Anthropometric Growth Pattern in Ethiopian Infants and Children: An Evaluation Based on Different International Growth References

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A B S T R A C T

At the population level international growth references have been widely used as useful tools to assess a number of situations, i.e.: to predict local and general emergencies related to food and nutrition; to assess the equity of distribution of economic resources within and between communities; to evaluate the suitability of weaning practices and to screen and following at-risk groups. Nevertheless, recently several concerns were raised regarding the adequacy of currently existing growth references involving study design, population sample, time validity, and evaluation of infant and children well-being in terms of food availability and nutritional adequacy. As in the past, discussion involve also suitability of local or national reverences versus the international ones. This paper focusses on the re-evaluation of the main auxometric indexes, i.e.: height for age, weight for height and BMI in a sample of infant and children aged between 24 and 120 months from urban and rural Ethiopia. Previous evaluation based on the NCHS-1977 growth references led to striking results in terms of growth retardation while a recent evaluation based on NCHS-2000 (NHANES) growth references gave better but contradictory pictures. As consequence, concerns on the adequacy of international references use in infant and children growth assessment in the developing countries seem to be widely justified while local or national well built growth references should offer the possibility for a most realistic evaluation.

Key words: *malnutrition, evaluation, growth parameters, international references, Ethiopia*

Introduction

Since 1960s several international agencies as WHO and FAO periodically stress the importance of growth studies and support them particularly in developing countries, since such studies provide a suitable tool for evaluating adequacy of nutrition. Children's growth and development are considered sensitive detectors of the gross health level of a given population and reflect its present and past nutritional conditions. However the reliable anthropometric evaluation of the »normality« of growth in children belonging to different ethnic background, social conditions and dietary intake, and environmental stressors deserves caution. To allow comparison of measurements between ethnically different samples of children measured in different geographical areas at different times, a WHO Working Group[1] elaborated the general guidelines for the use and interpretation of anthropometric indicators of the nutritional status mainly based on the grounds of growth studies of children in reference populations. In view of the fact that US-NCHS data[2] were considered to fulfill the basic requirements of a reliable reference frame, they have been proposed as international reference values for comparison and evaluation of the nutritional status of different groups of children[1,3]. Consequently many fieldworkers have used the NCHS references for screenings for malnourished children. Since then many students have used the malnutrition in children. Several authors however have criticized[4,5] the generalized use of the NCHS reference data for screening of children from developing countries and suggest the opportunity to use local growth references[4,5]. In view of this criticism is the aim of this study to check the reliability of these NCHS data on a sample of children from rural areas of Ethiopia. In a first step their nutritional status was evaluated using the 1977-NCHS references[2] and subsequently those of the most recent (US-NCHS) NHANES references[6].

Outlines of nutritional distress in Africa

Although growth is known to be influenced by genetic as well as by environmental factors, the latter are of greater importance. For it is under optimal levels of environmental conditions that genetic factors become most effective. The past decades have witnessed a proliferation of research on the interaction of nutrition and human development, unfortunately however the harnessing of this wealth of information to reduce the incidence of malnutrition has been less successful. Thus notwithstanding massive efforts in developing countries with augmentation of annual food production by 2.8% and a dramatic increase of the prevalence of contraceptive practice has led to a reduction of annual population growth to 2.2%, children in 1984 still went to be hungry, and still the prognosis for ending world hunger is not encouraging. Sub-Saharan Africa has had an aggregate malnutrition rate of nearly 30% for the last decade. While malnutrition prevalence has decreased significantly in most other developing countries in the last years, it has been nearly static for Sub-Saharan Africa. Nutritional studies have found that linear growth (height for age) and ponderal growth (weight for age) have different nutritional requirements. While inadequate energy intake is the main reason for wasting (low weight for height), stunting (low height for age) can be caused by numerous inadequacies. Thus growth analyzed by the anthropometric indices as weight for age and height for age serves as a sensitive indicator of health and nutritional status of children. Currently, about a one-fourth of African primary schoolchildren lie under the fifth centile of US-NCHS Reference Standard for height and weight for age recommended by WHO when local standards are not available.

Short description of growth and nutrition in Ethiopia

Ethiopia is one of the largest and most populous countries in northeastern Africa (Figure 1). The Ethiopian population is of great diversity, with differences in cultural background and traits, methods of gaining a livelihood, languages and religions. Many languages and dialects are spoken, they may be grouped into two major language groups i.e. Semitic and Cushitic languages. Semitic includes Amharic, the official national language, Tigrigna, Tigre and Guragigna, and Cushitic includes Oromigna, Somali, Sidama and Afar. Although there is often a great mix of religions in any given place, Muslims (47.5%) are the most numerous of the total Ethiopian population, Coptic Christians amount to 37.5% and the remainder includes various indigenous religions. There does not exist any statistic on the distribution of religions amongst the various ethnic groups, however the majority of the Amhara, who are mainly concentrated in the Center and the North of the highland, are Coptic Christians. The Oromo, who live in the South of the highland and in the Southern lowlands, on the other hand are mainly Muslims, and indigenous religious groups are mainly represented in the Southeast and

Fig. 1. Map of Ethiopia.

Southwest of the lowlands. Ethiopia is most densely populated in the highland areas, and almost 90% of the people lives outside the cities. For the year 1989, Minca estimated the size of the total population of Ethiopia about 49 million, with an increase of the mean population density from 23 to 38 inhabitants per km^2 during the last decade. More than 45% of the people are 15 years old and younger, and both birth and death rates are high i.e. crude birth rate 45.13 and crude death rate 17.63 (as expressed per 1000 persons).

With an average life expectancy at birth of about 45 years for males and 49 years for females, it ranges among the lowest of the world. Disease and malnutrition continue to be the major problem of Ethiopian children, and the present study was made possible by Italian efforts to improve the distressing medical and sanitary situation in Asela and surroundings, the capital of one of the most densely inhabited highland area. In cooperation with the Ethiopian sanitary authorities the Italian Ministry of Foreign Affairs it was decided to build an hospital in Asela and to set up a maternal and child health program. The task of the present study to investigate and evaluate the nutritional status of infants and children in Amhara and Oromo was an integral part of this program.

Sample and Methods

212 female and 209 male infants and children aged between 2 and 10 years (Table 1) have been investigated between 1992 and 1993 in urban and rural areas of Ethiopia. The age of children was recorded by interviews with the parents, which consisted primarily of their mothers. Interviews were conducted by a medical doctor and a nurse. All participants were examined by a physician, and were free from overt disease at the time of the study. All study protocols were approved by the Regional Sanitary Centre of Asela (the capital of the region formerly

TABLE 1

AGE DISTRIBUTIONS (YEARS) OF THE 209 MALES AND 212 FEMALES INFANTS AND CHILDREN INVESTIGATED IN ASELA, ETHIOPIA

Age	Males	Females
2	8	2
3	11	18
4	29	21
5	39	32
6	25	21
7	28	35
8	32	35
9	23	24
10	14	24
Total	209	212

named Arssi) and informed consent was obtained from the participants' parents. Both interviews and measurements were performed in health centres, schools and in the hospital in Asela and in six neighbouring villages situated at an altitude of about 2200 meters. The measurements were standardized by assessments of intra- and inter-observer variability and regular calibration of the measuring equipment was performed. The measurements included body height (measured to the nearest 0.1 cm with a Martin metal anthropometer) and body weight (measured to the nearest 0.1 kg with a portable mechanical scale).

These measurements have been selected according to WHO[2,5] recommendations on the principle of their maximal informative value for nutritional state of infants and children. Consequently the means and standard deviations of the following parameters have been calculated: weight for age, height for age and BMI. These parameters and indices correspond to those used to set up global reference values. The reference values used for comparison with the Ethiopian children were: 1977 NCHS references[2] standards for height for age, weight for age and 2000 (NHANES) NCHS[6] references for the same parameters, with the inclusion of the Body Mass Index. Since for many reasons Ethiopian references proposed by Eksmyr in 1970[7] are hardly comparable with our data, as a first approach the National Centre for Health Statistics growth charts, -curves and -tables were used as references in accordance with WHO recommendations. Data analysis includes calculation of distribution and a normality check of each auxometric parameter by Kolmogorow-Smirnof non parametric test; the LMS parameters are: the median (M), the generalized coefficient of variation (S) and the power in the Box-Cox transformation[8,9]. The comparison with the corresponding values obtained from the international references completed the analysis.

Results

All the auxometric parameters were normally distributed. The only exception was weight of five years old males. The anthropometric parameters height for age and weight for age do not differ significantly between females and males at any age (Table 2 and Table 3).

Furthermore in Asela, on the basis of both the 1977 and 2000 US-NCHS (NHANES) standards, in both sexes height and weight were below the 50th percentile with a consistent concentration of the values below the 10th percentile. This is particularly striking in Table 4, where the highest numbers of children who are extremely small for their age (below the 3rd centile and between the 3rd and the 10th centile) are those 2, 3 and 4 years old, and similarly those whose weights are extremely low for their age (Table 4).

As regards both references however values of BMI seem to be distributed in a more balanced way and a consistent frequency of children clusters between the 20th and the 80th centile, showing prevalence of a substantial constitutional equilibrium among the subjects taken into

TABLE 2

MEANS AND STANDARD DEVIATION OF HEIGHT (CM) FOR AGE IN INFANTS AND CHILDREN FROM ASELA

	Height						
	Males				Females		
Age	Mean	N	Std. Deviation	Age	Mean	N	Std. Deviation
2	74.50	8	3.60	2	74.25	2	2.47
3	83.71	11	3.16	3	81.59	18	4.33
4	93.12	29	5.92	4	92.19	21	4.33
5	100.73	39	6.04	5	102.30	32	6.59
6	106.02	25	4.03	6	109.02	21	6.82
7	112.70	28	6.70	7	112.96	35	6.84
8	119.03	32	5.97	8	119.86	35	5.96
9	126.34	23	5.65	9	125.29	24	8.06
10	129.34	14	8.40	10	129.69	24	7.16
Total		209		Total		212	

TABLE 3

MEANS AND STANDARD DEVIATION OF WEIGHT (KG) FOR AGE IN INFANTS AND CHILDREN FROM ASELA

	Weight						
	Males				Females		
Age	Mean	N	Std. Deviation	Age	Mean	N	Std. Deviation
2	9.46	8	1.38	2	8.95	2	0.78
3	11.13	11	1.24	3	10.98	18	1.53
4	13.52	29	1.62	4	13.08	21	1.78
5	15.33	39	1.82	5	15.77	32	2.48
6	17.26	25	2.25	6	18.05	21	3.35
7	19.61	28	2.66	7	18.97	35	3.78
8	20.87	32	2.77	8	20.70	35	2.79
9	24	23	2.95	9	23.12	24	3.07
10	25.21	14	2.99	10	25.12	24	3.93
Total		209		Total		212	

TABLE 4

CENTILE DISTRIBUTION FOR HEIGHT, WEIGHT AND BMI AMONG 421 MALES AND FEMALES, FROM ASELA, ETHIOPIA

Weight	1–3	3–10	10–20	20–50	50–80	80–90	90–97	97–100	p<0.05
1977	189	100	61	53	14	3	1	0	
2000	242	62	55	51	8	3	0	0	
Height									p<0.05
1977	376	25	8	9	3				
2000	261	66	40	38	14	2			
BMI									p<0.05
1977	119	71	19	55	72	17	21	47	
2000	67	53	58	91	90	32	26	4	

consideration. This trend appears most evident as regards the 2000 NCHS reference standards (Table 5). Notwithstanding the fact that comparison of height, weight and BMI values of the children with the 1977 and 2000 NCHS reference standards for same ages shows a similar general distribution, results highlight differences particularly below the 3rd percentile. Thus, identifying nutritional status of children belonging to ethnical origin and socio-economic conditions different from those of the subjects taken into consideration in setting up the international reference standards, errors may be made which may greatly increase the risk of obtaining unreliable identification of undernourished children.

Concluding Remarks

The proposed local reference standard for growth of Ethiopian children can hardly be used for a fully reliable comparison with our data in order to identify the degree of under-nutrition in Asela's growing population. Nevertheless it can be easily ascertained that our data of height and weight observed among the children from Asela substantially overlap those obtained by Eksmyr[9] for a sample of Ethiopian Private School children (Addis Ababa) of the same age range. This observation, together with the results exposed above, leads to the conclusion that identification of malnourished children by anthropometric variables should be done preferably using local references. This conclusion is consistent with the statement that there are rather small differences between groups with similar socio-economic status and different ethnic background, in contrast to great differences between population groups with similar ethnicity and different socio-economic backgrounds[10]. If one »standard for all«, built in an optimal socio-economic environment (as in the case with 1977 and 2000 US-NCHS standards), is taken as the only reference, it is assumed that only a different socio-economic background justifies the observed differences of growth in different population contexts. In our opinion, both socio-economic and genetic backgrounds as well as their mutual interaction have to be taken into account for the construction of anthropometric growth references. In this sense, the conclusion reported above strengthens the opinion of Goldstein and Tanner[11], who also stress the use of local standards in particular conditions.

TABLE 5
CENTILE DISTRIBUTION OF 421 ETHIOPIAN INFANTS AND CHILDREN (MALES AND FEMALES) FOR AGE, ACCORDING TO 1977 AND 2000 NCHS INTERNATIONAL REFERENCES

1977 * 2000 Crosstabulation										
		2000								Total
		1–3	3–10	10–20	20–50	50–80	80–90	90–97	97–100	
1977	1–3	189								189
	3–10	53	44	3						100
	10–20		18	43						61
	20–50			9	44					53
	50–80				7	7				14
	80–90					1	2			3
	90–97						1			1
	97–100									
Total		242	62	55	51	8	3			421

1977 * 2000 Crosstabulation										
		2000								Total
		1–3	3–10	10–20	20–50	50–80	80–90	90–97	97–100	
1977	1–3	261	57	32	18	6	2			376
	3–10		9	6	8	2				25
	10–20			2	5	1				8
	20–50				7	2				9
	50–80					3				3
	80–90									
	90–97									
	97–100									
Total		261	66	40	38	14	2			421

1977 * 2000 Crosstabulation										
		2000								Total
		1–3	3–10	10–20	20–50	50–80	80–90	90–97	97–100	
1977	1–3	67	45	7						119
	3–10		8	51	12					71
	10–20				19					19
	20–50				52	3				55
	50–80				8	64				72
	80–90					14	3			17
	90–97					9	12			21
	97–100						17	26	4	47
Total		67	53	58	91	90	32	26	4	421

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ANTROPOMETRIJSKI OBRASCI RASTA U ETIOPIJSKE NOVOROĐENČADI I DJECE: PROCJENA TEMELJENA NA RAZLIČITIM MEĐUNARODNIM REFERENCAMA ZA RAST

S A Ž E T A K

Na nivou populacije, međunarodne reference za rast se široko upotrebljavaju kao korisni alati za procjenu brojnih slučajeva, tj. kako bi se predvidjele lokalne i generalne pojave vezane uz prehranu, kako bi se ocijenila ravnopravnost distribucije ekonomskih resursa u i između zajednica, kako bi se odredila pogodnost praksi prestanka dojenja te kako bi se odredile i pratile rizične grupe. Nedavno su se pojavile određene zabrinutosti vezane uz pogodnost postojećih referenci rasta koje uključuju dizajn istraživanja, uzorak populacije te evaluaciju dobrobiti novorođenčeta i djeteta u smislu dostupnosti hrane i nutricionističke adekvatnosti. Kao i u prošlosti, diskutira se također o pogodnosti lokalnih ili nacionalnih autoriteta spram međunarodnih. Ovaj rad fokusira se na reevaluaciju glavnih auksometrijskih indeksa, tj, visina za dob, težina za visinu te inteks tjelesne težine u uzorku novorođenčadi i djece u dobi od 24 do 120 mjeseci iz urbane i ruralne Etiopije. Prethodne evaluacije bazirane na NCHS-1977 referenci rasta pokazale su zapanjujuće rezultate vezano uz retardaciju rasta dok nedavne procjene temeljene na NCHS-2000 (NHANES) referenci rasta daju bolje ali kontradiktorne slike. Kao posljedicu, zabrinutost oko pogodnosti upotrebe međunarodnih referenci u procjeni rasta djece i novorođenčadi čini se opravdana dok lokalne ili nacionalne dobro izgrađene reference rasta trebaju pružiti mogućnost za realističnije evaluacije.