THE USE OF PERCENTILE CHARTS IN THE NUTRITIONAL ASSESSMENT OF CHILDREN FROM PRIMITIVE COMMUNITIES*

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A child's growth and physical development are determined by an interaction of genetic and environmental factors. Where environmental factors such as food, clothing, housing, recreation and rest are all entirely favourable and ill-health is absent, an individual should attain the growth potential determined by his genetic constitution. If the diet is deficient or unbalanced, the environment unfavourable, or prolonged ill-health occurs, the full growth potential is not realized and the child's body measurements fall in the lower range and below the normal range of values found in children who have enjoyed every advantage. That there should be a wide range of normal values, rather than a mean value, is a natural consequence of the genetic variation among normal individuals.

This wide range in the body measurements of children may be expressed graphically according to age, by means of percentile charts based on the measurements of large numbers of healthy children. In the last 20 years such percentile charts have been drawn up for child population groups in a number of centres.[1-3] Of these, the Boston percentile charts[2] are, perhaps, the best-known in this country and are most widely used for comparison.

In a recent health and nutritional status survey,[4] a number of body measurements were made on 301 Pedi schoolchildren living in the Bantu homeland of Sekhukhuniland, Northern Transvaal. This survey was undertaken to obtain data from a representative sample of Bantu schoolchildren living under unsophisticated rural conditions, at a time of severe and prolonged drought.

METHODS

In 1965, between 6,000 and 7,000 children were enrolled in the 19 schools under the control of the Sekhukhune Bantu School Board. These schools are scattered around an area of some 400 square miles and are attended by about 50% of the eligible children in the area. Attending scholars come, by and large, from the more enlightened, and therefore probably slightly more privileged, section of the community. In the more primitive families some antipathy towards schooling still exists and activities such as herding take preference over school attendance. Children under 7 years are not enrolled by the schools, and there is a sharp fall-off in the number of children over 12 years, although there does not appear to be an upper age limit and a few young adults attend classes.

For the purpose of this survey, children between 7 and 15 years were grouped according to sex and year of age, so that there were 9 groups of boys and 9 of girls. As in other primitive communities, exact age is not always known, though it is usually possible to determine the year in which a child is born. Thus age was reckoned on 1 July 1965 by calculating 1965 less the year of birth. The survey was completed during August and September 1965.

A sample representative of the total school population, within the stated age limits, was drawn by giving a number to each child and then selecting 20 children of either sex in each age-group by means of random number tables. This sample was slightly larger than desired, to allow for 'non-response'. Thirteen body measurements were taken on each child, using standard anthropometrical equipment and technique.[5] Only height, weight and pelvic breadth are reported here. In addition, full clinical examination was carried out, with emphasis on the detection of those clinical signs generally accepted as indicative of nutritional defect. Serum-protein determination, urine and blood analyses were also performed. Findings will be reported fully in subsequent communications.

RESULTS

The number of children of either sex in each age-group was too small for the construction of percentile charts. Instead, mean values and standard deviations were determined (Tables I - IV). In order to represent these values in a manner immediately meaningful, diagrams were drawn up in which the figures were plotted against the percentiles for Boston children (Figs. 1 - 6).

Weight

In general, the mean weight of the boys was more than that of the girls at each age (Table I). Only at the age of 15 years do the girls show a marked increase in weight and become significantly heavier than the boys.

Comparisons of weights with the Boston percentiles[2] show that the mean weights of Pedi girls (Fig. 1) lie between the Boston third and tenth percentiles. At 9, 10 and 13 years, the mean weight of Pedi boys (Fig. 2) is slightly better than the corresponding tenth percentile, but at 15 years the mean is well below the Boston third percentile. The individual weight of 39·5% of all the children examined was found to be below the Boston third percentile.

The difference between the mean weight of consecutive age-groups varies, and the standard deviations are greatest in the older age-groups, corresponding to the variable onset of the puberty growth spurt.[6] Instances where the mean weight of an age-group is more than that of the one following are accounted for by the smallness of the samples.

Height

Until the age of 10 years, the mean height of boys is lower than that of girls of corresponding age. Thereafter, mean heights of boys are greater (Table II).

Comparison with the Boston percentiles[2] shows that the mean heights of younger girls (Fig. 3) are above the corresponding Boston tenth percentile, but from the age of 10 years lie between the third and tenth percentiles, falling below the third percentile at 15 years. The mean height measurements of boys (Fig. 4) correspond fairly closely with the Boston tenth percentile, and only fall to the third

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percentile at the age of 15 years. The individual height of 33·2% of all the children examined was found to be below the Boston third percentile.

TABLE I. MEAN WEIGHT IN KG. (LB. IN BRACKETS)

Age (years)		*Boys*	*Girls*
7	Mean	20·41 (45·04)	20·78 (45·77)
	SD	2·61 (5·76)	1·76 (3·87)
8	Mean	22·63 (49·88)	20·68 (45·58)
	SD	3·23 (7·12)	3·53 (7·78)
9	Mean	26·63 (58·69)	24·40 (53·81)
	SD	5·31 (11·73)	2·80 (6·17)
10	Mean	29·44 (64·93)	25·31 (55·79)
	SD	4·00 (8·81)	4·34 (9·57)
11	Mean	28·67 (63·23)	26·81 (59·11)
	SD	3·30 (7·28)	4·47 (9·85)
12	Mean	31·75 (70·03)	32·07 (70·69)
	SD	4·32 (9·52)	6·08 (13·44)
13	Mean	35·79 (78·87)	33·29 (73·44)
	SD	6·94 (15·27)	5·13 (11·31)
14	Mean	38·19 (84·23)	37·01 (81·61)
	SD	7·76 (17·06)	6·35 (13·97)
15	Mean	37·88 (83·53)	42·73 (94·23)
	SD	6·40 (14·09)	12·84 (28·25)

TABLE II. MEAN HEIGHT (IN CM.)

Age (years)		*Boys*	*Girls*
7	Mean	117·72	120·04
	SD	5·61	4·27
8	Mean	123·89	124·60
	SD	7·12	7·40
9	Mean	129·92	130·06
	SD	10·17	5·44
10	Mean	137·79	130·89
	SD	5·57	8·21
11	Mean	136·91	133·99
	SD	6·78	7·81
12	Mean	143·17	142·49
	SD	8·59	10·73
13	Mean	148·29	145·10
	SD	11·36	6·16
14	Mean	150·09	147·87
	SD	9·44	6·91
15	Mean	152·08	149·13
	SD	8·40	6·62

TABLE III. MEAN PELVIC BREADTH (IN CM.)

Age (years)		*Boys*	*Girls*
7	Mean	18·24	18·36
	SD	1·11	0·42
8	Mean	19·16	19·12
	SD	0·96	1·15
9	Mean	19·95	19·41
	SD	1·45	0·87
10	Mean	20·77	20·26
	SD	1·05	1·46
11	Mean	20·31	20·11
	SD	0·69	1·03
12	Mean	21·48	21·42
	SD	1·12	1·34
13	Mean	22·04	21·85
	SD	1·47	1·06
14	Mean	22·53	22·79
	SD	1·80	1·58
15	Mean	23·11	24·20
	SD	1·52	3·71

TABLE IV. PELVIC BREADTH / HEIGHT RATIO

Age (years)	*Boys*	*Girls*
7	0·15	0·15
8	0·15	0·15
9	0·15	0·15
10	0·15	0·15
11	0·15	0·15
12	0·15	0·15
13	0·15	0·15
14	0·15	0·15
15	0·15	0·16

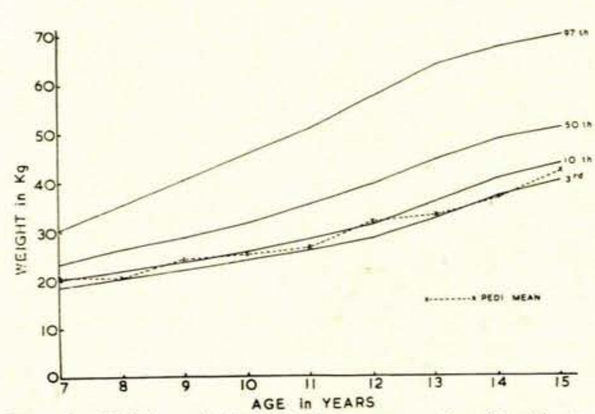

Fig. 1. Weight of Pedi girls compared with Boston percentiles.

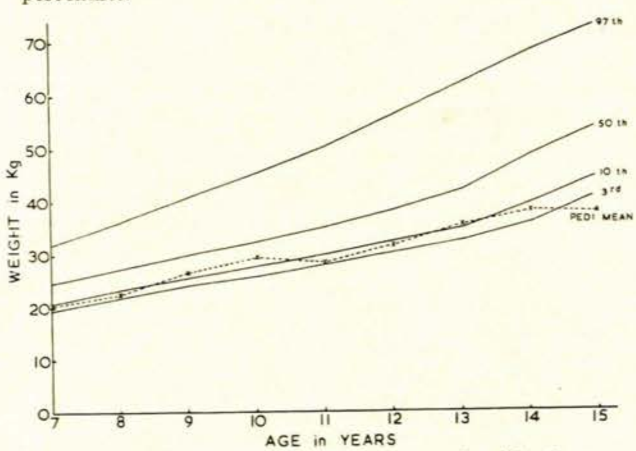

Fig. 2. Weight of Pedi boys compared with Boston percentiles.

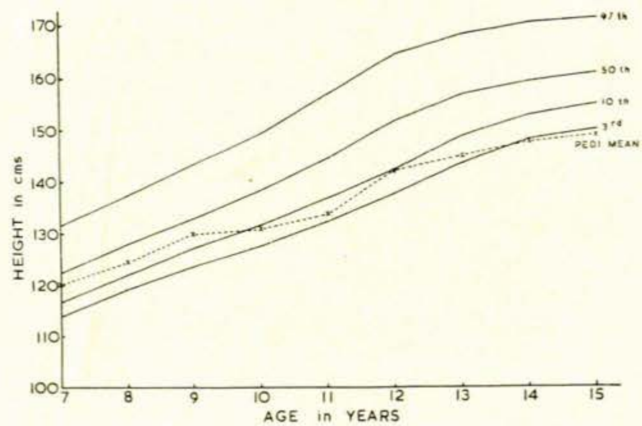

Fig. 3. Height of Pedi girls compared with Boston percentiles.

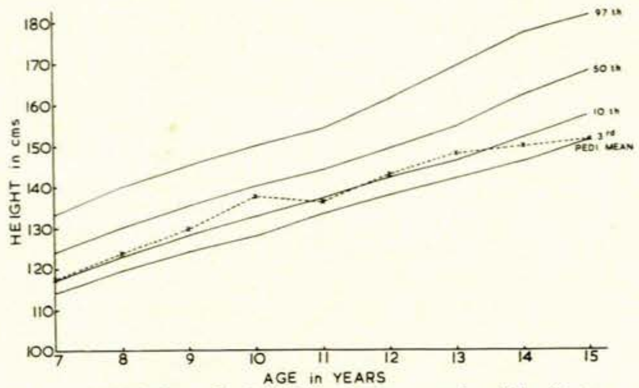

Fig. 4. Height of Pedi boys compared with Boston percentiles.

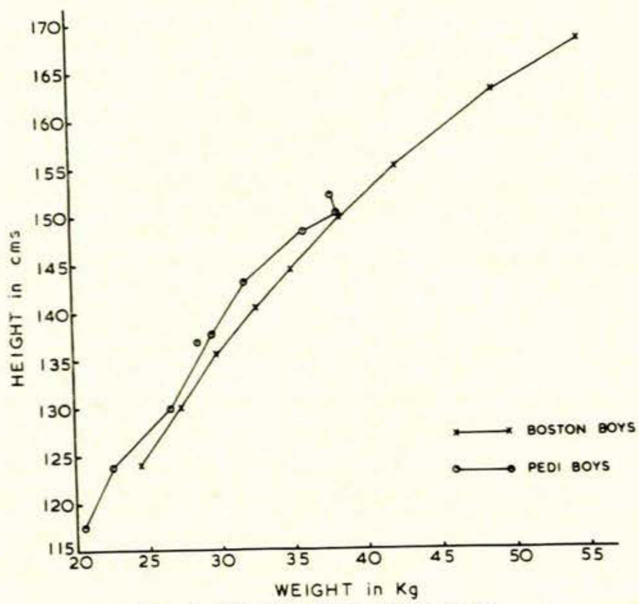

Fig. 5. Height/weight ratio in boys.

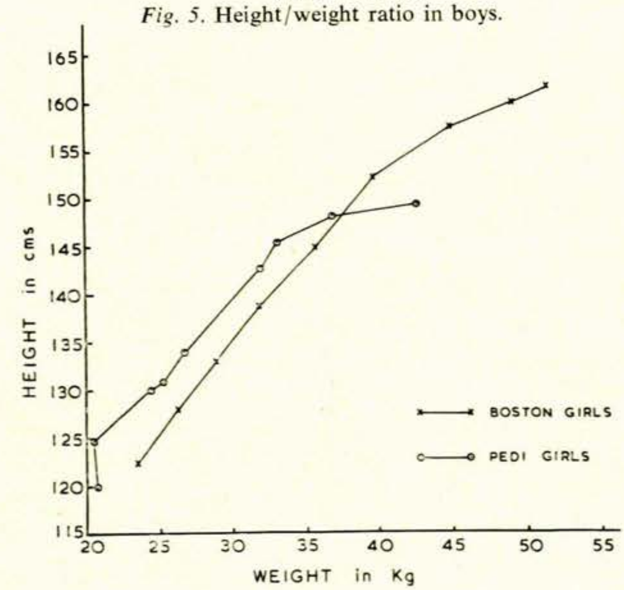

Fig. 6. Height/weight ratio in girls.

The differences between mean heights are greatest in the younger consecutive age-groups. From the age of 12 years in the case of girls, and 13 years in the case of boys, the differences are small. Standard deviations of height measurements are smaller than those of weight measurements and an increase in standard deviation towards the age of puberty is not seen.

Height/Weight Ratio

A comparison may be made between the Pedi and Boston height/weight ratios using a graph on which height is plotted as ordinate and weight as abscissa. Pedi boys (Fig. 5) are shown to weigh less at any given height than do Boston boys. The relationship is the same for younger girls (Fig. 6), but as they mature, Pedi girls show a disproportionate increase in weight. The height range of the older Boston girls is never attained, though weight range becomes the same.

Pelvic Breadth

Mean measurements for younger girls lie close to the Boston[2] tenth percentiles (Fig. 7), but the increase from the

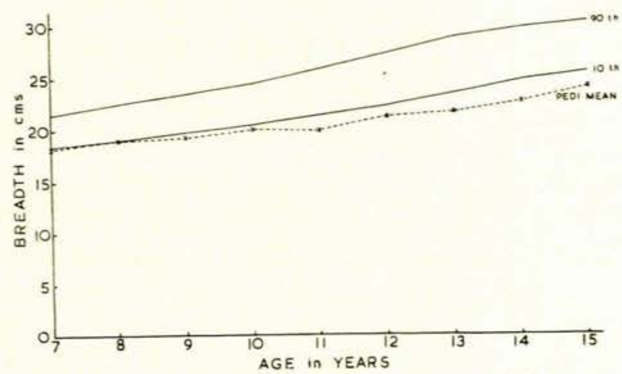

Fig. 7. Pelvic breadth of Pedi girls compared with Boston percentiles.

age of 11 years, associated with pubescence in the Boston girls, is not found, and mean measurements fall well below the tenth percentile. Only at the age of 15 years do the greater mean and greater standard deviation suggest a puberty spurt (Table III).

Mean measurements for boys correspond closely to the Boston tenth percentile until the thirteenth year (Fig. 8).

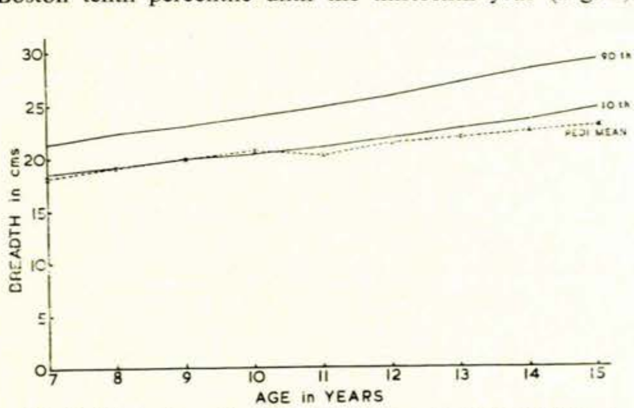

Fig. 8. Pelvic breadth of Pedi boys compared with Bost percentiles.

Thereafter they fall below, again suggesting the delayed pubescent increase of the Pedi boy. The pelvic breadth/height ratio (Table IV), which gives a rough idea of body build,[7] is the same at all ages and in both sexes. The low value of this ratio is consistent with the finding of ectomorphy as the predominant somatotype among the children.

DISCUSSION

The assessment of the physical growth of Pedi children by comparison with figures for North American children would at first seem to be illogical. The former are Bantu living under primitive tribal conditions in an arid subtropical area 4,000 feet above sea-level, while the latter are middle-class Caucasians living in the sophisticated and privileged environment of America's temperate eastern seaboard. There exists, however, much evidence to suggest that this is a rational step.

Comparison of the percentile charts for Boston children[2] and those for London children[3] show little variation in the range of normal values, and, as Ford[8] has demonstrated, in a number of studies where growth data are insufficient to calculate percentiles the mean values for children in developed countries correspond closely to the Boston fiftieth percentile. This suggests that where all environmental factors approach the ideal and children are able to fulfil their genetically determined growth potential, racial differences are slight. Further evidence in support of this statement is provided by Kahn and Freedman's study[9] of privileged Bantu children and by Greulich's study[10] of Japanese children. Kahn and Freedman found that mean measurements exceeded the Iowa fiftieth percentile,[11] and Greulich found that Japanese children growing up in California were taller and heavier than their contemporaries growing up in Japan. The Californian Japanese had a range of measurements which corresponded closely to those of American children of Caucasian descent.

The presence of a secular growth trend has been demonstrated whenever the contemporary findings of height and weight have been compared with those of previous decades. Thus, in 1941, Meredith[12] noted that the average American boy was 6% taller and 12 - 14% heavier than the average American boy of his age in 1890. The average 14-year-old Negro boy showed an increase in stature of over 8% and in weight of 15% during this 50-year period. Weir[13] examined findings in surveys of London schoolboys between 1905 and 1949 and showed a mean height increase of 5·99% and a mean weight increase of 15·5%. Tanner[14] noted that North American, British, Swedish, Polish and German data between 1880 and 1950 showed secular trends of a very similar magnitude. Walker *et al.*[15] have evidence of the same trend in Bantu schoolchildren.

This secular trend is related to improved nutrition and environment. This is confirmed by its cessation during times of national hardship and privation, such as occurred in Europe during the two world wars.[16,17] Children in the middle- and lower-income groups, who suffered most deprivation, then showed actual decreases in mean stature. Children in the upper-income groups, whose diet was less restricted, maintained their mean height and weight, but without increase. The trend was renewed when food became plentiful once more on the cessation of hostilities.

It has been noted in comparative studies that mean height and weight measurements for children from upper-income groups exceed mean measurements for children from lower-income groups.[18] While all socio-economic groups participate in the general improvement, there is evidence that children from lower-income groups have progressed relatively more than those of upper-income groups, leading to a narrowing of the class 'gap'. Thus Clements[16] notes that between 1880 and 1947, British boys between the ages of 5 and 7 years showed, on average, an increase in height of 2·5 inches and in weight of 4 lb. Children in the lower-income group, however, showed average increases of 5·5 inches and 10 lb. Howe and Schiller[17] found that, in Stuttgart, children drawn from low-income families have increased in height and weight proportionately more than children drawn from high-income families. The improvements in environment and availability of food which have paralleled these changes have been greater in poor families than in wealthy families which have always enjoyed relative plenty.

In 1883, the British Association Anthropometric Committee[19] wrote, 'Full stature is attained earlier in the well-fed and most favoured class than in the ill-fed and least favoured classes of the community'.

In 1880, increases were found in the mean stature of army recruits until the age of 24 years. In 1952, Clements and Pickett[20] were able to show that Scotsmen of all social classes reach maximum adult stature by their nineteenth year. Because of this trend to earlier full maturity, several authors[13,17,21] have expressed doubt that there has been any significant secular increase in the average mean height of British men in the last century. Apparent changes have been due to an accelerated rate of growth with earlier attainment of maximum height. Whereas previously poor nutrition and disease prevented many in the the lower-income groups from achieving their genetically determined maximum height, their improved health, nutrition and social factors now make this possible. There is an over-all approximation towards the maximum height previously found only in the upper-income groups. Tanner,[14] however, feels that a true secular height increase of 1 cm. per decade can still be demonstrated for fully grown adults.

The close approximation of mean measurements in various privileged communities, the effect of war on the secular growth trend, the gradual disappearance of a social gradient with respect to mean measurements, and the fact that children are reaching maximum height at an earlier and more uniform age, all appear to be closely correlated with nutritional standards. As the diet of underprivileged communities improves, so one may anticipate closer approximation between their growth percentiles and those of the privileged communities. The prevention and control of disease, together with adequate housing and education, no doubt play a secondary role. Racial differences appear to be of minor importance.

Since, in the absence of chronic ill-health, the mean height and weight of children are determined largely by their nutrition, Caucasian percentile charts provide the paediatrician working among underprivileged children anywhere with a rapidly applicable yardstick for nutritional assessment. Well-nourished, healthy children will have measurements within the range of the Caucasian percentile charts, irrespective of racial or climatic considerations.

When this yardstick is applied to the data collected from Pedi schoolchildren, it appears that their nutrition is inadequate. Clinical examination showed no evidence of active or chronic ill-health and this was borne out by blood and urine analyses. The climate of Sekhukhuniland is unlikely to have deleterious effects on the health of children living in the area. Prolonged drought, however, aggravated the shortage of food.

Schendel *et al.*[22] used the serum albumin concentration as a biochemical index of the protein sufficiency of the diet and defined three ranges of levels. In the absence of other pathology, they regarded the marginal range 2·78-3·52 G/100 ml. as evidence of dietary protein deficiency. Twenty-seven per cent of the Pedi children had serum albumin levels below 3·52 G/100 ml. This finding correlates well with the presumptive evidence of undernutrition obtained from a comparison of Pedi and Boston weight and height figures.

The picture of Pedi children, from a primitive community, fits into the concept referred to in the discussion and supports the idea that the anthropometric survey of children is of value. A justifiable opinion of the adequacy of the children's diet may be formed from a simple study of height and weight—which, of all physical measurements, are the easiest to obtain.

SUMMARY

Mean physical measurements obtained in a recent survey of Pedi schoolchildren are presented. These are compared diagrammatically with Boston percentiles. It is reasoned that a valid assessment of nutritional status can be obtained when the physical measurements of underprivileged children are compared with the percentile charts based on the measurements of Caucasian children.

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