Anthropometric measurements and amounts of body fat and serum cholesterol in samples of three Nigerian populations

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1. Skinfold thicknesses, arm circumferences, heights, weights and serum cholesterol levels were determined in ninety-one university students, 207 soldiers and 102 out-patients, all male subjects. Some of these measurements were used to determine the amount of body fat, Quetelet's index and mid-arm muscle circumference.

2. Quetelet's indices and body-fat values obtained were similar to previously reported values for lean or moderately built males.

3. Serum cholesterol levels were generally low, with means ranging from 3·98 mmol/l for 18- to 29-year-old students to 5·19 mmol/l for 40- to 69-year-old out-patients.

4. The mean values for triceps skinfold thickness, the amount of body fat and serum cholesterol levels for healthy adults obtained in this study are probably normal for northern Nigerian populations.

5. There was a significant correlation between the amount of body fat and values for triceps and subscapular skinfold thicknesses, Quetelet's index and body-weight for all adults. The correlation between muscle circumference and the amount of body fat was significant for all subjects except adult soldiers.

The technique for estimating the amount of body fat from measurements of skinfold thickness has been used for over 20 years. During this period, Rathbun & Pace (1945), Brozek & Keys (1951), Pascale, Grossman, Sloane & Frankel (1956), Parizkova (1961), Fletcher (1962) and Steinkamp, Cohen, Gaffey, McKay, Bron, Siri, Sargent & Isaacs (1965) have either formulated, or used, various equations for the estimation of body density from skinfold thicknesses. Some have measured body density by underwater weighing (Durnin & Taylor, 1960; Parizkova, 1961; Hunt & Heald, 1963; Durnin & Rahaman, 1967). Body density was then used to predict the amount of body fat. These studies have involved American, British and European populations and yielded reference values that might or might not be applicable to African populations. A study of home-based Cape Verde Islanders and Cape Verdeans who had migrated to the United States of America showed that home-based Cape Verdeans had significantly lower skinfold thicknesses, serum cholesterol levels and serum triglyceride levels than Cape Verdeans resident in the United States of America (Albrink & Meigs, 1971). Native Cape Verdeans are known to be relatively free of coronary diseases. Technologically under-developed populations similar to the native Cape Verdeans are common in many African countries. This study was therefore designed to obtain comparable results from Nigerian populations. Such a study, it was hoped, could help to establish local standards for comparison with those already available.

EXPERIMENTAL

Subjects

The samples for this study included 207 soldiers of the Army Depot, Zaria, 102 adult out-patients of a rural Hospital in Malumfashi, northern Nigeria, and ninety-one young adult male medical and pharmacy students of Ahmadu Bello University. The out-patients had ailments that ranged from backaches, headaches and boils to mild anaemia (confirmed by results of blood tests being published in a separate paper). Our choice of out-patients was not completely unbiased as some of those randomly selected refused to submit to the test and more willing out-patients (often volunteers) had to be accepted. Values obtained from the students, it was hoped, would serve as local references that could be compared to those of well-nourished young adult males in other parts of the world. Twenty-five of the 207 soldiers were 13- to 17-year-old adolescents recently recruited to undergo a 5-year Secondary-Military course and were, therefore, comparable to ordinary, adequately nourished adolescents of the local population. These twenty-five soldiers will be referred to as adolescent recruits. Females were excluded from this study because of the problems of modesty and the Moslem religion that would have arisen in measuring skinfold thicknesses, for example, the subscapular and the supra-iliac.

Methods

Skinfold thickness was measured at the biceps, triceps, subscapular, and supra-iliac sites using a skin caliper (Holtain, Ltd, Bryberian, Crymmych, Pembrokeshire, UK) which exerted a constant pressure of 100 kN/m². All measurements were taken on the left side of the body according to WHO recommendations (Falkner, 1960). The technique described by Fletcher (1962) was adopted in measuring each skinfold thickness.

Arm circumference was measured using a Miniflex metal tape (Model no. 3055; Robone Chesterman, Pembrokeshire, UK) at a site half-way between the tip of the acromion and the olecranon process. The height of each subject was measured with the subject standing erect and looking straight ahead. Body-weight was measured using a portable precision balance (Model LPP/A; C. Morgan & Sons, London). Each weight was determined only when the subject stood perfectly still and looked straight ahead. The weights of six pairs of shorts and six pairs of trousers of different materials were determined and the appropriate average weight subtracted from the weight of the subject; all soldiers wore shorts, all students wore trousers and the out-patients wore either shorts or trousers.

Blood for serum cholesterol determinations was obtained with a minimum of stasis from a vein near the ante-cubital fossa of the arm. After being allowed to clot for at least 30 min, the blood samples were centrifuged and the serum separated using a pipette. Serum cholesterol values were determined by the method of Abell, Levy, Brodie & Kendell (1952).

Calculations

Body density was calculated from the following equations used by Durnin & Rahaman (1967):

$$Y = 1\cdot1610 - 0\cdot0632X, \text{ for men;}$$

$$Y = 1\cdot1533 - 0\cdot0643X, \text{ for boys;}$$

where Y is the predicted body density and X is the log of the sum of four skinfold thicknesses. From the density values obtained, the amount of body fat was calculated using Siri's (1956) equation:

$$\text{body fat (\% of body-weight)} = ((4\cdot95 \div \text{density}) - 4\cdot5) \times 100.$$

Mid-arm muscle circumference was calculated from the equation: $C_1 = C_2 - \pi S$, where C_1 is the mid-arm muscle circumference (mm), C_2 is the arm circumference (mm), and S is the triceps skinfold thickness (mm).

Quetelet's index was calculated by dividing the body-weight (kg) by the square of the height (m²).

Significance of differences between means was determined using Student's t test and $P \leqslant 0\cdot05$ was taken as statistically significant.

RESULTS

Table 1 summarizes the values for skinfold thicknesses, heights, weights and Quetelet's index within different age groups of the three population samples. The biceps and supra-iliac skinfold thicknesses were used only to calculate the sum of the four skinfold thicknesses and the amount of body fat and, therefore, have not been presented individually. Because of the small number of subjects above 40 years of age, all out-patients between 40 and 69 years of age were grouped together.

The triceps skinfold thickness was essentially the same for all ages of all subject groups studied. The lowest value (4·9 mm for the 30- to 39-year-old out-patients) was not significantly different ($P > 0\cdot05$) from the highest value (6·3 mm for soldiers of the same age-group). The adolescent recruits had lower total skinfold thicknesses than all older groups. The total skinfold thicknesses for 18- to 29-year-old students and soldiers, although no different from each other, were significantly higher than those for the out-patients of the same age-group. This difference was also reflected in the significantly lower value for subscapular skinfold thickness for the 18- to 29-year-old out-patients compared to those for either the soldiers or students ($P < 0\cdot01$). For the 30- to 39-year-old group, however, neither the total nor the subscapular skinfold thickness for soldiers was statistically different from those for out-patients.

On the average, 18- to 29-year-old out-patients were shorter than the students and weighed less than either the students or the soldiers ($P < 0\cdot01$). The heights and weights of soldiers and out-patients did not vary substantially with difference in age. Mean Quetelet's indices were highest in soldiers and lowest in out-patients.

Results shown in Table 2 suggested that adolescent males had higher body-fat

Table 1. *Skinfold thicknesses (mm), heights, weights and Quetelet's indices for three populations of Nigerian males of different ages*

Age range (years)	13–17		18–29						30–39				40–69	
Subjects	Adolescent recruits		Students		Soldiers		Out-patients		Soldiers		Out-patients		Out-patients	
No. of subjects	26		91		170		43		11		39		20	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Skinfold														
Triceps	5·3	0·23	5·4	0·14	5·4	0·08	5·1	0·20	6·3	0·91	4·9	0·30	5·0	0·35
Subscapular	6·6	0·22	9·0	0·22	8·9	0·14	7·1	0·24*†	12·5	0·52	7·5	0·34	7·7	0·63
Total	23·7	0·80	27·8	0·64	27·1	0·40	24·0	0·85†	28·2	2·46	24·7	1·18	25·3	1·65
Height (m)	1·645	0·0088	1·716	0·0064	1·702	0·0045	1·685	0·0088*	1·683	0·0177	1·687	0·0089	1·683	0·137
Weight (kg)	46·9	1·69	61·5	0·65	63·0	0·46	56·5	1·04*†	63·8	2·18	57·7	1·26	56·9	1·83
Quetelet's index‡ (kg/m²)	18·2	1·0	20·9	1·9	21·9	1·4	19·9	2·2	22·3	3·1	20·2	2·2†	19·9	4·1

* Mean values for out-patients significantly different from those for students (*P* < 0·01).
† Mean values for out-patients significantly different from those for soldiers (*P* < 0·01).
‡ Body-wt ÷ square of the height.

Table 2. *Amounts of body fat, serum cholesterol levels and mid-arm muscle circumferences for three populations of Nigerian males of different ages*

Age range (years)	13–17		18–29						30–39				40–69	
Subjects	Adolescent recruits		Students		Soldiers		Out-patients		Soldiers		Out-patients		Out-patients	
No. of subjects	26		91		170		43		11		39		20	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Body fat (% of body-wt)	15·6	0·76	12·3	0·33	12·2	0·16	10·8	0·38†	13·0	1·60	11·9	0·54†	11·2	0·70
Serum cholesterol (mmol/l)	4·54	0·19	3·98	0·09	4·76	0·09*	4·60	0·12‡	5·10	0·47	4·74	0·12‡	5·19	0·17
Muscle circumference (mm)	227	4·8	242	2·0	268	1·2*	249	3·6†	267	3·4	245	4·7†	343	5·4

* Mean values for soldiers significantly different from those of students (*P* < 0·01).
† Mean values for out-patients significantly different from those of soldiers (*P* < 0·01).
‡ Mean values for out-patients significantly different from those of students (*P* < 0·01).

Table 3. *Correlation coefficients* (r) *for the amount of body fat and measurements of body size for three populations of Nigerian males of different ages*

Age range (years) ...	13–17	18–29			30–39		40–69
Subjects ...	Adolescent recruits	Students	Soldiers	Out-patients	Soldiers	Out-patients	Out-patients
No. of subjects ...	26	91	170	43	11	39	20
Body fat (% of body-wt) *v.*:							
Quetelet's index†	0·49	0·22*	0·31	0·34*	0·73	0·50	0·55
Triceps skinfold	0·72	0·59	0·60	0·76	0·76	0·83	0·82
Subscapular skinfold	0·72	0·60	0·77	0·92	0·92	0·88	0·83
Body-wt	0·33^{NS}	0·36	0·33	0·51	0·85	0·32*	0·65
Muscle circumference	0·52	0·22*	0·11^{NS}	0·41	0·12^{NS}	0·32*	0·71

NS, not significant ($P > 0.05$).
All values of *r* significant at $P < 0.01$ except: * $P < 0.05$.
† Body-wt ÷ square of the height.

contents than older males. As can be predicted from values for total skinfold thickness, the mean amounts of body fat for students and soldiers were significantly higher than those for out-patients of all ages ($P < 0.01$). Among adult out-patients, the body-fat contents varied little with age.

In sharp contrast to the pattern obtained for skinfold thickness and body-fat content, mean serum cholesterol levels for students were significantly lower than those for the soldiers or out-patients of all ages ($P < 0.01$). There was a discernible tendency for the serum cholesterol level to increase with increasing age in adults. The level of serum cholesterol for out-patients was (mmol/l): 18- to 29-year-old group 4·60, 30- to 39-year-old group 4·74 and 40- to 69-year-old group 5·19. The serum cholesterol levels (mmol/l) for soldiers increased from 4·54 for adolescent recruits to 4·76 for 18- to 29-year-old soldiers and to 5·10 for the 30- to 39-year-olds.

Adult soldiers of all ages had consistently higher mid-arm muscle circumferences than either students or out-patients ($P < 0.01$).

The correlation coefficient for the subscapular skinfold thickness *v.* the amount of body fat was consistently the highest (Table 3), with corresponding values for triceps skinfold thickness and, in descending order, Quetelet's index and body-weight *v.* the amount of body fat, which were all significant ($P \leqslant 0.05$) for adults. For the adolescent recruits, there was no significant correlation between body-weight and the amount of body fat. In this study, *r* values obtained for regressions of serum cholesterol level *v.* the amount of body fat were as high as 0·47, but in no instance was the *r* value significant. Correlation coefficients for the amount of body fat *v.* mid-arm muscle circumference were significant for adolescent recruits, students and out-patients but not for soldiers.

DISCUSSION

The rather narrow range of triceps skinfold thicknesses obtained for all healthy subjects and out-patients in this study (4·9–6·3 mm) is remarkably similar to that reported by Albrink & Meigs (1971) for the very lean native Cape Verde Islanders

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(4·6–6·1 mm). Of the four skinfold thicknesses measured in this study, the triceps skinfold thickness is considered the most sensitive indicator of energy reserve (Jelliffe, 1966). The results for the triceps, therefore suggest a close similarity, at least in terms of energy reserves, between our subjects and the native Cape Verdeans, who are also known to have a very low incidence of coronary diseases (Albrink & Meigs, 1971).

The low total skinfold thicknesses of the adolescent recruits do not necessarily represent a lower body-fat content than in their adult counterparts. It has been shown that adolescent males have lower mean body densities, reflecting higher fat contents than those of adult males (Durnin & Rahaman, 1967). The specific equation which takes account of the lower body densities of the adolescents has, therefore, been used here to calculate the amount of body fat for this group. Consistent with the concept that subscapular skinfold thickness most closely reflects the subcutaneous and, to a large extent, the total body-fat content (Garn, Rosen & McCann, 1971), subscapular skinfold thickness variations closely paralleled the variations in the total skinfold thicknesses from which the amount of body fat was calculated (Table 1).

The results of Eksmyr & Engsner (1971) suggest that the sums of the triceps and subscapular skinfold thicknesses are essentially the same for British and privileged Ethiopian boys of similar ages. In our study, the sums of four skinfold thicknesses were used to calculate the total body-fat content. The assumption here is that the total subcutaneous and body fat, rather than the fat distribution at specific sites, are comparable in male Caucasians or Negroids of comparable Quetelet's indices and ages.

Values obtained for Quetelet's index were very similar to other values for 'weight corrected for height' that have been reported for traditionally lean or moderately built populations (Shaper, Williams & Spencer, 1961; Durnin & Rahaman, 1967; Albrink & Meigs, 1971).

The significantly lower serum cholesterol levels of students compared to those of either soldiers or out-patients could be due to a difference in the diet of those groups. But no plausible conclusions can be drawn from these observations, since a full investigation of the diets of the different groups was not carried out. Values for serum cholesterol obtained for all subjects in this study are generally low compared to those reported for European or American subjects (Jelliffe, 1966; Montoye, Epstein & Kjelsberg, 1966; Albrink & Meigs, 1971), but are similar to the values previously reported for residents of Ibadan, Nigeria (Edozien, 1958). Similarly low values for serum cholesterol have been found to be associated with a low incidence of coronary diseases in Cape Verdeans (Albrink & Meigs, 1971); a similar association may exist in our populations. This suggestion is strengthened by the observation that indigenous Africans are generally less susceptible to severe atherosclerosis (Strong, Wainright & McGill, 1959; Scott, Daodu, Florentine, Davies & Coles, 1961; Miller, Spenser & White, 1962; Williams, 1971).

Values for muscle circumference obtained in this study for adult soldiers are slightly higher, and those for students and out-patients slightly lower, than the WHO standard of 253 mm for adult males having an adequate protein-energy intake (Jellife, 1966). The WHO standard triceps skinfold thickness for adult male Europeans and North Americans is 12·5 mm (Jelliffe, 1966). Compared to our mean triceps

skinfold thickness of 5·34 mm for adult Nigerians, this suggests an inadequacy of total energy reserve even in our healthy adult subjects. The relatively low triceps skinfold thicknesses of even our healthy subjects cause an over-estimation of mid-arm muscle circumferences and its use as a nutritional index for our populations is, therefore, questionable. But our values for triceps skinfold thickness were generally similar to the low values for triceps skinfold thickness of Tanzanian adolescents and adult Cape Verdeans (Robson, 1964; Albrink & Meigs, 1971) and suggested the need for establishing local standards especially in developing tropical regions. The relatively lower triceps skinfold thicknesses were consistent with our generally low body-fat contents and serum cholesterol levels. The mean values for these measurements are, therefore, probably normal for Nigerians.

Of all measurements that have previously been correlated with the amount of body fat, the correlation coefficient for subscapular skinfold thickness *v.* the amount of body fat was consistently the highest (Tanner, 1951; Montoye *et al.* 1966; Garn *et al.* 1971). Our results support this finding (Table 3). In addition, there was a significant correlation between values for triceps skinfold thickness, Quetelet's index and body-weight and the amount of body fat for all groups except the adolescent recruits. For the latter, body-weight was not a good indicator of the body-fat content. Previous workers who have tried to correlate body-fat content and serum cholesterol levels have obtained values for correlation coefficients which are significant for some populations but not others. The highest value so far known to be reported is 0·43 (Tanner, 1951; Montoye *et al.* 1966). In our study, even the value of 0·47 that we obtained was not statistically significant.

We had set out in this study to document some anthropometric and related measurements in soldiers, university students and residents of a rural area (Malumfashi). We succeeded in obtaining results for only some out-patients and these cannot be considered as true representatives of the rural community of Malumfashi. The measurements for adolescents, students and soldiers obtained here, although generally lower than some of the values previously published, can be used as standards for future investigations of the local population. We do not suggest that these 'standards' represent the true values for the local population, only those for healthy soldiers and university students in this area. The general agreement of our results with previous reports concerning comparable populations strongly suggests that the anthropometric techniques used in the present study are suitable for use by epidemiologists, nutritionists and clinicians interested in assessing the nutritional status of populations, especially in the developing world.

REFERENCES

Abell, L. L., Levy, B. B., Brodie, B. B. & Kendell, F. E. (1952). *J. biol. Chem.* **195,** 357.

Albrink, J. A. & Meigs, J. W. (1971). *Am. J. clin. Nutr.* **24,** 344.

Brozek, J. & Keys, E. (1951). *Br. J. Nutr.* **5,** 194.

Durnin, J. V. G. A. & Rahaman, M. M. (1967). *Br. J. Nutr.* **21,** 681.

Durnin, J. V. G. A. & Taylor, A. (1960). *J. appl. Physiol.* **15,** 142.

Edozien, J. C. (1958). *W. Afr. J. Med.* **8,** 121.

Eksmyr, R. & Engsner, G. (1971). *Envir. Child Hlth* **17,** 110.

Fletcher, R. F. (1962). *Clin. Sci.* **22,** 333.

Falkner, F. (1960). *Modern Problems in Pediatrics* p. 439. Basle and New York: S. Karger.

Garn, S. M., Rosen, N. N. & McCann, M. B. (1971). *Am. J. clin. Nutr.* **24,** 1380.

Hunt, E. E. & Heald, F. P. (1963). *Ann. N.Y. Acad. Sci.* **110,** 532.

Jelliffe, D. B. (1966). *The Assessment of the Nutritional Status of the Community* pp. 217, 218, **242.** Geneva: World Health Organization.

Miller, D. C., Spenser, S. S. & White, P. D. (1962). *Am. J. Cardiol.* **10,** 432.

Montoye, H. J., Epstein, F. H. & Kjelsberg, M. O. (1966). *Am. J. clin. Nutr.* **18.** 397.

Parizkova, J. (1961). *Metabolism* **10,** 794.

Pascale, L. R., Grossman, M. I., Sloane, H. S. & Frankel, T. (1956). *Hum. Biol.* **28,** 165.

Rathbun, E. N. & Pace, N. (1945). *J. biol. Chem.* **158,** 667.

Robson, J. R. K. (1964). *J. trop. Med. Hyg.* **67,** 209.

Scott, R. F., Daodu, A. S., Florentine, R. A., Davies, J. N. P. & Coles, R. M. (1961). *Am. J. Cardiol.* **8,** 165.

Shaper, A. G., Williams, A. W. & Spencer, P. (1961). *E. Afr. med. J.* **38,** 569.

Siri, W. E. (1956). In *Advances in Biological and Medical Physics* p. 90 [J. H. Lawrence and C. A. Tobias, editors]. London and New York: Academic Press Inc.

Steinkamp, R. C., Cohen, N. L., Gaffey, W. R., McKay, T., Bron, G., Siri, W. E., Sargent, T. W. & Isaacs, E. (1965). *J. chron. Dis.* **18,** 1291.

Strong, J. P., Wainright, J. & McGill, M. C. (1959). *Circulation* **20,** 1118.

Tanner, J. M. (1951). *J. Physiol., Lond.* **115,** 371.

Williams, A. O. (1971). *Br. Heart J.* **33,** 95.