ANTHROPOMETRICAL EVALUATION

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SUMMARY

Anthropometric measurements of 260 rural and 247 urban adult Venda males were obtained during an extensive nutrition survey in 1968.

The results showed that the body-weights of the rural Venda were significantly lower than those of their urban counterparts, although their heights did not differ. Except for the bi-acromial width the differences in the skeletal measurements were not significant. This indicates that the differences in body-weight can be ascribed mainly to differences in muscularity or percentage of body fat, or both. The mean arm muscle area and the calf-circumference were higher in the urban than in the rural Venda. Above the age of 30 years significant differences were found in the percentages of body fat of the two samples, that of the urban Venda being the greater.

The differences in muscularity and body fat of the two samples could be attributed mainly to differences in activity and dietary patterns. The urban Venda were physically more active than the rural, which could explain why the former were more muscular than the latter. It further appears that the better protein status of the urban subjects could also have contributed to the difference in muscularity.

The dietary surveys showed adequate intakes of calories by the rural Venda, and that the intakes of the urban Venda were not appreciably higher. In spite of this and their greater activity the average percentage of body fat of the urban sample was higher than that of the rural, an anomaly which suggests that not all the calories ingested were available to the rural Venda.

The following body measurements were recorded: weight; height; cristal height; intercristal width; bi-acromial width; bi-epicondylar widths of the humerus and the femur; ulnar length; upper arm and calf circumferences; and triceps-, biceps-, subscapular-, supra-iliac and calf skinfold thicknesses. Where possible, the measurements were taken on the left side of the body, and were made according to the methods described by Smit *et al.*[1] except for the circumferences of the mid upper arm and calf, and the subscapular skinfold.

The mid upper arm circumference was measured with the arm dependent, and not with the forearm bent at 90° as described by Smit *et al.*[1]

The calf circumference was measured in a horizontal plane at the level of the greatest circumference while the subjects stood erect with the feet slightly apart and the body-weight thus evenly distributed between the lower limbs.

The subscapular skinfold was measured immediately below the tip of the inferior angle of the scapula with the subject's hands resting on his hips.

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Two additional skinfolds, which were not described in the paper of Smit *et al.*,[1] were also measured, viz. the biceps and the supra-iliac skinfolds. The biceps skinfold was measured over the muscle belly, at the same level at which the arm circumference was determined, with the arm slightly bent, and the subject's hand resting against the body of the observer. The supra-iliac skinfold was measured just above the iliac crest in the mid-axillary line.

Some of the above measurements were used to calculate the percentage body fat and the cross-sectional muscle area of the upper arm. These figures give a simplified, though representative index of body fat[2] and muscularity[3]† of the test subjects. The calf circumference was also used as an indication of muscularity, although it is not as accurate an indication as the cross-sectional muscle area of the upper arm, because the calf skinfold thickness, in addition to being extremely difficult to measure on some subjects, is not representative of the fatty layer around the leg at the level of the circumference measurement.

The percentage body fat was calculated according to a formula by Durnin and Ramahan[2] which was based on an equation of Siri:[4]

$$\text{percentage body fat} = \left\{ \left[\frac{4{\cdot}95}{\text{body density}} \right] - 4{\cdot}5 \right\} \times 100$$

The body density was calculated by using the equation of Durnin and Ramahan:[2]

body density = 1·1610—0·0632 × log of the sum of the triceps-, biceps-, subscapular- and supra-iliac skinfolds.

In the study of Durnin and Ramahan[2] the skinfold measurements were taken on the right side of the body, while in the present survey they were taken on the left side of the body of all the subjects. However, this should not affect the validity of the comparisons which are made in this article between the age-groups and the localities.

The muscle area of the cross-section of the left arm was used as a criterion of muscularity for comparative purposes, and was calculated according to the formula:

$$\text{muscle area (mm}^2) = \pi \left[\left\{ \frac{1}{2\pi} C - \frac{1}{4}(V_1 - V_2) \right\}^2 - \frac{1}{2\pi} B \right]$$

where C = arm circumference,
V_1 = triceps skinfold,
V_2 = biceps skinfold,
B = humerus circumference.

The humerus circumference was determined by the following formula (based on unpublished data): humerus circumference = 29·4016 + 0·5955 × humerus bi-epicondylar width.

Analysis of the data. Each sample was divided into four age-groups, viz. 20 - 29, 30 - 39, 40 - 49 and 50 years and above. The few individuals under the age of 20 years were included in the 20 - 29-year age-groups. Within each sample the variables were tested for significant differences at the 5% level both by a one-way analysis of variance in

†Brozek only recommends a correction for subcutaneous fat, whereas a correction for bone was made in addition to those for the skinfolds in this study.

respect of the age-groups, and by a regression analysis of the effect of the individual ages on these variables.

In addition, the rural and urban samples were compared in respect of each of the relevant variables, using a statistical technique developed by Steffens,[5] which indicates those ages between which the two samples differ significantly.

RESULTS

The means and the standard deviations of the various anthropometrical measurements of the four age-groups in each sample, as well as those of each total sample, are presented in Tables I and II.

TABLE I. MEANS AND STANDARD DEVIATIONS OF BODY-WEIGHTS AND SKELETAL MEASURMENTS OF RURAL AND URBAN SAMPLES

	Age-group									
	20 - 29 years		30 - 39 years		40 - 49 years		50 years and above		Sample mean	
Measurement	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban
Number of subjects in sample	**134**	**39**	**41**	**49**	**44**	**102**	**41**	**57**	**260**	**247**
Body-weight (kg)	**56·8**	**60·1**	**58·9**	**63·5**	**56·7**	**64·6**	**54·9**	**65·8**	**56·8**	**64·0**
SD	**5·6**	**7·2**	**6·0**	**7·8**	**8·0**	**9·5**	**8·8**	**10·2**	**6·7**	**9·1**
Height (mm)	**1 675·6**	**1 675·5**	**1 689.5**	**1 667·4**	**1 667·1**	**1 681·9**	**1 661·2**	**1 686·0**	**1 674·1**	**1 678·9**
SD	**54·1**	**62·8**	**56·3**	**66·6**	**65·1**	**62·2**	**58·7**	**67·1**	**57·5**	**64·2**
Cristal height (mm)	**1 031·5**	**1 038·6**	**1 034·8**	**1 036·2**	**1 033·0**	**1 044·7**	**1 028·5**	**1 053·9**	**1 031·5**	**1 044·2**
SD	**45·9**	**47·2**	**44·9**	**55·0**	**45·2**	**46·2**	**41·9**	**49·0**	**45·9**	**49·0**
Intercristal width (mm) ...	**252·7**	**252·4**	**258.4**	**259·5**	**258·9**	**262·2**	**260·9**	**266·0**	**255·9**	**261·0**
SD	**13·1**	**14·0**	**13·9**	**13·1**	**15·9**	**14·2**	**15·8**	**16·1**	**14·5**	**15·0**
Bi-acromial width (mm) ...	**366·3**	**381·2**	**375·0**	**382·2**	**369·8**	**386·6**	**368·0**	**385·2**	**368·5**	**384·6**
SD	**18·8**	**16·7**	**16·4**	**18·8**	**20·7**	**19·3**	**17·7**	**21·3**	**18·8**	**19·3**
Humerus bi-epicondylar width (mm)	**65·0**	**65·7**	**66·7**	**66·5**	**66·3**	**67·0**	**65·9**	**67·5**	**65·6**	**66·8**
SD	**3·3**	**3·6**	**2.9**	**4·1**	**3·1**	**4·0**	**3·3**	**4·3**	**3·3**	**4·0**
Femur bi-epicondylar width (mm)	**88·9**	**88·3**	**89·0**	**89·4**	**88·6**	**89·5**	**88·7**	**89·9**	**88·8**	**89·4**
SD	**3·8**	**3·4**	**3·8**	**3·8**	**4·0**	**4·7**	**4·8**	**4·3**	**4·0**	**4·3**
Ulnar length (mm)	**279·7**	**283·0**	**284·5**	**283·0**	**282·9**	**285·8**	**283·5**	**288·1**	**281·6**	**285·3**
SD	**12·7**	**11·9**	**12·6**	**15·5**	**12·1**	**13·6**	**12·0**	**15·6**	**12·6**	**14·3**

TABLE II. MEANS AND STANDARD DEVIATIONS OF SKINFOLD THICKNESSES, PERCENTAGES OF BODY FAT, ARM MUSCLE AREAS AND CALF CIRCUMFERENCES

	Age-group									
	20 - 29 years		30 - 39 years		40 - 49 years		50 years and above		Sample mean	
Measurement	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban
Number of subjects in sample	**134**	**39**	**41**	**49**	**44**	**102**	**41**	**57**	**260**	**247**
Triceps skinfold (mm)	**6·8**	**6·3**	**6·7**	**8·2**	**6·3**	**8·1**	**6·1**	**8·8**	**6·6**	**8·1**
SD	**2·2**	**1·8**	**2·4**	**4·1**	**2·3**	**3·7**	**2·2**	**4·7**	**2·2**	**3·9**
Biceps skinfold (mm)	**3·7**	**3·2**	**3·3**	**3·5**	**3·5**	**2·8**	**2·9**	**3·5**	**3·3**	**3·4**
SD	**0·7**	**0·6**	**1·0**	**1·2**	**0·7**	**1·2**	**0·9**	**1·5**	**0·9**	**1·2**
Subscapular skinfold (mm)	**8·0**	**8·3**	**8·7**	**11·5**	**8·4**	**11·2**	**8·9**	**12·5**	**8·3**	**11·1**
SD	**1·7**	**2·0**	**2·5**	**6·6**	**2·3**	**5·7**	**4·2**	**6·7**	**2·5**	**5·9**
Supra-iliac skinfold (mm) ...	**5·6**	**5·0**	**5·8**	**7·1**	**5·3**	**8·3**	**6·0**	**8·7**	**5·6**	**7·7**
SD	**2·1**	**1·7**	**3·4**	**5·2**	**2·3**	**6·7**	**3·8**	**6·5**	**2·7**	**6·0**
Calf skinfold (mm)	**9·7**	**8·3**	**6·7**	**8·7**	**5·7**	**7·7**	**5·6**	**7·5**	**7·9**	**7·9**
SD	**3·5**	**3·6**	**3·6**	**4·4**	**2·3**	**3·9**	**2·5**	**3·7**	**3·7**	**3·9**
% body fat	**10·8**	**10·3**	**10·8**	**12·7**	**9·9**	**12·9**	**10·2**	**13·7**	**10·5**	**12·6**
SD	**2·4**	**2·5**	**3·4**	**5·0**	**3·4**	**5·3**	**4·3**	**5·4**	**3·1**	**5·0**
Arm muscle area (mm) ...	**4 098·3**	**5 260·7**	**4 501·7**	**5 408·2**	**4 237·4**	**5 608·4**	**4 032·5**	**5 592·6**	**4 174·8**	**5 510·9**
SD	**694·4**	**1 033·9**	**738·2**	**659·5**	**710·6**	**925·9**	**708·0**	**991·9**	**718·9**	**918·4**
Calf circumference (mm) ...	**334·4**	**337·7**	**329·6**	**345·4**	**321·0**	**343·3**	**316·2**	**341·7**	**328·5**	**342·5**
SD	**19·0**	**22·5**	**20·9**	**16·5**	**24·0**	**25·3**	**26·2**	**24·2**	**22·5**	**23·1**

In Figs. 1 - 6 the group means together with the regression lines of certain variables on age are given separately for the rural and urban Venda. They serve to illustrate the effect of age, and the differences between the geographical samples.

The results are divided into 4 major categories, viz. body-weight, body dimensions, adipose tissue and muscularity. Each is discussed separately.

Body-weight

The body-weights of the 4 ten-year age-groups of the rural Venda did not differ significantly, and no significant effect of age was found by means of regression analysis (Fig. 1). The mean weight of the total sample was 56·8 kg

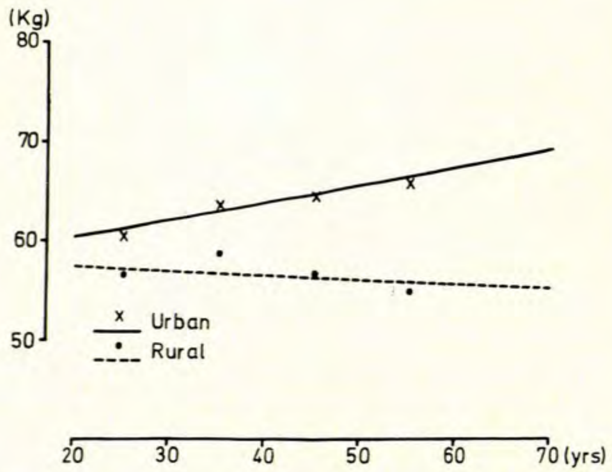

Fig. 1. Regression lines of body-weight together with group means for urban and rural Venda.

(Table I). In the case of the urban subjects, however, the body-weights increased significantly with age ($P < 1\%$). The mean body-weight was 64·0 kg (Table I). The difference between the body-weights of the rural and the urban Venda was significant above the age of 21 years ($P < 5\%$).

Body Dimensions

The mean body and cristal heights, the bi-acromial widths, the humerus and femur bi-epicondylar widths and the ulnar lengths, together with the standard deviations of each, are presented in Table I for each age-group. The more important findings are discussed below.

There were no significant differences in the skeletal measurements of the four age-groups in either geographical sample, nor any significant trend with increasing age except for the intercristal and bi-acromial widths.

In both samples the intercristal widths increased with age ($P < 1\%$). This increase was more pronounced in the urban sample (Fig. 2).

The bi-acromial widths were only slightly, and not significantly, affected by age in both samples. Those of the urban sample were significantly higher ($P < 5\%$) than those of their rural counterparts (Fig. 3).

Adipose Tissue

No significant differences were found between the percentages of body fat of the 4 age-groups of the rural sample. Regression analysis, however, indicated a small but significant decrease in the body fat content with increasing age ($P < 5\%$) (Fig. 4). On the other hand, a significant increase with age in the percentage body fat of the urban sample was found ($P < 1\%$).

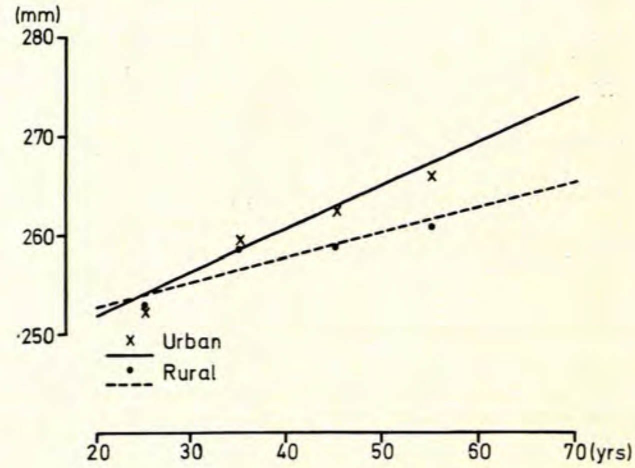

Fig. 2. Regression lines of intercristal width together with group means for urban and rural Venda.

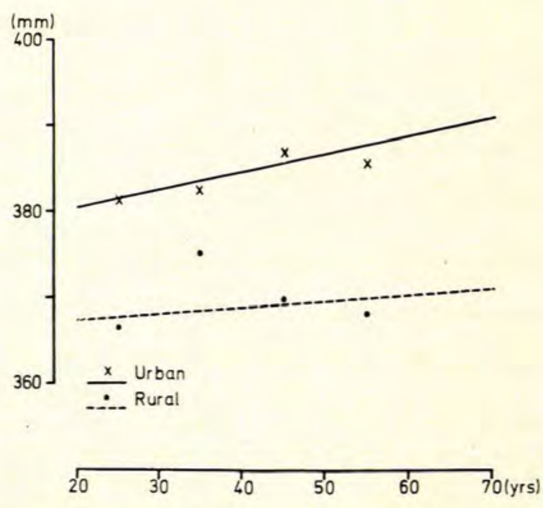

Fig. 3. Regression lines of bi-acromial width together with group means for urban and rural Venda.

In both samples there were no significant differences between the percentages body fat of the Venda below the age of 31 years, whereas they differed significantly above this age ($P < 5\%$).

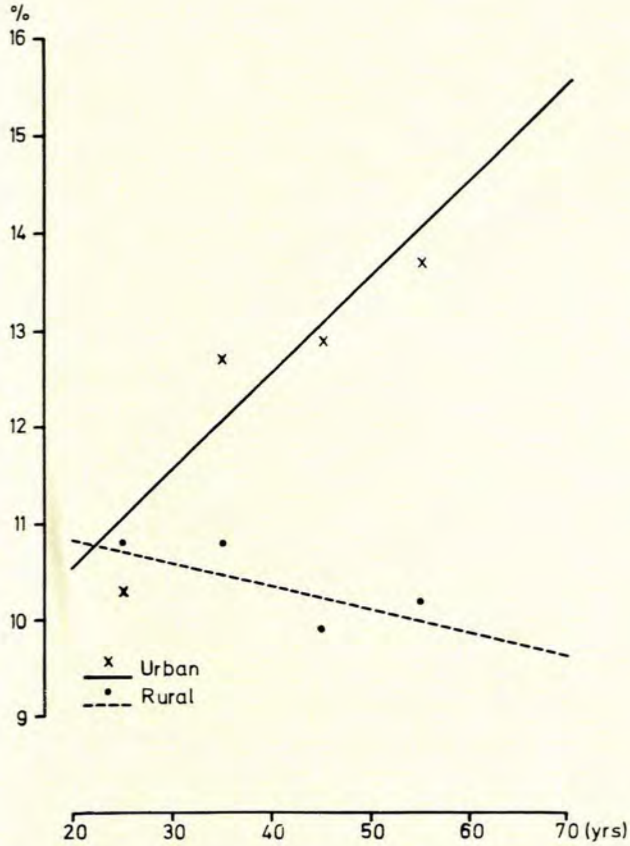

Fig. 4. Regression lines of percentage body fat together with group means for urban and rural Venda.

Muscularity

Cross-sectional muscle area of arm. The muscularity of the arm of the four age-groups of the rural sample differed significantly ($P < 1\%$). The 30 - 39 and 40 - 49-year groups were more muscular than the other two groups (Fig. 5, Table II), the mean muscle area of the 30 - 39-year group being the greatest. The arm muscle area of the urban Venda increased significantly ($P < 5\%$) with age, but no significant differences between the four age-groups were found.

In the case of the rural subjects the mean cross-sectional muscle area of the arm was 4 174·8 mm², while the corresponding area for the urban sample was 5 510·8 mm² (Table II). The difference between the arm musculature of these two samples was significant ($P < 5\%$).

Calf circumference. Increasing age had a significant effect ($P < 1\%$) on the calf circumference of the rural Venda, which decreased linearly with age (Fig. 6). This measurement of the urban Venda was unaffected by age ($P > 5\%$). There was virtually no difference between the measurements of the rural and urban Venda below the age of 23 years, but thereafter significant differences were found ($P < 5\%$).

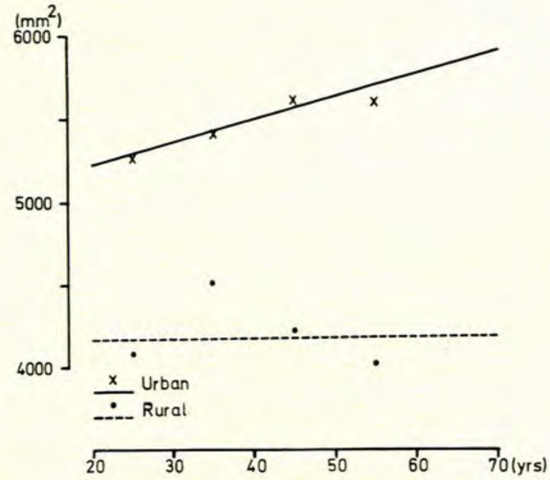

Fig. 5. Regression lines of arm muscle area together with group means for urban and rural Venda.

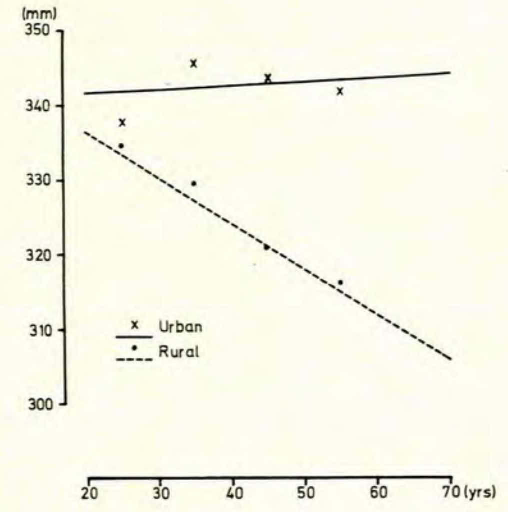

Fig. 6. Regression lines of calf circumference together with group means for urban and rural Venda.

DISCUSSION

Much has been written on the use of body measurements ('nutritional anthropometry')[6] in the evaluation of man's nutritional status.[1,3,7-10] These measurements can provide useful though limited information for the assessment of the nutritional status of population groups. It appears that they may have greater value in comparative studies to assess the effect of diet on the body build of population groups. In the present study we are dealing with two samples of a single racial group from different environments and geographical areas from which direct comparisons can be made in order to determine the effect on body build of the change from the one way of living to the other.

The body-weights of the rural Venda were significantly lower than those of their urban counterparts ($P < 5\%$). The heights, however, did not differ appreciably. Except for the bi-acromial measurements, the differences in the skeletal measurements were not significant. This indicates that the differences in body-weight can be ascribed mainly to differences in either musculature or percentage of body fat or both. The mean arm muscle area and the mean calf-circumference were higher in the urban than in the rural Venda. The percentage body fat did not differ for the youngest age-groups of the two samples, but significant differences were found for the three older groups ($P < 5\%$). In these age-groups the urban Venda had higher percentages of body fat than the rural.

The differences between the two samples in respect of musculature and body fat may be attributed mainly to differences in activity and dietary patterns.

The rural Venda still live largely in their traditional manner. They rely mainly on their own crops, edible wild plants and veld fruit for their food supply. Hunting is prohibited, and the domesticated animals which are kept provide only an irregular supply of meat. The urban Venda, on the other hand, have no natural food resources and are therefore compelled to purchase their food.

Only 47 of the 260 rural Venda subjects were employed, and all of these worked as labourers on farmlands and in nearby plantations. More than 80% of these 47 labourers were between the ages of 30 and 49 years. The increase in upper arm musculature observed in this age range (Fig. 5) could therefore have been due to their greater physical activity in comparison to that of men below 30 or above 50 years. From this low rate of regular employment it is clear that the rural Venda were, on the whole, relatively inactive. In spite of their apparent inactivity no increase in the degree of fatness was observed with age, in contrast to the findings of other workers on other populations.[11,12]

Durnin and Ramahan[2] found that the mean percentage of body fat of those subjects which they subjectively (by appearance) assessed as being thin, according to body build, was 10·6. The rural Venda gave the impression of being thin. Their mean percentage body fat was 10·5 (range 4·3 - 21·7), which closely corresponds to that of the above research workers. From the above discussions one can conclude that the daily caloric intakes of the rural Venda were only marginally adequate for their daily needs.

The urban Venda appeared more sturdy than their rural counterparts. Ninety-six per cent of them were employed either as clerks or as labourers by firms in Johannesburg. About 88% of these were classified as labourers, 64·1% of whom did hard manual work. These figures indicate that the urban were physically more active than the rural subjects. This difference in the activity patterns of the subjects in the two areas may partially account for the difference in muscularity between the two groups.

The mean percentage body fat of the 20 - 29-year urban group was 10·3, and increased sharply in the second age-group to 12·7 (Table I, Fig. 4). The percentage body fat of the oldest group showed a further increase, being 13·7. This body fat increase with age of the urban subjects indicates that, in spite of their being physically more active than their rural counterparts, their calorie intakes in general were more than adequate for their daily needs. The mean percentage of body fat of the 30 - 39, 40 - 49 and 50-years-and-over age-groups was 13·1 (range 4·1 - 30·7). By appearance they were judged to be of intermediate build. Durnin and Ramahan[2] found that those test subjects which they subjectively classified as of intermediate body build had a mean percentage body fat of 14·2.

The dietary surveys showed adequate intakes of calories, mainly from cereals, by the rural subjects in general, and that the intakes of the urban subjects were not appreciably higher. In spite of this and the greater activity of the urban subjects — most of the rural subjects being unemployed — the average percentage of body fat of the urban group was higher than that of the rural Venda. This anomaly could be explained by the fact that the calories of the rural Venda were predominantly derived from maize-meal porridge, and that this porridge, as prepared by the Bantu, probably contains a considerable amount of indigestible starch.

The biochemical studies indicated that the protein nutrition status of the urban sample was substantially superior to that of the rural. The mean serum albumin values of the urban sample were significantly higher than those of the rural, and 26·9% of the rural subjects were found to be in the 'low' range of protein nutrition, while 2·8% were classified as 'deficient', compared with 2·4% of the urban subjects in the low range. This difference in protein nutrition could also have contributed to the differences in muscularity between the rural and urban subjects.

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