East African Medical Journal Vol. 79 No. 5 May 2002
ALTERNATIVE METHODS FOR ASSESSING GROWTH IN CHILDREN UNDER FIVE YEARS OF AGE
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ALTERNATIVE METHODS FOR ASSESSING GROWTH IN CHILDREN UNDER FIVE YEARS OF AGE

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ABSTRACT

Objective: **To establish alternative methods for growth assessment in children under five years of age.**
Design: **A cross sectional study of healthy Malawian children.**
Setting: **Postnatal wards and under-five clinics at the Queen Elizabeth Central Hospital, Ndirande and Chilomoni Health Centres in Blantyre city, Malawi.**
Main outcome measures: **Cephalic, thoracic and pelvic measurements and their indices were examined for assessment of growth in these children. Thoracic and pelvic measurements were found to be the most appropriate alternative parameters to weight.**
Results: **All measurements significantly correlated positively with weight but their indices did not. The degree of significance, however, was higher in pelvic and thoracic dimensions ($P = 0.000$) than in cephalic ones ($P < 0.001$ for maximal cephalic length (MCL) and $P < 0.022$ for maximal cephalic breadth (MCB), respectively. The MCL also showed a high correlation with age ($R = 0.842$, $P = 0.002$) but age only correlated moderately with the MCB ($R = 0.569$). The thoracic circumference (TC) and inter-nipple distance (IND) showed a very high positive correlation with age ($R = 0.908$, $P = 0.005$) and $R = 0.870$, $P = 0.001$), respectively. Similarly, a high positive correlation was shown with age by pelvic circumference (PC) and inter-spinous distance (ISD), ($R = 0.891$, $P = 0.006$ and $R = 0.692$, $P = 0.027$), respectively. Whereas the pelvic index positively correlated with age ($R = 0.040$), cephalic and thoracic indices significantly correlated negatively with age. Skull shapes were dolicocephalic in 43.6% of the children, mesocephalic in 31.1% and branchycephalic in 25.3%, a clear difference from Caucasian children reported earlier by other authors.**
Conclusion: **We have established that cephalic, thoracic and pelvic dimensions significantly correlate positively with weight as age does but their indices remained relatively constant. More importantly, thoracic and pelvic measurements were the most appropriate alternative methods for growth assessment in our studied population.**

INTRODUCTION

As a human being develops from a neonate to an adult the body undergoes changes in size, composition and shape of constituent organs(1). Postnatal growth of the calvarial skeleton is related to cerebral growth. It is rapid during the first year of life, slower towards the seventh year by which time it reaches an almost adult dimension(1) and expansion is largely concentric for most of the period of growth of the vault(2). It has also been reported that during the first and early second years, growth of the vault is mainly by ossification at apposed margins of bones, accompanied by accretion and absorption of bone at the surfaces(2). Growth in breadth of the skull occurs at sagittal, sphenofrontal, sphenotemporal and occipitomastoid sutures and there is little or no sexual difference in the skull until puberty(3).

At birth the thoracic circumference is about 2 cm less than the head circumference and the two circumferences remain about the same until the child is about two years old(4). After two years, the chest continues to grow rapidly while the head only increases slightly and these measurements are significant as diagnostic tools in malignancies or vascular anomalies(4).

The assessment of developmental milestones in children has so far relied heavily on the weight-for-age index. In their study of Scandinavian subjects, however, Illingworth and Eid(5) utilised head and abdominal circumferences and suggested that the head circumference might be linearly correlated to weight of newborn. In 1990 Didia *et al*(6) also studied the relationship between the head circumference and weight of the newborn to maternal anthropometric parameters in Nigerian subjects. These studies underscore the need to explore other parameters to supplement weight in assessment of growth. Often times the weight-for-age index has been limited in rural areas when weighing scales are not available or get out of use. Under these circumstances and for a new or alternative method to succeed, the instruments must be appropriate: simple and cheap, easy to use, give reproducible results,

and in this case provide a pattern of change with age as weight does.

Nonetheless, little has been reported on thoracic and pelvic parameters and their correlation with age and weight in black Africa, and certainly none exists for children in Malawi. The aim of this study was therefore to look for alternative anthropometric methods, which might be useful in Malawi and the sub-region, for assessing the development of growth in children less than five years of age.

MATERIALS AND METHODS

Children: Measurements of the maximal cephalic length and breadth, inter-nipple distance, thoracic circumference, inter-spinous distance, pelvic circumference and weight were made on 657 children under the age of five years. Of these 587 healthy children were studied, 281 were females and 306 were males. The study was carried out in postnatal wards and in under-five clinics at the Queen Elizabeth Central Hospital and at Ndirande and Chilomoni Health Centres. Mothers' consent was sought before recruiting children into the study; those with chronic infection (30), overt malnutrition (20) and those with skin infections (20) were excluded.

Measurements: The maximal cephalic length (MCL) was defined as the distance from glabella to maximal occipital point, while maximal cephalic breadth (MCB) as the bi-parietal distance and was measured at right angles to sagittal plane. The inter-nipple distance (IND) is the distance between the nipples and the thoracic circumference (PC) was the widest part of the thorax taken at the nipple line. The inter-spinous distance (ISD) is the distance between the anterior superior iliac spines, while the pelvic circumference (PC) was taken at this spinous line(3). A non-tensile measuring tape was used to take measurements, but cephalic dimensions used calipers calibrated to 1 mm. Children were weighed on a health-o-meter professional scale (Pat no. D 327,227) calibrated to 0.1 g.

Indices: Cephalic, thoracic and pelvic indices were derived from the measurements indicated above. The cephalic index was defined as the maximal cephalic breadth divided by maximal cephalic length; the thoracic index as the ratio of inter-nipple distance divided by thoracic circumference, and the pelvic index as the inter-spinous distance divided by pelvic circumference. The measurements and their indices were then used to determine the pattern of change with age and their correlation with weight.

Analysis: The body measurements and their indices were then correlated to age and a two-way analysis of variance was carried out on correlation coefficients of the same parameters. The correlation coefficients were determined by Pearson Product Moment Correlation formula {Woodward and Francis, 1980 (7)} as follows

$$r = \frac{\Sigma XY - \frac{(\Sigma X)(\Sigma Y)}{n}}{\sqrt{(\Sigma X^2 - \frac{(\Sigma X)^2}{n})(\Sigma Y^2 - \frac{(EY)^2}{n})}}$$

where, r = correlation coefficient; X and Y = any two random variables; n= number of observations or subjects.

The interpretation of the calculation was as follows: little if any correlation = 0.00 to ± 0.25, low correlation = ± 0.26 to ± 0.49, moderate correlation = ± 0.50 to ± 0.69, high correlation = ± 0.70 to ± 0.89), very high correlation = ± 0.90 to ± 1.00.

RESULTS

Cephalic, thoracic and pelvic measurements: Table 1 shows the correlation of cephalic, thoracic and pelvic parameters as well as weight of Malawian children with age. The results indicate that cephalic measurements showed high correlation with age, but age only showed moderate correlation with MCB. With thoracic measurements, there was a very high positive correlation with TC and IND (Table 1). Table 1 also shows a high positive correlation between age and PC (R = 0.891, P = 0.0606), but ISD correlated moderately with age (R = 0.692). Whereas the cephalic and thoracic indices significantly correlated negatively, the pelvic index correlated positively with age, although this was not significant. As expected weight showed a very high positive correlation with age.

Table 1

The correlation of age with various parameters of the body among Malawian subjects

Parameter	Correlation with age	P
MCL	0.842	0.002 (s)
MCB	0.569	0.088 (ns)
B/L	-0.662	0.037 (s)
TC	0.908	0.003 (s)
IND	0.870	0.001 (s)
IND/TC	-0.713	0.020 (s)
PC	0.891	0.006 (s)
ISD	0.692	0.027 (s)
ISD/PC	0.040	0.909 (ns)
Weight	0.957	0.0002 (s)

Note: s = significant, ns = not significant; MCL = mean cephalic length, MCB = mean cephalic breadth, B/L = cephalic index: TC = thoracic circumference, IND = inter-nipple distance, IND/TC = thoracic index. PC = pelvic circumference, ISD = inter-spinous distance, ISD/PC = pelvic index.

Indices: Table 2 shows the pattern of change of cephalic, thoracic and pelvic indices with age. Examination of the various age groups indicates that these indices generally remained unaltered with age.

Correlation of coefficients: The correlation of coefficients of the various body parameters and their indices are shown in Table 3. The results show that age and all measurements correlated significantly positively to weight but the indices were not. The degree of significance was higher in pelvic and thoracic dimensions (P = 0.000) than in cephalic ones (P < 0.001 and P < 0.022 for MCL and MCB, respectively).

Table 2

The pattern of change of body indices with age among Malawians

Age in months	Cranial index (B/L)	Thoracic index (IND/TC)	Pelvic index (ISD/PC)
6	78.7	25.5	37.3
12	77.3	25.8	36.9
18	76.3	25.2	36.9
24	73.4	25.1	36.5
30	77.4	24.7	36.6
36	77.8	25.5	36.7
42	75.3	25.5	37.5
48	76.5	24.6	37.2
54	74.1	23.7	34.5
60	70.6	24.5	38.9

Table 3

Correlation coefficients of body measurements and their indices with weight among Malawian subjects using a 2-way variance

Parameter	Weight	Estimate	P
Age	.9416	10	.000 (s)
MCB	.7070	10	.022 (s)
MCL	.8929	10	.001 (s)
B /L	*	10	*
IND	.9088	10	.000 (s)
TC	.9782	10	.000 (s)
IND/TC	*	10	*
ISD	.6996	10	.024 (s)
PC	.9675	10	.000 (s)
ISD/PC	*	10	*
Weight	1.000	10	*

Note: s = significant; * = cannot be computed

Shapes of skulls: The skulls were dolicocephalic in 256 children (43.6%), mesocephalic in 183 (31.1%) and branchycephalic in 148 children (25.3%), respectively.

DISCUSSION

Cranial dimensions: This study has demonstrated a high positive correlation between the mean cephalic length and age (R = 0.842), indicating that age has a statistically significant effect on this parameter (P = 0.002). On the other hand, the mean cephalic breadth, (MCB) showed a moderate positive correlation (R = 0.569) although there was no significant increase (P = 0.881) with respect to age. The differential growth shown here could be due to the growth of the cerebrum. The cephalic length commonly shows areas of ossification at apposed margins of cranial bones, which possess an osteogenic layer, accompanied by some accretion and absorption of bone at the surfaces; these factors adapt to continually altering curvatures(3). The cephalic breadth might be due to ossification taking place at sagittal, spheno-frontal, spheno-temporal and occipito-mastoid sutures and petro-occipital cartilaginous joints. It might also be explained by the development of masticatory and neck muscles.

Thoracic measurements: The high positive correlation between the maximal thoracic circumference (TC) and age (R = 0.908, P = 0.003) showed a corresponding increase of the thoracic circumference with age. Most probably this could be due to the growth of intra-thoracic viscera (heart and lungs) and to some measure by growth of abdominal organs (liver and spleen). The same reasons might apply to the high positive correlation shown between the mean inter-nipple distance (IND) and age (R = 0. 870, P = 0.001).

Pelvic measurements: A high positive correlation was also demonstrated between the pelvic circumference and age (P = 0.006). The increase in pelvic circumference with age might be due to the development of muscles attached to the corresponding bones of the pelvis since it provides attachment to a large number of muscles of the trunk and the lower limb. The growth of pelvic viscera and raised intra-abdominal pressure resulting from defecation and micturition could also play a role in pelvic enlargement although these only explain the increase in pelvic circumference in general regardless of sex, and we found no significant difference in pelvic circumference between the sexes (P > 0.05, t-Test). This finding is unlike reports that showed some differences between male and female as early as the fourth month of foetal life, more especially with the pubic arch and sub-pubic angles(3), but we did not investigate this aspect in the present study.

Correlation of coefficients: We have confirmed that weight is an important index for assessing developmental milestones of growth in children less than five years of age (1 ,5, 6). We have also established that cephalic, thoracic and pelvic dimensions positively and significantly correlate with weight as age does, but their indices remained fairly constant. The degree of significance was higher in pelvic and thoracic dimensions than cephalic ones, suggesting that thoracic and pelvic measurements were the most appropriate alternative methods for assessing growth in these children, followed by cephalic dimensions. However, since this was a cross-sectional study, there is need to carry out a prospective study to ascertain if the body indices (cephalic, thoracic and pelvic) are indeed inappropriate for assessment of developmental milestones in children in this population.

Body indices: We have demonstrated that the pattern of change of body indices remained relatively constant with increasing age. In general these indices assess body proportions (1, 4, 6), but the cephalic index is also used to show variations in the shapes of skulls. It has been reported in Caucasians, for instance, that if this index is below 74.9% it describes a dolichocephalic shaped skull, that it is elongated antero-posteriorly; when 75.0 - 79.9% the skull is rounded or mesocephalic, and if 80 - 84.9% the skull is pointed posteriorly or has a branchycephalic shape(3). These indices are clearly different from those reported in the present study, where 43.6% were dolicocephalic, 31.1% mesocephalic and 25.3% were branchycephalic, respectively, and this is indicative of racial differences(8).

CONCLUSION

Cephalic, thoracic and pelvic dimensions significantly correlate positively with weight as age does but their indices remained relatively constant. Moreover, thoracic and pelvic measurements were the most appropriate alternative methods for growth assessment in our subjects.

ACKNOWLEDGEMENTS

We wish to thank parents and guardians of our subjects, the staff of Queen Elizabeth Central Hospital Paediatrics Department, Ndirande and Chilomoni Health Centres, Mr H. Misiri of Community Health Department for statistical help and Mrs A Machonjo of Anatomy Department for secretarial assistance.

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