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Nutritional anthropometry in children from 0 to 6 years of age in different geographical areas

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SUMMARY Anthropometric data of 12,769 clinically normal children 0–6 years of age from 12 different geographical areas in Africa and Asia are presented.

Height, weight, arm circumference and triceps skinfold thickness were measured and presented for age. Derived variables, as muscle circumference, muscle area and muscle proportion-for-age were computed. Weight, arm circumference and muscle area-for-height were calculated.

Comparison of these 12 cross-sectional growth patterns shows important differences between groups.

The observed differences show that height-for-age, weight-for-age, arm circumference-for-age and weight-for-height are not sufficient to describe adequately and to interpret the variations in nutritional status.

Introduction

The growth curves of children of 0–6 years of age from different regions in Africa and Asia are presented in order to stimulate further research on nutritional assessment, based on anthropometry, and to complement the published data of local growth patterns (1).

Subjects and methods

Between 1974 and 1978 13,109 children of 0–6 years of age were examined clinically and measured for height, weight; arm circumference and triceps skinfold thickness (Table I). They were from 12 different geographical areas in Africa and Asia, with important differences in genetic background, in ecology (climate, rainfall, altitude) and in feeding pattern and available food, as well as in socio-cultural factors.

The clinical assessment and measurements were made during the mother and child clinics. Special attention was paid at village level to receiving attendance of more than 90% of the children in the village. The children with severe acute illness were treated and, together with those presenting a chronic physical handicap, were not included in the study.

Children with clinical features of malnutrition were also excluded so that only 12,769 *normal* children are considered here. The number, sex and geographical distribution of the different group of these children are given in Table I.

They were weighed with a springscale (CMS Ltd) or a beam scale (Continental Ltd) to the nearest 100g and all scales were regularly checked with standards weights. In children aged up to 2 years, length was measured to the nearest millimetre with a tape-measure (type Stanley), in the recumbent position. In children over 2 years, height was measured to the nearest millimetre with a "microtoise" (type Stanley). Measuring and weighing were by well trained local personnel. Mid-arm circumference (AC) was assessed with a flexible steel tape-measure 6 mm wide, reading to the nearest millimetre. The tape measure was used on the left upper mid-arm,

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Table I *Geographical area, number and sex of the children, and staple food of the different groups*

Nr	Region	Ethnic group	Country	Geographical area	Number of *Normal* children Boys	Girls	Staple food
Central Africa							
1		Wazimba	Zaire	Eastern Zaire (Kasongo)	989	948	Cassava, rice
2		Warega	Zaire	Eastern Zaire (Kalima)	1115	1081	Cassava, dry rice, ground nuts
3		Bangus	Zaire	Eastern Zaire	816	783	Cassava, roots, leaves, bananas
4		Ngbaka	Zaire	North Western Zaire Ubangi (Gemena)	369	330	Maize, cassava
5		Bantandu	Zaire	Western Zaire (Kisantu)	457	434	Cassava, maize, dried fish, ground nuts
North Western Africa							
6		Moba	Togo	North Togo	579	546	Millet, maize, rice
7		Gourma	Togo	North Togo	264	244	Millet, maize, rice
8		Mossi	Bourkina Faso	Yako	600	624	Millet, vegetable leaves
Asia							
9		Bengali	India	Eastern India (Calcutta)	153	128	Rice, vegetable oil, various leaves
10		Warli Kokona	India	Western India (Bombay)	330	305	Rice, vegetables Milk, butter fat
11		Oroan	India	North-East India (Ranchi)	653	621	Wet rice, potato, flour
12		Thai	Thailand	North Eastern Thailand (Khon Khaen)	189	192	Rice, sunflower oil, raw fish
Subtotal					6513	6256	
Grand total					12769		

Table II *Measured and derived variables*

Measured variables	
Height-for-age	Means of height plotted on the midpoint of each age-class.
Weight-for-age	Means of weight plotted on the midpoint of each age-class.
Arm-circumference-for-age	Means of the arm circumference plotted on the midpoint of each age-class.
Triceps-skinfold-for-age	Means of triceps skinfold plotted on the midpoint of each age-class.
Derived variables	
Muscle-circumference-for-age*	Means of muscle circumference plotted on the midpoint of each age-class.
Muscle-proportion-for-age*	Means of muscle area/arm area plotted on the midpoint of each age-class.
Weight-for-height	Means of weight for each 2 cm height-class.
Arm-circumference-for-height	Means of arm circumference of each 2 cm height-class
Muscle-circumference-for-height*	Means of muscle circumference for each 2 cm height-class
Muscle-area-for-height*	Means of muscle area for each 2cm height-class.

*Muscle included bone.

held to the horizontal by the examiner. The measure container was left dangling, resulting in a constant traction of about 70 g. The triceps skinfold thickness (TS) was measured with a Harpenden skinfold caliper (John Bull) as recommended by Edwards (2). The last two measurements AC and TS were all taken by the same person.

The muscle circumference, muscle area and arm area were calculated according to Jelliffe (3)*. Further, weight-for height (4), arm circumference-for-height (5), muscle circumference and muscle area-for-height were computed. Muscle proportion was defined as the proportion of the arm area taken up by muscle (muscle area/total arm area). Table II enumerates the different anthropometric variables.

Age was rounded to the nearest month. The date of birth was either known or else confirmed by a careful interview of the mother by a local nurse, well known to the population. For the analysis of the data, different age/classes were defined, taking into account the growth rate and the necessity to obtain a sufficient number of children in each age/class: the

*In this study: muscle = muscle included bone

Table III *Height, weight, arm circumference, muscle circumference and muscle proportion for the different age classes (Warega boys)*

Age range (months)	Number of children	Height		Weight		Arm circumference	
		Mean (cm)	S.E.M.	Mean (kg)	S.E.M.	Mean (cm)	S.E.M.
0–1	2	51·20	0·80	3·30	0·20	10·30	0·20
1–2	33	53·65	0·48	4·75	0·18	11·28	0·21
3–5	40	59·82	0·46	5·88	0·11	11·88	0·12
6–8	57	64·71	0·33	7·12	0·14	12·02	0·13
9–11	53	68·44	0·33	7·80	0·17	12·44	0·15
12–14	64	70·40	0·34	8·28	0·14	12·40	0·12
15–17	67	73·53	0·41	8·77	0·15	12·56	0·12
18–20	63	75·36	0·50	9·28	0·17	12·72	0·14
21–23	69	77·39	0·47	9·80	0·18	12·96	0·14
24–26	64	80·65	0·52	10·74	0·21	13·27	0·14
27–29	52	80·62	0·64	11·02	0·20	13·47	0·13
30–35	117	84·21	0·44	11·83	0·16	13·79	0·10
36–41	124	86·23	0·37	12·31	0·13	13·93	0·09
42–47	80	89·74	0·67	13·24	0·20	14·21	0·11
48–53	88	93·53	0·55	14·28	0·19	14·41	0·10
54–59	65	95·00	0·57	14·30	0·23	14·04	0·15
60–71	77	98·86	0·51	15·26	0·21	14·26	0·09

Age range (months)	Number of children	Muscle circumference		Muscle proportion	
		Mean (mm)	S.E.M.	Mean	S.E.M.
0–1	2	84·15	0·43	0·67	0·02
1–2	33	85·03	1·36	0·57	0·01
3–5	40	89·91	1·04	0·57	0·01
6–8	57	94·46	1·07	0·62	0·01
9–11	53	97·57	1·09	0·62	0·01
12–14	64	97·52	0·87	0·62	0·01
15–17	67	99·50	0·94	0·63	0·01
18–20	63	100·38	0·97	0·63	0·01
21–23	69	101·36	0·91	0·62	0·01
24–26	64	103·95	1·07	0·62	0·01
27–29	52	103·81	1·11	0·60	0·01
30–35	117	105·15	0·82	0·59	0·01
36–41	124	105·76	0·71	0·58	0·01
42–47	80	109·20	1·06	0·59	0·01
48–53	88	111·86	0·95	0·61	0·01
54–59	65	109·48	1·32	0·61	0·01
60–71	77	114·24	1·04	0·64	0·01

figures given in Tables III–V for the Warega boys are for all groups and both sexes separately.

For each variable in each age/class normal distribution was acertained by the Kolmogorov-Smirnoff goodness of fit test (6) or the Shapiro-Wilk test (7). The latter if $n<51$.($P<0·05$) height, weight, arm circumference, muscle circumference and muscle proportion for age were normally distributed ($P<0·05$) and are presented in Table III. The triceps skinfold and the arm muscle area-for-age were not normally distributed. Therefore, as described by Tanner (8), a logarithmic transformation for these variables was tried. This gave a normal distribution, log triceps skinfold and log arm muscle area are presented (Table IV). Similarly, after ascertainment of normal distributions of weight, arm circumference, muscle circumference, and arm muscle area for the different height classes, the mean and standard error of the mean were computed (Table V). All these data were plotted by age and height and the different groups were compared.

All statistical evaluations, graphs and tests were computed using the Statistical Analysis System (SAS).

Table IV *Log triceps skinfold and log arm muscle area (mean, S.E.M.) for the different age-classes (Warega boys)*

Age range (months)	Number of children	Log triceps skinfold		Log muscle area	
		Mean	S.E.M.	Mean	S.E.M.
0	2	0·78	0·04	2·75	0·00
1–2	32	0·94	0·02	2·76	0·01
3–5	40	0·96	0·01	2·81	0·01
6–8	57	0·91	0·01	2·85	0·01
9–11	53	0·92	0·01	2·88	0·01
12–14	64	0·92	0·01	2·88	0·01
15–17	67	0·91	0·01	2·89	0·01
18–20	63	0·92	0·01	2·90	0·01
21–23	68	0·94	0·01	2·91	0·01
24–26	64	0·95	0·01	2·93	0·01
27–29	52	0·98	0·01	2·93	0·01
30–35	117	1·01	0·01	2·94	0·01
36–41	123	1·02	0·01	2·95	0·01
42–47	80	1·01	0·01	2·97	0·01
48–53	88	1·00	0·01	3·00	0·01
54–59	64	0·98	0·01	2·98	0·01
60–71	77	0·94	0·01	3·01	0·01

Table V *Weight, arm circumference, muscle circumference and arm muscle area (means and S.E.M.) for the different height-classes (Warega boys)*

Height-classes (cm) range	Number of children	Weight (kg)		Arm circumference (cm)		Muscle circumference (cm)		Arm muscle area (mm^2)	
		Mean	S.E.M.	Mean	S.E.M.	Mean	S.E.M.	Mean	S.E.M.
48–49·9	2	3·3	(*)	9·4	(*)	7·6	(*)	465·10	(*)
50–51·9	9	3·6	0·12	10·3	0·33	7·8	0·25	492·61	31·720
52–53·9	11	4·7	0·21	11·3	0·23	8·4	0·18	566·15	24·396
54–55·9	8	5·0	0·17	11·4	0·30	8·5	0·21	581·65	28·397
56–57·9	10	5·6	0·24	11·9	0·33	8·9	0·19	631·20	26·536
58–59·9	18	5·7	0·12	11·9	0·16	9·0	0·12	644·80	16·828
60–61·9	13	6·3	0·19	12·1	0·27	9·2	0·21	673·26	30·195
62–63·9	23	6·5	0·12	11·7	0·19	9·1	0·13	667·78	18·765
64–65·9	24	7·0	0·13	12·0	0·17	9·5	0·13	719·64	20·368
66–67·9	48	7·4	0·13	11·9	0·12	9·4	0·08	711·58	12·835
68–69·9	56	7·9	0·16	12·4	0·13	9·7	0·09	759·12	14·944
70–71·9	44	8·5	0·14	12·5	0·17	9·8	0·11	768·21	17·210
72–73·9	49	8·7	0·12	12·6	0·16	9·8	0·12	776·58	19·079
74–75·9	58	9·1	0·13	12·7	0·12	10·0	0·09	807·23	14·537
76–77·9	71	9·8	0·11	13·0	0·11	10·1	0·08	822·58	13·137
78–79·9	53	10·6	0·14	13·3	0·14	10·3	0·10	849·75	16·391
80–81·9	69	10·9	0·13	13·4	0·13	10·3	0·09	843·66	15·078
82–83·9	69	11·3	0·13	13·6	0·11	10·3	0·09	845·53	15·389
84–85·9	65	11·9	0·15	13·8	0·11	10·6	0·09	893·13	14·878
86–87·9	83	12·6	0·11	14·2	0·11	10·7	0·08	920·52	14·377
88–89·9	64	13·0	0·13	14·2	0·11	10·8	0·09	935·16	15·819
90–91·9	50	13·3	0·15	14·0	0·14	10·9	0·12	943·57	20·274
92–93·9	39	14·0	0·19	14·2	0·16	11·1	0·12	983·89	22·145
94–95·9	45	14·4	0·17	14·3	0·14	11·2	0·12	1001·92	21·880
96–97·9	44	15·2	0·18	14·5	0·13	11·3	0·12	1021·43	21·629
98–99·9	33	14·9	0·22	14·2	0·15	11·3	0·12	1026·16	22·242
100–101·9	28	16·0	0·28	14·4	0·15	11·7	0·12	1084·83	22·061
102–103·9	14	16·9	0·41	15·0	0·24	12·2	0·24	1195·77	45·907
104–105·9	17	16·8	0·31	14·4	0·30	12·1	0·26	1167·19	52·307
106–107·9	9	17·4	0·42	15·0	0·42	12·4	0·34	1233·76	69·524
108–109·9	3	17·7	(*)	14·9	(*)	12·3	(*)	1204·69	(*)
110–111·9	3	18·6	(*)	15·3	(*)	13·1	(*)	1373·59	(*)

(*) Number too small for reliable computation.

Results and discussion

In view of the amount of material, the results will not be discussed in full. To highlight the different statements, only four of the 12 groups, showing clear-cut differences, are presented. Because of the identity of the conclusions for boys and girls, only the former are reported.

The means for height-for-age with the 95% confidence limits, are plotted. Figure 1(a) shows that the Mossi are significantly taller than the Warega and Figure 1(b) that the Wazimba are comparable to Oroans, with the Warega significantly smaller than the two other groups.

Considering weight-for-age the means of the Mossi and the Warega do not differ [Fig. 2(a)]. The Warega are similar to the Wazimba, but the Oroans are lighter [Fig. 2(b)]. After 30 months the Wazimba even tend to be heavier than the Warega. The Oroans are comparable to the Mossi in height-for-age (Fig. 1), but in weight-for-age they score lower than the Mossi, even lower than the Warega, although the latter are smaller.

In weight-for–height the Warega rise above the Mossi [Fig. 3(a)], and above the Oroans [Fig. 3(b)] when taller than 75 cm. The Wazimba and Warega scores are identical, although we know the latter to be significantly smaller.

Comparison of arm-circumference-for-age [Fig. 4(a)] of the Warega and the Mossi demonstrates clearly that the Warega score lower before 15 months of age and higher after 25 months, while crossing-over occurs between 18 and 24 months. The arm-circumference of the Wazimba [Fig. 4(b)] is comparable to that of the Warega, the Oroans scoring significantly lower than the other two groups.

The skinfold-for-age of the Warega is identical with that of the Mossi below one year of age, but thereafter it is strikingly different, not only in level,

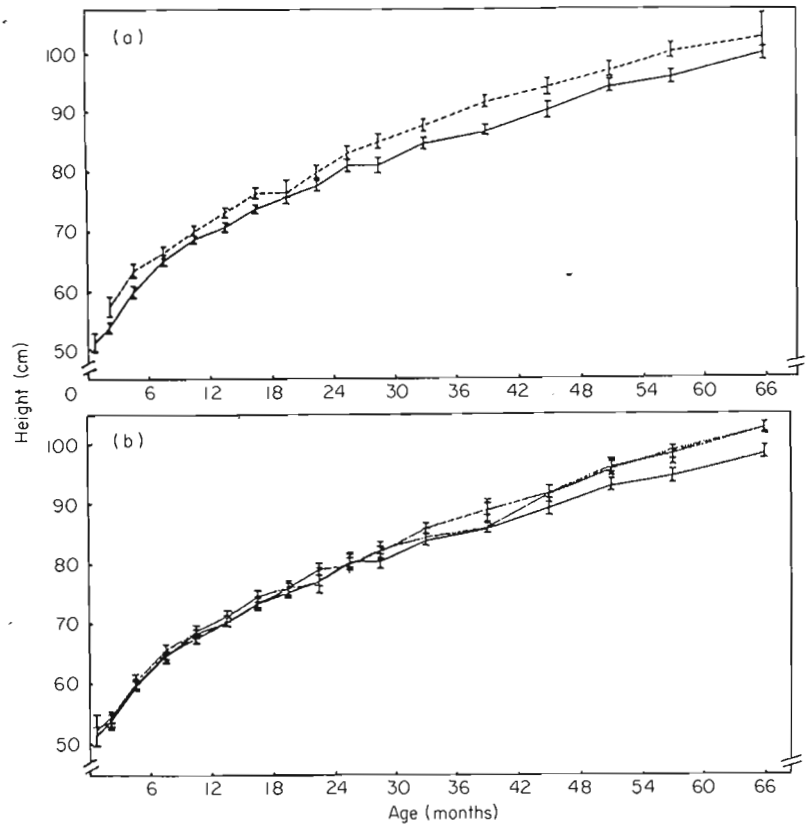

Figure 1 Height for age: Means and 95% confidence limits; (a) comparison between Warega and Mossi, boys. ——, Warega; ------, Mossi. (b) Comparison between Warega, Wazimba and Oroan, boys. ——, Warega;, ------, Wazimba; ....., Oroans.

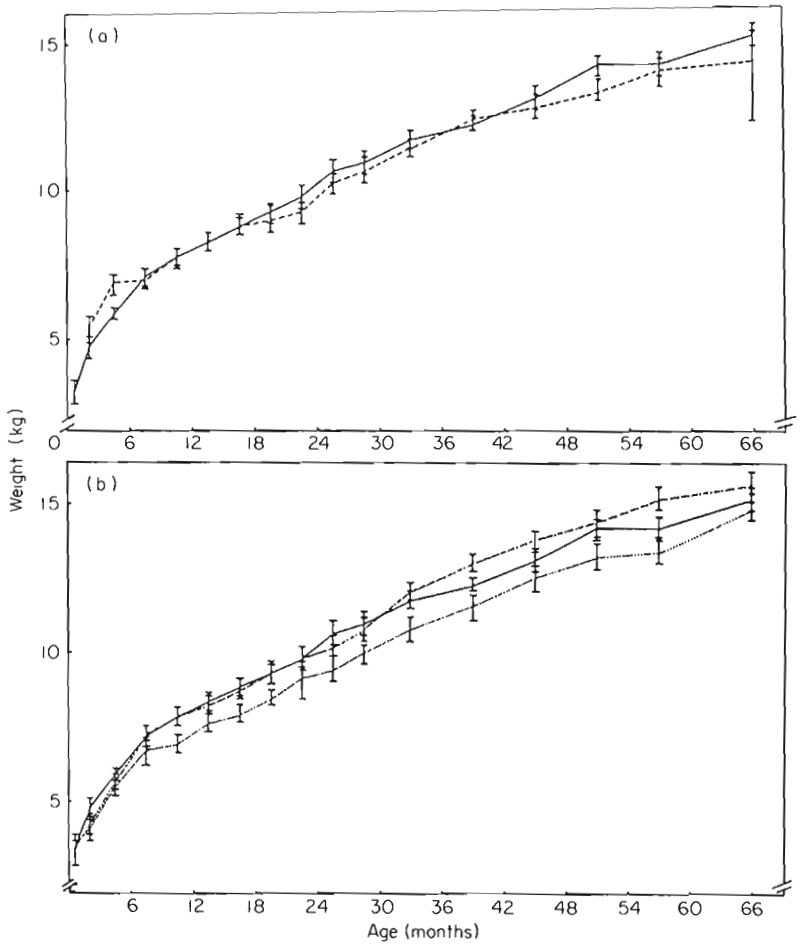

Figure 2 Weight for age: Means and 95% confidence limits; (a) comparison between Warega and Mossi, boys. ——, Warega; ------, Mossi. (b) Comparison between Warega, Wazimba and Oroan, boys. ——, Warega; ------, Wazimba; ....., Oroans.

but also in shape [Fig. 5(a)]. This suggests that the difference in arm circumference between those groups is due to fat accumulation in the Waregan after 1 year of age. The skinfold-for-age [Fig. 5(b)] of the Warega is identical with that of the Wazimba, and in both it is strikingly different from that of the Oroans, who are comparable with the Mossi [Fig. 5].

The muscle-circumference-for-age [Fig. 6(a)] of the Warega is comparable with that of the Mossi and of the Oroans [Fig. 6(b)] but the Wazimba have the highest score-for-age after 30 months of age.

The proportion of the muscle area to the total arm-for-age is lower in the Warega (about 60%) than the Mossi (about 70%) [Fig. 7(a)] and highest in the Oroans [Fig. 7(b)].

Arm-circumference-for-height in the Warega is identical with that in the Wazimba [Fig. 8(a)], greater than in the Mossi, and much greater than in the Oroans, who have 75 cm of height and tend to score lower than the Mossi [Fig. 8(b)].

The muscle-circumference-for-height (Fig. 9) and muscle-area-for-height below 85 cm of height, (Fig. 10) is greatest in the Mossi followed by the Wazimba and the Warega. Above this height, it is identical in the three groups but the Oroans score here significantly lower.

In summary, the Warega are the smallest and fattest children of the different groups and the Oroans are the thinnest and lightest. The Mossi also have little fat, but have a lot of muscle. The Wazimba are

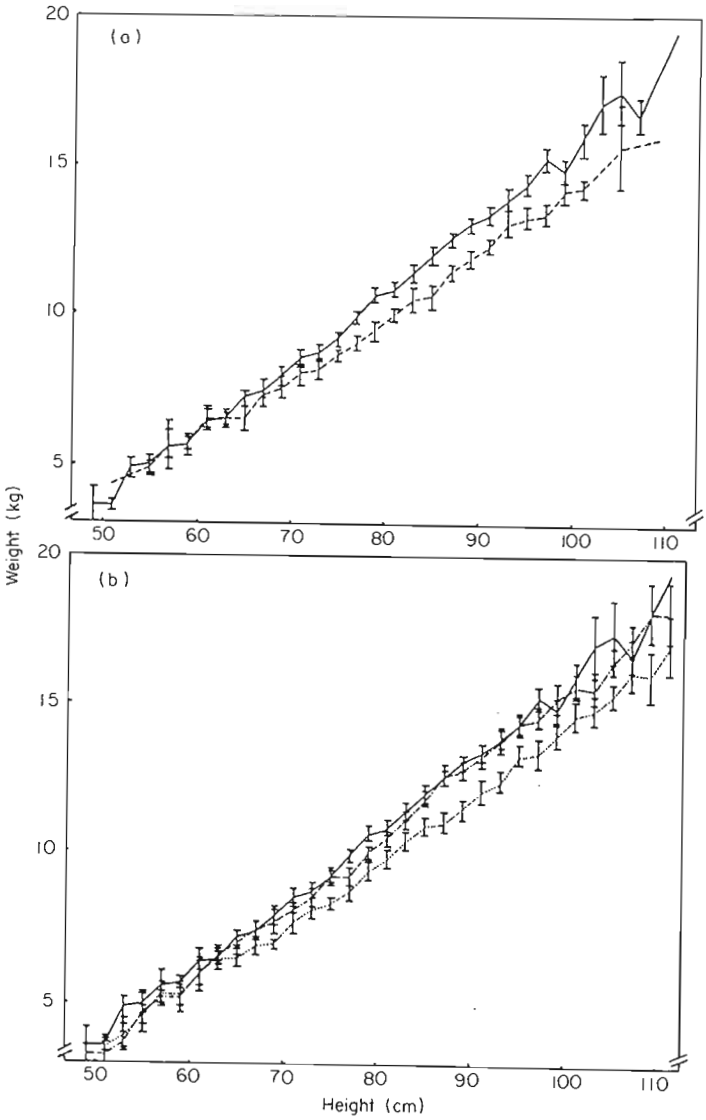

Figure 3 Weight for height: Means and 95% confidence limits; (a) comparison between Warega and Mossi, boys. ——, Warega; ------, Mossi. (b) Comparison between Warega, Wazimba and Oroan, boys. ——, Warega; ------, Wazimba; ....., Oroans.

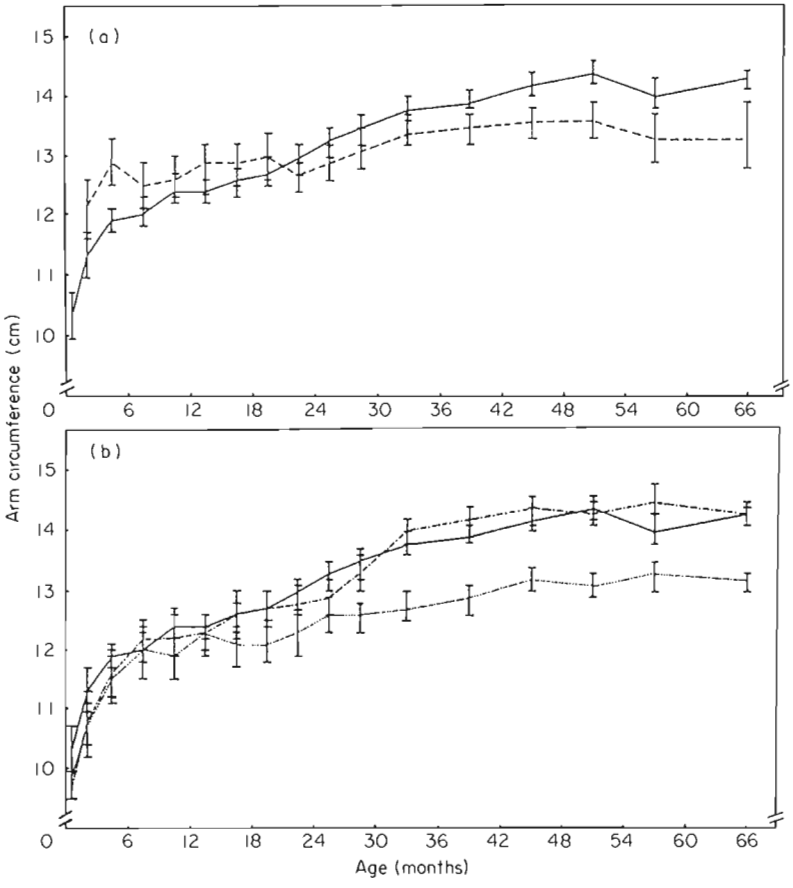

Figure 4 Arm circumference for age: Means and 95% confidence limits; (a) comparison between Warega and Mossi, boys. ——, Warega; ------, Mossi. (b) Comparison between Warega, Wazimba and Oroan, boys. ——, Warega; ------, Wazimba; ……, Oroans.

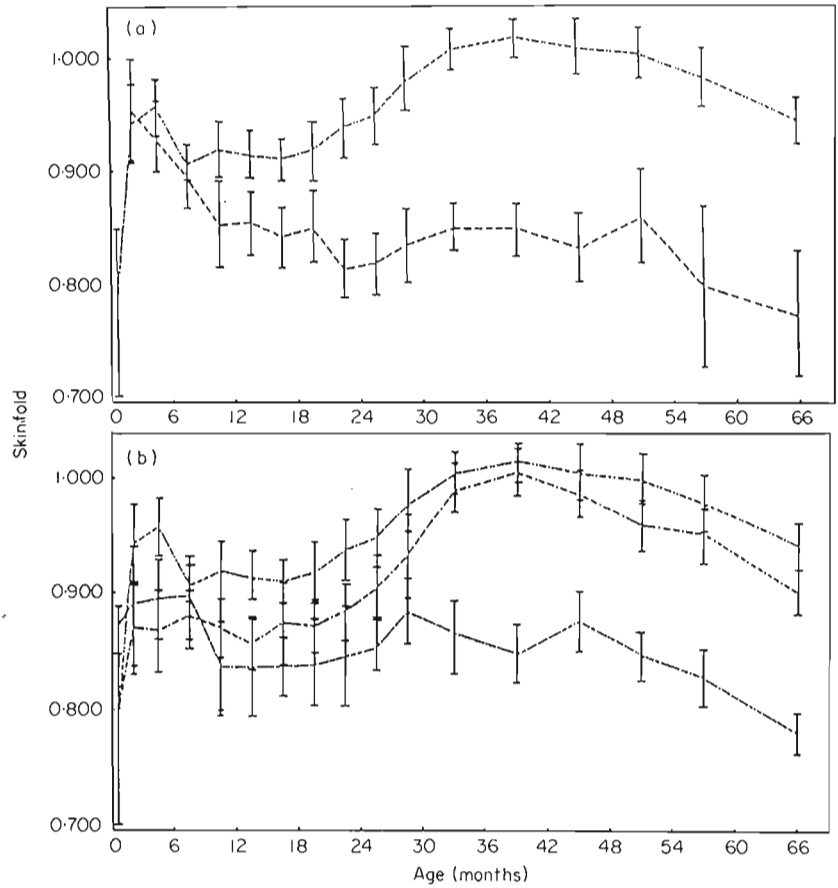

Figure 5 Logarithmic transformation of triceps skinfold for age: Means and 95% confidence limits; (a) comparison between Warega and Mossi, boys. ——, Warega; ------, Mossi. (b) Comparison between Warega, Wazimba and Oroan, boys. ——, Warega; ------, Wazimba; ....., Oroans.

tall and heavy with a lot of fat but not as much as the Warega.

Conclusion

Comparison of these four groups from different third world communities demonstrates fundamental differences in various anthropometric variables. The aim of this paper is to stress the necessity of using different variables to describe, and probably to understand correctly, the characteristics of each group. Looking only for one anthropometric variable, as weight-for-age or even for two variables, as weight-for-age and weight-for-height, gives incomplete evidence of the differences and can even be misleading.

Children from geographically very distant areas may show similarities in some variables (e.g., the Mossi and the Oroans for skinfold-for-age) whereas clear-cut differences may be found between groups from the same region (e.g., the Wazimba and the Warega for height-for-age).

Splitting up the weight into two parts (muscle and fat) seems to open up a broad way for further research. These conclusions could have important consequences in functional anthropometry and in screening children for malnutrition.

We are particularly grateful to our colleagues from the Study group of Tropical Child Health in the Tropics, Dr M Tshibemba and Dr Manshande JP.

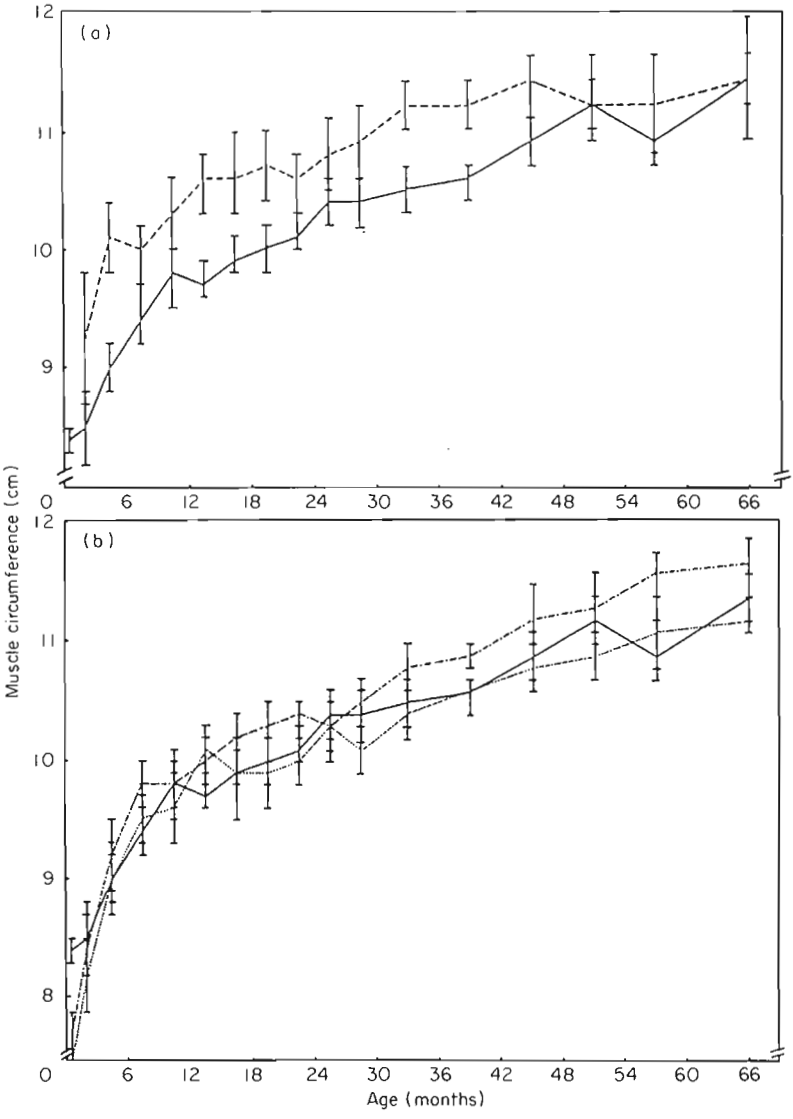

Figure 6 Muscle circumference for age: Means and 95% confidence limits; (a) comparison between Warega and Mossi, boys. ——, Warega; ------, Mossi. (b) Comparison between Warega, Wazimba and Oroan, boys. ——, Warega; ------, Wazimba; ....., Oroans.

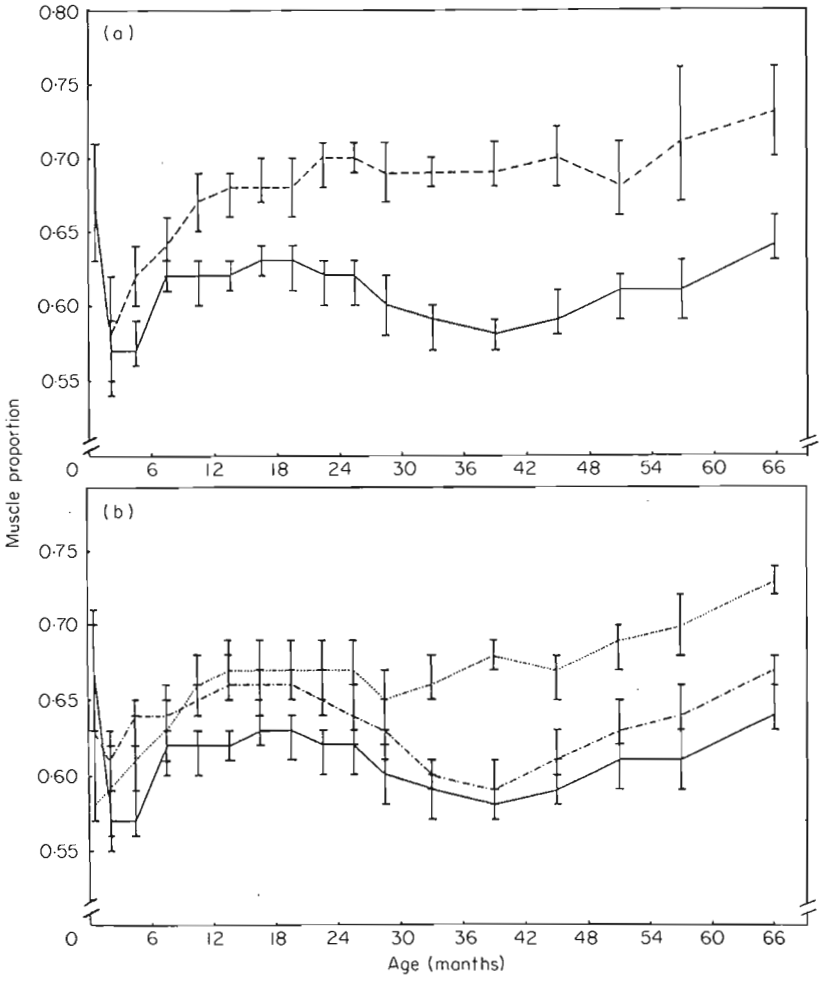

Figure 7 Muscle proportion for age: Means and 95% confidence limits; (a) comparison between Warega and Mossi, boys. ——, Warega; ------, Mossi. (b) Comparison between Warega, Wazimba and Oroan, boys. ——, Warega; ------, Wazimba; ……, Oroans.

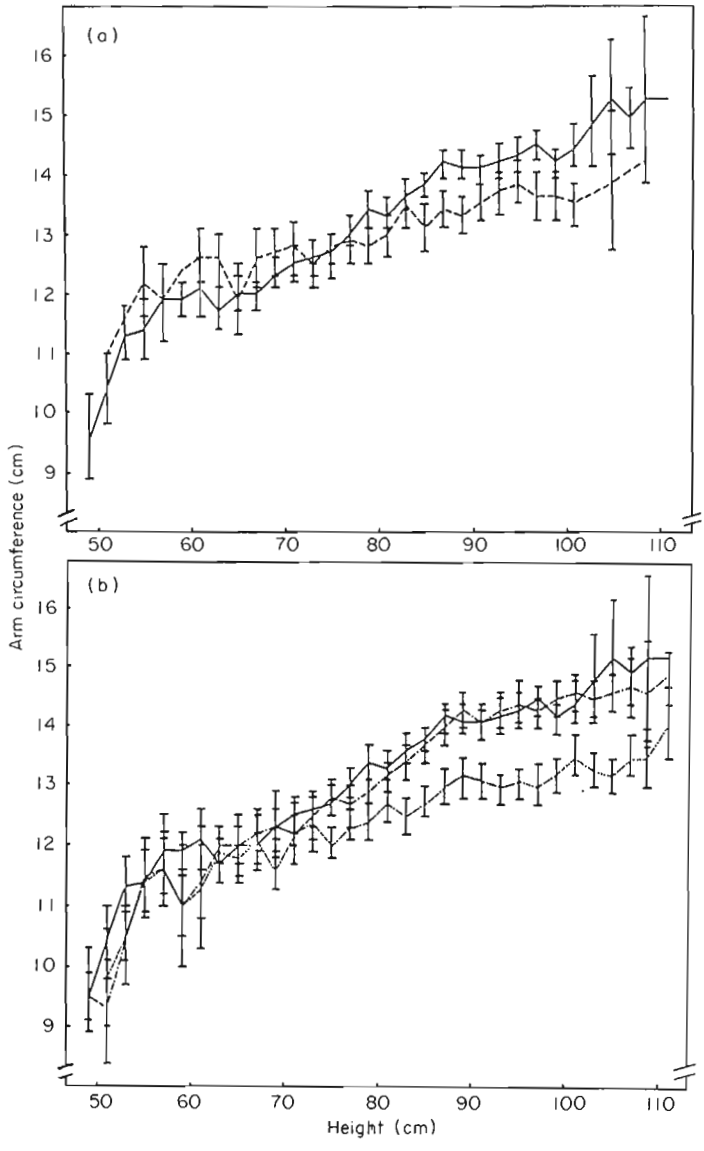

Figure 8 Arm circumference for height: Means and 95% confidence limits; (a) comparison between Warega and Mossi, boys. ——, Warega; ------, Mossi. (b) Comparison between Warega, Wazimba and Oroan, boys. ——, Warega; ------, Wazimba; ....., Oroans.

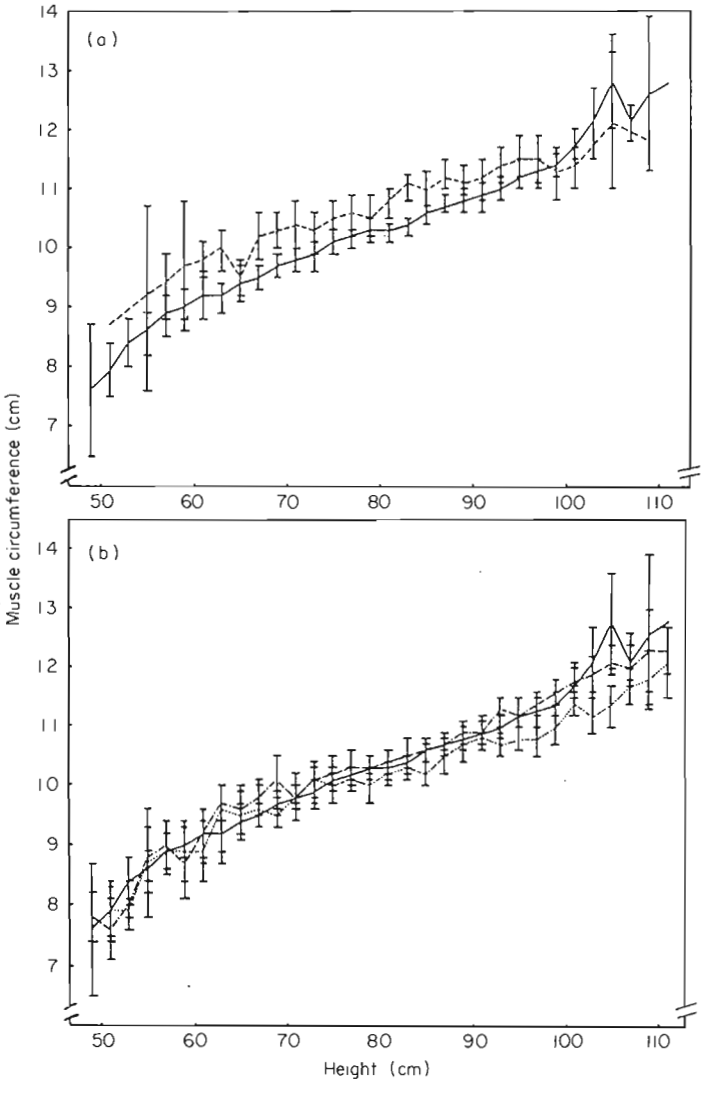

Figure 9 Muscle circumference for height: Means and 95% confidence limits; (a) comparison between Warega and Mossi, boys. ——, Warega; ------, Mossi. (b) Comparison between Warega, Wazimba and Oroan, boys. ——, Warega; ------, Wazimba; ....., Oroans.

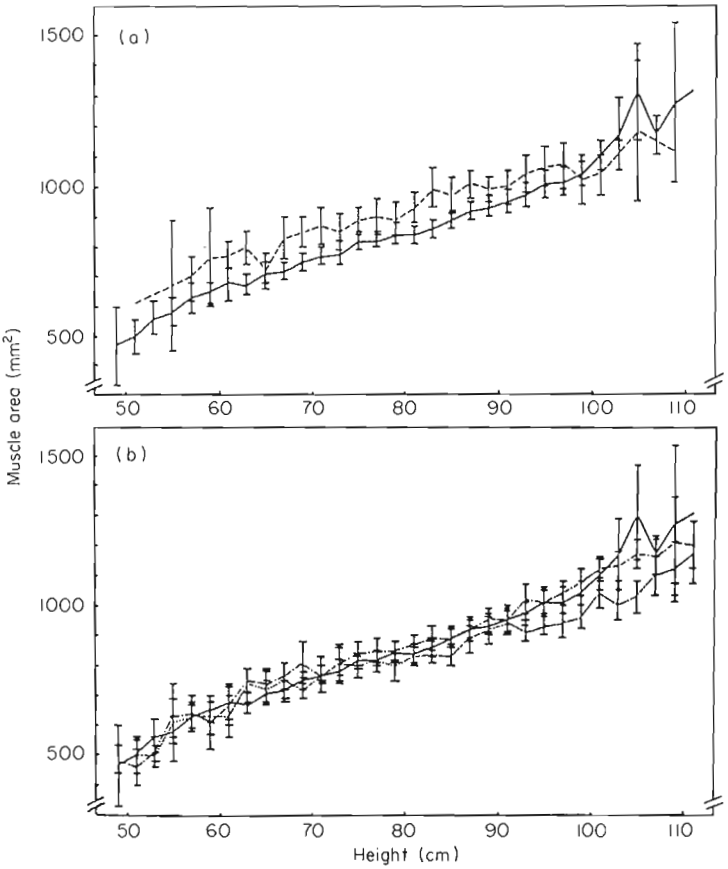

Figure 10 Muscle area for height: Means and 95% confidence limits; (a) comparison between Warega and Mossi, boys. ——, Warega; ------, Mossi. (b) Comparison between Warega, Wazimba and Oroan, boys. ——, Warega; ------, Wazimba; ....., Oroans.

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