.98	1.36	1.42
Nitrogen (g)	10.4	10.6	8.7	11.4
Sodium (mEq)	31	29	212	147
Chloride (mEq)	30	36	173	121
Potassium (mEq)	70	103	68	61
Magnesium (mEq)	7.4		3.2	
Calcium (mg)	104		99	
Phosphate (mg)	157		737	
Osmolality (mOsm)	968		963	
N'methylnicotinamide (mg)	2.2		3.2	
Copper (μg)		99		98
Zinc (μg)		654		619
17-ketosteroids (mg)	4.8		9.6	
17-ketogenic steroids (mg)	3.8		7.8	

[a]The 4 subjects who provided samples in 1968 had been among the 6 subjects who gave urine samples in 1967.

[b]Collected at Dobe under the same conditions as San samples.

with London pressures (Hamilton et al. 1954, p. 11), which are typical of any developed community. Mean blood pressures do not rise with age in the San, and we did not find anyone with hypertension. This is very unusual: in most societies one would expect to find diastolic blood pressures over 110 mm Hg in about 5 percent of men 50–60 years, 8 percent over 60 years, and in 8 percent and 11 percent of women at corresponding ages (Ask-Upmark 1967). None of the San had mean diastolic pressures over 110 mm Hg. Kaminer and Lutz (1960, p. 289) found a similar absence of high blood pressure in Central Kalahari San in 1958, even though they did not have the good age estimates which we had in the present study. We have been able to find reports of only about a dozen communities whose mean blood pressures do not increase as they get older (Truswell et al. 1972, p.5). They are nearly all very isolated groups of people with simple technology.

In our full report on the San's blood pressures (Truswell et al. 1972, p. 5), we considered why they should be free of hypertension. First, they are living on a low salt regime. Their urinary sodiums and chlorides (Table 8.7) are very low and correspond to NaCl intakes around 2.0 grams per day. There is no salt available to the San at Dobe; the nearest source is 35 miles away at the South West Africa Administration's Bushman Settlement at Chum!kwe. A very low salt diet will cure high blood pressure: it would seem likely that a low salt diet will prevent it. Secondly, the San are thin—not only their arm circumferences, where blood pressures are measured by the indirect sphygmomanometric method, but their bodies as a whole. It is known that increased adiposity is correlated with increased blood pressure (Kannel et al. 1967, p. 48). The San do not have the increased adiposity seen in middle age in developed countries. Yet thinness cannot be the sole explanation because hypertension is sometimes seen in thin people. The third possible explanation for the San's freedom from high blood pressure is freedom from mental stress. We are not enthusiastic about this explanation. Living on a Hebridean island or on the edge of the primeval forest in the Congo

Table 8.8. Mean blood pressure of San in different age groups compared with London measurements by Hamilton et al. (1954). Men and women combined: systolic/diastolic

	15–19	20–29	30–39	40–49	50–59	60–69	70–83
San	117/74	119/74	117/74	116/75	121/75	122/70	120/67
London	117/70	122/74	124/77	132/80	145/87	160/90	168/90

does not protect against hypertension (Hawthorne et al. 1969, p. 651; Miller et al. 1962, p. 432). Furthermore it is notoriously difficult to quantify mental stress.

Heart Disease

Clearly the San are not troubled by hypertensive heart disease, the second most common type (Wood 1956). Nor did we find clinical evidence of coronary heart disease, the commonest type in industrial countries. In taking histories we did not find anyone who was subject to angina pectoris or who had heard of sudden death. Any chest pains we encountered were unilateral, probably related to pneumonia or originating in the chest wall. We saw no one with arterial disease of the legs.

In our examinations in 1967 and 1968 we found three cases of mitral valve disease, doubtless of rheumatic and streptococcal origin. Extrasystoles were encountered in three people over the age of 50 years. Six old people (58–72) had mild to moderate aortic ejection murmurs. We noted some degree of emphysema associated with chronic bronchitis in six San, all but one over the age of 60 years. Only one showed heart failure, a child of four who appeared to have active rheumatic fever. The other people with mitral murmurs, all those with aortic murmurs, and those with extrasystoles were asymptomatic. A minority with emphysema complained of shortness of breath on exertion; more of them complained of cough or unilateral chest pains.

Rheumatic heart disease and emphysema are certainly present among the San and appear to be relatively frequent. The aortic ejection murmurs heard in elderly people are not associated with signs of valve narrowing and we think they are caused by either aortic valve roughening or dilation of the aorta with age. This appeared to be a fairly benign condition. Systolic murmurs like this are common in the aged (Editorial 1968b, p. 530).

On the third medical visit, Dr. Kennelly confirmed the foregoing observations and found more subtle, innocent cardiac murmurs in some young adults. One man appeared to have had cardiomyopathy or myocarditis.

The main purpose of the third visit was to record electrocardiograms (ECGs) of the San. Nothing has been published before on this aspect. We were interested first to see if we could detect ECG evidence of silent coronary disease and secondly to see whether their ECGs showed any unusual features. Ninety-seven resting ECGs were recorded in clinically normal adults; some of the adults were

retested after sprinting in the soft sand. We found no indication of coronary disease; no case of T wave inversion or flattening over the left ventricle was seen, and Q waves were absent (Kennelly, Truswell, and Schrire 1972, pp. 1093–1097).

However, the ECGs show a number of differences from the usual Caucasian patterns. The patterns resemble those which have been previously found in a percentage of apparently normal African and black U.S. subjects (Walker and Walker 1969, p. 441).

(1) 21 subjects (16 men) had high voltage in precordial leads. This might perhaps be explicable by thin chest walls.

(2) ST-segment elevation in precordial leads is seen in more of the San than in any other reported study of normals (Kennelly, Truswell, and Schrire, 1972). It is twice as common in males, occurring in mild degree in 89 percent. Elevated ST-segments usually become isoelectric after exercise.

(3) In a smaller proportion, more often women, T wave inversion is seen over the right ventricle. The cause of these two patterns is not clear, but they do not seem to have adverse prognostic significance (Walker and Walker 1969, p. 441).

Serum Lipids

Serum cholesterols were found to be very low. Many international surveys have shown that there is a negative correlation of serum cholesterol with the frequency of coronary heart disease both between populations (Keys 1970) and within populations (Kannel et al. 1971, p. 1). The Japanese and the Bantu, well known to have little coronary disease, have serum cholesterols averaging around 170 mg per 100 ml (Bronte-Stewart et al. 1955, p. 1103; Keys et al. 1958, p. 83). The San's serum cholesterols (Table 8.6) are about 50 mg per 100 ml lower again, which makes them one of the populations with the lowest serum cholesterols in the world. This alone might be a sufficient explanation for their apparent freedom from coronary disease.

The serum phospholipids are low, though not as far below western values as the cholesterols. The San were not always necessarily fasting when their blood samples were taken. If they had had a little to eat, it would not have affected their cholesterol or phospholipid concentrations but could have increased triglycerides. Despite this, their triglycerides were low as well. Our cholesterol values agree closely with the mean of 121 mg per 100 ml reported by Bersohn and Tobias in Central Kalahari San (Tobias 1966, p. 190). Miller and his associates have reported even lower serum lipids in a small number of

Central Kalahari San (Miller, Rubenstein, and Astrand 1968, p. 414; Editorial 1968a, p. 315); however their methodology was somewhat unorthodox.

We found that serum cholesterols show no significant variation with age or sex. They were a little higher in those who were getting some milk from Hereros in the district (Truswell and Hansen 1968b, p. 684) and in three pregnant women examined in 1969.

The very low cholesterols in the San can be explained largely by their diet which is very low in saturated fat and rich in polyunsaturated fat. Their major source is mongongo nuts (*Ricinodendron rautanenii*), which contain 57 percent fat. (Wehmeyer, Lee, and Whiting 1969, p. 1529). On gas chromatography (Engelter and Wehmeyer 1970, p. 25) this contains only a trace of myristic (14:0) and 10 percent of palmitic acid (16:0), but there is 43 percent linoleic acid (18:2) and 22 percent of a very late peak on gas chromatography which is probably α-eleostearic acid (Chisholm and Hopkins 1966, p. 390), a conjugated 18:3 fatty acid. The high ratio of 18:2 to 14:0 + 16:0 fatty acids should produce low serum cholesterols (Hegsted et al. 1965, p. 281). There is apparently no information on the nutritional effect of α-eleostearic acid; but since it is polyunsaturated, a cholesterol-lowering effect would be expected.

The other major source of dietary fat for the San is the meat of wild animals obtained by hunting. Although the meat and fat of farm animals in developed countries is very saturated, wild game in Africa have much less fat on and between the meat fibers, and the fat is less saturated and contains appreciable amounts of polyunsaturated fatty acids (Crawford 1968, p. 1329; 1969 p. 1419).

Our measurements of serum triglyceride fatty acids (Table 8.9) reflect the San's dietary intake of fatty acids. They show low proportions of the saturated fatty acids myristic (14:0) and palmitic (16:0), but high lionleic (18:2) and arachidonic (20:4) acids together with an acid, "x" which we were not able to identify completely. It is an 18:3 isomer and might therefore be derived from

Table 8.9. Mean percentage of fatty acids in fasting serum triglycerides

	Fatty acid									
	12:0	14:0	16:0	16:1	18:0	18:1	18:2	"x"[b]	20:1	20:4
San	2.0	1.0	25.1	2.6	6.1	34.2	25.9	1.8	0.7	0.5
Controls[a]	0.7	3.6	34.5	6.7	4.8	40.4	9.3	–	–	tr

[a]Controls were white office workers (35–55 years old) in Cape Town.
[b]"x" is an unsaturated 18 carbon fatty acid, probably an isomer of linolenic (18:3).

α-eleostearic acid, the unusual fatty acid in mongongo nuts. It is not present in the serum triglycerides of other population groups in southern Africa (Truswell and Mann 1972, p. 15), except for the Ovambos of northern Namibia (Watermeyer et al. 1972, p. 1390) in smaller concentration. They eat moderate amounts of mongongo nuts.

An additional factor probably helps to determine the San's low serum cholesterols. Although large amounts of exercise have little effect, repeated *prolonged* exercise *does* lower serum cholesterol (Gsell and Mayer 1962, p. 471). There is no reason to postulate that the unusual feedback mechanism which may keep Masai serum cholesterols low (Bliss et al. 1971, p. 694) is important in San. Unlike the Masai the San eat very little saturated fat. The low triglyceride concentrations seen in the San can be attributed to their low carbohydrate diets (Mann et al. 1970, p. 870) and lack of adiposity (Albrink, Meigs, and Granoff 1962, p. 484).

Hematology

During the clinical examinations we checked hemoglobin concentrations in anyone who appeared to have pale mucous membranes. We found no one with anemia except a baby with malaria. We assessed that the San's iron and vitamin B_{12} intake was adequate because of their regular consumption of meat and that they should be receiving adequate folate from liver and green leaves.

A more detailed examination of the San hematological status was carried out by Metz and Hart in collaboration with H.C. Harpending (1971) during a visit in late September 1969 to Dobe, Mahopa, and as far south as ≠To//gana. The first point of importance is that hookworm *Necator americanus* ova were found in 3 out of 18 fecal samples. If hookworm infestation is heavy, it can cause chronic occult blood loss from the bowel and lead to iron deficiency. Forty percent of the San showed mild eosinophilia, suggesting infestation with this or other helminth parasites.

However, the San are very rarely anemic. Only one out of 38 males had a hemoglobin under 13 g per 100 ml and only one out of 113 nonpregnant females had a hemoglobin below 11.5 per 100 ml. Serum iron concentrations averaged 117 μg in men and 97 μg per 100 ml in nonpregnant women. They ranged from 20 to 224 μg per 100 ml. Only 16 in all had serum irons below 70 μg per 100 ml and only 6 (5 women) had subnormal transferrin saturation. Metz and his colleagues pointed out that the Bantu iron cooking pots, which many San have adopted, are an important source of dietary iron.

There is a low incidence of folate deficiency. Only 8 percent of men and 3 percent of women neither pregnant nor lactating had serum folate concentrations below 3 ng/ml. Of 9 pregnant women 2 had low serum folates; another one had low transferrin saturation, but all the pregnant women had hemoglobins of at least 11 g per 100 ml.

The San's vitamin B_{12} concentrations averaged 650 pg/ml. They were all above the lower limit of normal for other populations, and in some subjects they were elevated, ranging to over 1,500 pg per ml. Vitamin B_{12} binding serum proteins were increased, however. It is therefore difficult to be sure whether the serum vitamin B_{12} levels result from this or from good dietary intakes or both. Vitamin B_{12} binding proteins increase in liver disease; but when they do, only the α-binding proteins are increased. In the San both α- and β-vitamin B_{12} binding proteins are elevated. Increased vitamin B_{12} binding proteins have been reported in other non-Caucasian people in Africa, such as Bantu and Cape Coloreds.

Glucose Tolerance Tests

In October 1970 Joffe's party visited Dobe and carried out oral glucose tolerance tests on 15 San (8 men, 7 women). They reported that plasma glucose concentrations were a little higher than in white controls in Cape Town (Joffe et al. 1971). Plasma growth hormone concentrations were not significantly different from controls and were promptly suppressed by glucose. Plasma insulins were low. Serum albumins were normal (averaging 3.7 g per 100 ml).

These results certainly do not indicate that the San have diabetes. The deviations are well within the normal, nondiabetic range (Jackson 1964). Joffe and associates compared their results to similar findings in central African pygmies. However, we find it difficult to draw any conclusions from this work, which fell into a number of methodological pitfalls. Their controls, unlike ours, did not have their tests done and samples collected in the field and carried back to the laboratory under the same conditions. The investigators measured the San's glucose tolerance tests in the afternoon, an unconventional time. Although their 10 control subjects also had afternoon tests, the latter did not have morning tests. Jarrett's group has now clearly shown that plasma glucose is higher and insulin lower in afternoon glucose tolerance tests, compared with the standard morning test (Jarrett et al. 1972, p. 199).

Joffe's group does not appear to have matched the ages of its subjects to those of the controls; plasma glucose levels increase with

age. In addition the San were given relatively large doses of glucose because they were not adjusted for body weight. Lastly the study assumed that the San had been eating a high carbohydrate diet for the week before the tests, which seems rather improbable.

Lactose Tolerance Tests

Jenkins and colleagues (1974) did oral lactose tolerance tests on 40 adult bushmen at Tsum!kwe in Namibia. Only one subject absorbed well; in other words 97 percent were lactose intolerant. With a sample this size, this figure is not distinguishable from around 90 percent of Bantu who have adult lactase deficiency (Jersky and Kinsley, 1967; Cook 1973). Indeed adults of most populations in the world have lactase deficiency. Adult lactase *persistence* is the exception, occurring only in northern Europeans and Hamitic Africans.

The San do not drink milk but intestinal lactase is not an inducible enzyme. Jenkins and colleagues thought that special caution would be needed if the San were to be offered milk or milk powder. In fact none of the San tested by the Jenkins group had any adverse symptoms following 50g of lactose used for the test meal, which corresponds to the lactose in over a liter of milk, consumed rapidly. In adult lactase deficiency milk tolerance is unusual with ordinary intakes of milk (Pettifor and Hansen, 1974) presumably because there are still low activities of brush border lactase, unlike congenital lactase deficiency in which this enzyme is virtually absent.

Seasonal Changes in Nutritional Status

Thirty-three adults (over 20 years), 17 girls and 13 boys were examined at Dobe first at the end of the dry season when food and water were scarce in October 1967. The same individuals were re-examined in the same way and by the same examiners after the wet season in April–May 1968. Some of the changes in the *adults* are summarized in Table 8.10. Skinfold thickness and serum albumin increased despite evidence that malaria had been prevalent. In April 1968 spleens were palpable in 16 as aginst 12 people in the previous dry season and where a spleen had been palpable in 1967, it tended to be larger after the rains.

In the *children* mean weights and heights increased during the 6 months in almost all, no doubt because of growth. We have nothing to compare the growth rate against in these individuals. It is not very helpful to group children of different ages but the mean gain of

height was substantial, 2.7 cms in girls under 15 years and 3.0 cms in the boys. In 5 San who had finished growing there was no change in height which indicates that the change was not methodological. Skinfold thickness (the sum of measurements at 3 sites, mid-triceps, subscapular and abdominal) increased in 16 and decreased in 9 of the boys and girls combined (see Figure 8.2).

In summary the Bushmen had more varied food to eat in April 1968. Our measurements indicate that the adults were fatter. The children had been growing satisfactorily and most were fatter.

Nutrition—Energy or Calories

We have paid particular attention to the question, Are the San adequately nourished? They *are* thin. Are they too thin? Is there evidence that they suffer in any way because they do not get or do not eat enough food? In the section on Anthropometry we have described the San as very thin by all the standards of developed countries. Hammel (1964, p. 413) states that they have one of the lowest adiposity coefficients in the world. Tobias considers them undernourished: "The Bushmen have probably improved but slightly from an extremely poor nutritional state to a still poor one" (Tobias 1971, p. 27). "It has long been known that, under conditions of better nourishment, Bushmen grow taller than otherwise" (Tobias 1962). De Almeida wrote about the San in nearby southern Angola that they "are a clear case of semi-starvation" (de Almeida 1965, p. 5). Birch and Gussow have concluded that there is a growing body

Table 8.10. Changes in adult San (over 20 years) October 1967 to April/May 1968[a]

Measurement	n	October 1967	April/May 1968	Change	P (Wilcoxon)
Weight (kg)	28	43.74	43.99	+0.26	NS
Subscapular[b] skinfold (mm)	33	6.41	7.51	+1.10	0.001
Spleen (mean number of fingers enlarged)	33	0.42	0.76	+0.34	NS
Serum albumin (G/100 ml)	8	3.51	4.03	+0.52	< 0.01
Serum cholesterol (mg/100 ml)	13	120.8	119.6	-1.2	NS

[a]Only people older than 20 years are included because those between 15 and 20 may have grown in the interval.

[b]Triceps skinfolds not shown because the measurement site was changed for some of the subjects between the 2 visits.

of evidence "that among groups who are endemically short, increase in stature follows an improvement in economic status, and that the shortness of such groups under their original environmental conditions arises not from 'short genes' but from social and environmental inadequacies" (1970, p. 113).

Richard Lee has disagreed (Lee 1969c, p. 47) with our provisional view that "chronic or seasonal calorie insufficiency may be a major reason why San do not reach the same adult stature as most other people" (Truswell and Hansen 1968a). One of Lee's points was that in July 1964 he estimated the nutrients available to one group at 2140 calories and 93 grams of protein for each man, woman, and child. But that was in July when, though food is not abundant, the minimum has not been reached. Between August and October, water is most limited and food most scarce. Elsewhere, Lee has written that "the San must resort to increasingly arduous tactics in order to maintain a good diet, or, alternatively they must content themselves with foods of less desirability in terms of abundance, ease of collecting, or nutritive value. It is during the three lean months of the year that the San life approaches the precarious conditions that have come to be associated with the hunting and gathering way of life" (Lee 1965). In these lean months, the foods eaten are mostly roots and bulbs, which would be expected generally to contain much water but to have low caloric density.

L. Marshall (1968, p. 94) has commented:

> It has been suggested that because they [the !Kung] do not have to work every day they can be said to have an "affluent society." This is a *bon mot* but does not add to the understanding of the reasons. . . . The !Kung we worked with are all very thin and . . . constantly expressed concern and anxiety about food. There must be reasons why they do not gather and eat more. I think energy for digging and the daylight hours come to an end for one thing. It has been suggested that they cannot eat more roots, berries, and seeds than they do, because the roughage is too much. Also, I believe we might look more into a possible social reason. If a woman gathered very much more than her family needed at a given time would it turn out that she was working for others?

As Lee himself showed, San who had obtained extra food from Hereros while they were growing were taller than average (1969c, p. 47).

After much analysis and discussion, our own view is that the San

eat considerably less for their energy output than western, industrialized people, particularly during the three dry months, August to October. They have, in consequence, thin layers of subcutaneous fat, which are an advantage when walking long distances in the sand in the prevailing hot weather. On the other hand thinness is a disadvantage in the cold winter nights (Wyndham et al. 1964, p. 868). Another consequence of the relatively small energy intakes during childhood in those living entirely on bush foods is that final stature is less than their maximum genetic potential. We do not know the maximum height of which the San are capable, but the tallest man we examined was 175 cm (5 ft 9 in) tall. Insufficient energy (calorie) intake is not, we believe, the only influence which prevents the San from reaching their maximal potential height. Malaria and other infections could also have some growth-retarding effect (McGregor, Billewicz, and Thomson 1961, p. 1). Even the early age when they start tobacco smoking might have an effect. The relatively short stature of the San is not a bad thing in itself, and by keeping the Kalahari San light it has considerable advantages in their environment. However, we do not consider that the available evidence entitles us to say that their small size is mainly determined genetically.

Qualitative Nutrition

Having considered overall energy intake, we are left with the question whether the San are qualitatively malnourished: is their diet lacking in any essential nutrient, and/or do they show clinical or biochemical signs of specific nutritional deficiency? We will discuss the important specific nutrients one by one.

Protein. Meat from animals, mongongo nuts, and *Bauhinia esculenta* are rich in protein (Wehmeyer, Lee, and Whiting 1969). Babies and young children receive breast milk for their first three years of life or more. We saw no child with kwashiorkor, and the San did not seem to know of such a disease. Edema was not seen in adults either. Serum albumins were within normal limits except in people who had an illness or a problem with obtaining food at the time we took blood. In a small sample (Table 8.10) mean serum albumins were lower in the dry season. Urine nitrogens (Table 8.7) were as high as in controls. Plasma aminoacid patterns were within normal limits (Table 8.11) except in a girl of eight years who was thin and said her father had not been able to hunt recently because he had been ill. However, a plasma aminoacid pattern reflects fairly recent protein intake (Saunders et al. 1967, p. 795), and this girl did have a normal

serum albumin of 3.95 grams per 100 ml. Upon comparison of our plasma aminoacids in San with findings reported in Babinga adult pygmies (Paolucci et al. 1969, p. 1652, and 1973, p. 429), both showed no signs of protein deficiency, though there were some interesting differences from controls, such as relatively high phenylalanine, serine, and glycine.

Vitamin A. High intakes would be expected from animals' livers. The serum vitamin A concentrations (Table 8.6) showed that the San were all very well nourished with Vitamin A[1]. They ranged from 51 to 194 μg per 100 ml in 1967 and from 26 to 126 μg per 100 ml in 1968. The low serum carotenoids indicate that their vitamin A must be eaten direct and not formed by splitting β-carotene.

Thiamin and Riboflavin. Thiamin and riboflavin should be adequately provided in the mixed diet the San eat. No clinical signs of deficiency were seen.

Niacin/Tryptophan. Niacin/tryptophan should be provided by the meat and some of the other foods of the San's mixed diet such as *Strychnos pungens* (Wehmeyer 1966, p. 1102). We saw no pellagrous

Table 8.11. Serum-free amino acids (mg per 100 ml)

	San adults 1967 men & women (n = 10), mean (& range)	Fasting controls[a] our laboratory 12 men & 12 women, mean (& range)	San girl of 8½ years (no. 147)
Taurine	1.92 (1.45 - 2.68)	1.42 (0.85 - 2.55)	2.44
Threonine	1.65 (1.43 - 2.24)	2.03 (0.69 - 3.45)	1.16
Serine	3.27 (2.80 - 3.99)	1.80 (0.63 - 2.84)	2.44
Glutamine	7.01 (5.67 - 8.19)	7.12 (4.21 - 11.08)	7.52
Proline	3.34 (2.37 - 5.78)	3.49 (1.15 - 7.23)	--
Citrulline	0.67 (0.56 - 0.81)	0.71 (0.46 - 0.96)	0.33
Glycine	3.56 (2.71 - 5.06)	2.11 (0.75 - 3.92)	2.95
Alanine	4.31 (3.12 - 6.34)	4.02 (2.11 - 6.20)	4.21
Valine	3.56 (1.66 - 6.11)	3.31 (2.20 - 4.59)	1.38
Methionine	0.39 (0.31 - 0.51)	0.47 (0.27 - 0.60)	0.21
Isoleucine	1.01 (0.81 - 1.26)	1.17 (0.79 - 1.83)	0.38
Leucine	2.56 (2.19 - 3.20)	2.05 (1.12 - 3.22)	1.43
Tyrosine	1.07 (0.80 - 1.67)	1.22 (0.83 - 1.63)	0.73
Phenylalanine	2.13 (1.75 - 3.04)	1.24 (0.73 - 2.25)	1.47
Ornithine	1.90 (1.03 - 3.73)	1.24 (0.53 - 1.93)	1.14
Lysine	2.87 (2.25 - 3.51)	2.91 (1.32 - 3.95)	1.58
Histidine	2.04 (1.30 - 2.70)	1.74 (0.87 - 2.32)	1.46
Arginine	2.71 (1.57 - 3.48)	1.49 (0.77 - 3.48)	1.69
Tryptophan	0.44 (0.25 - 0.52)		0.39

[a]Collected in Cape Town, not in the field.

skin changes. Urine N'methylnicotinamides (Table 8.7) were comparable to controls (both were somewhat lower than expected because of high blank readings). Plasma tryptophans seemed to be below normal values, but we did not have enough control serum left to compare with serum taken in the field.

Folic Acid and Vitamin B_{12}. Intakes and blood levels have been shown by Metz's team (Metz, Hart, and Harpending 1971) to be very satisfactory.

Vitamin C. Some of the bush foods are exceptionally rich in ascorbic acid, such as baobab flesh, *Adansonia digitata* (Wehmeyer 1966), and morula fruit, *Sclerocarya caffra* (Wehmeyer 1966; Fox 1966). Though there was periodontal disease, it did not have the features of scurvy.

Vitamin D. Despite the abundant sunlight, we saw craniotabes, the earliest sign of rickets, in three young infants who had been completely protected from sunlight since birth. In older infants and all other San there was nothing to suggest cholecalciferol deficiency.

Iron. Iron intake was adequate (Metz, Hart, and Harpending 1971; see this Chapter under Hematology).

Calcium. Calcium is present in the San's drinking water in the Dobe region since it comes from limestone wells. Urinary calciums were the same as in the controls (Table 8.7).

Sodium and Chloride. Lacking salt, the San's intakes were very low, and, consequently, so were urinary excretions. As discussed above, this may protect the San from hypertension. As expected, their kidneys had adjusted to the low intakes so that serum sodiums were normal.

Phosphorus. The San's urinary phosphates were very low. We wonder if this may not be because their diet lacks the cereals from which nearly all other population groups obtain large amounts of phosphate.

phosphorus in cereals ?

Iodine. Goiters were uncommon. Apart from mild physiological thyroid enlargements we only saw goiters in San who had been brought up on Gobabis or Ghanzi farms further south. We therefore conclude that dietary iodine is adequate in the Dobe region, and that the San do not obtain antithyroid substances in their bush food.

Other Trace Elements. With one or two exceptions we saw no fluorotic mottling of teeth. Urinary zinc and copper were normal.

To conclude, we do not know the significance, if any, of the low urinary phosphates. The low sodium chloride intakes are probably beneficial, rather than harmful. With these exceptions we found no

evidence of any qualitative nutritional deficiency in the San. This was not unexpected since mixed diets should protect against malnutrition. As a rule, barring accidents and illness, it would seem that
194 the only nutritional weakness of the San's diet is a shortage of energy (calories) usually in the dry spring season.

Further Studies to Part II

Aspects of !Kung demography are also discussed by Howell (1973, 1974), Harpending (1971), and Harpending and Jenkins (1973a, 1973b). See also Lee (1972d), and Yellen and Harpending (1972). 195
Medical and nutritional studies have appeared on various special topics: on the problem of heart disease see Truswell and Hansen (1968); Truswell, Kennelly, Hansen, and Lee (1972); Kennelly, Truswell, and Schrire (1972); and Truswell and Mann (1972). Nutritional studies are reported in Truswell et al. (1969); Hansen et al. (1969); Metz et al. (1971); Wehmeyer et al. (1969); Engelter and Wehmeyer (1970); Truswell (1972a, 1972b); and Lee (1973b).