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Nutritional assessment of infants and preschool children using two different anthropometric criteria of classification

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A comparison of two criteria for assessing malnutrition in infants and children has been carried out in a sample of 184 healthy infants and children grouped according to two different anthropometric criteria: considering the quantity of body mass for linear dimension by the ratio W/H; and considering the degree of wasting according to weight for height (WH).

Biochemical studies were also carried out in each child and correlated with body systems of classification. Total amino acids in serum and eryhtrocytes, the non-essential/essential amino acid ratio in serum and erythrocytes, total serum proteins and the albumin/alpha globulin ratio were investigated.

The results showed that both criteria were closely related, the linear regression between them was highly significant ($r = 0.931$). Nevertheless, the W/H criterion classified as undernourished a higher proportion of children, because it included those of delayed biological age though not malnourished. On the contrary, WH only classified as undernourished those who probably have actual malnutrition. Biochemical studies showed significant correlations with both criteria but higher r values were found for W/H in some cases.

Thus, classification on the basis of WH including the analysis of the degree of wasting and of stunting, is satisfactory for individual and community assessment, but it should include the classification of overweights. It must be stressed that both systems, being based on weight as the basis of classification, do not consider body composition and therefore can only assess whole body mass and thus only approximate the nutritional status.

Traditionally, nutritional assessment has been based upon the magnitude of weight impairment to chronological age [8, 18]. More recently, new criteria of classification have been developed which take into account height as well as body weight. According to Waterlow's proposal [27], the degree of wasting is measured on the basis of weight as the percentage of expected weight for actual height, independently of chronological age. McLaren and Read [22, 24] recommended the formula

actual weight/ actual height
expected weight/expected height,

a classification not independent of age.

As many controversial opinions have been expressed concerning the accuracy of both criteria of classification, especially in regard to their capacity to establish the limit of risk of malnutrition, we have attempted to correlate both of them with some

biochemical parameters widely applied for nutritional assessment and for the early diagnosis of malnutrition. A further aim was to compare the two systems in regard of their quality in the discrimination of underweight or overweight children among those who are supposed to be normal.

Materials and Methods

One hundred and eighty-four infants and children from two to six months old of both sexes, attending Day-Care Centres in the City of Havana, were studied. They represented a random sample of the children from each region of Havana included in the National Investigation of Growth, Development and Nutritional Status of Children attending Day-Care Centres, carried out in 1974 [17].

Anthropometric assessment was performed according to the methodology of the Cuban National Child Growth Study [16, 19]. The values obtained for weight and height were referred to the Preliminary Charts for weight, height and weight for height or length of the Province of Havana [19].

Infants and children comprising the sample were grouped according to two different anthropometric criteria:

1) Considering the quantity of body mass for linear dimension by the ratio

$$W/H = \frac{\text{Actual weight/Actual height}}{\text{Expected weight/Expected height for age}},$$

as proposed by McLaren and Read [24];

2) Considering the degree of wasting as proposed by Waterlow (27)

$$WH = \frac{\text{Actual weight}}{\text{Expected weight for Actual height}}.$$

In the second criterion we have included also children with more than 100% of weight for height, making 10% wide categories. This aspect has not been considered in the original proposition which was conceived solely for the evaluation of undernutrition.

A blood sample was drawn from each subject after a morning fast and collected in heparinized capillary tubes. The following determinations were carried out:

1) Total amino acids in plasma (TAAP) and erythrocytes (TAAE) by the colorimetric method of Rubinstein and Pryce [26].

2) Non-essential/essential amino acid ratio (ne/e) in plasma (Pne/e) and erythrocytes (Ene/e), according to Whitehead [29] with some modifications [15].

3) Total serum protein (TP) by the method of Gornall et al. [9].

4) The product albumin by alpha globulin ($A\alpha$) by Wieme's method [30].

5) The ratios erythrocyte/plasma for ne/e and for TAA were also calculated.

6) Erythrocytic ne/e ratio was obtained according to the percentage of non-essential and essential amino acids and their net value in plasma and total blood, considering the net blood volume (0.1 ml) and the haematocrit by the formula (13),

$$Z = \frac{(a - b)\,100}{\text{Haematocrit}} + b = \text{mg/dl of total}$$

amino acids in erythrocytes,

where a = total amino acids in total blood (mg/dl),
b = total amino acids in plasma (mg/dl),
Z = total amino acids in erythrocytes (mg/dl).

For erythrocytic total amino acids, the procedure was the same but referred to total amino acid concentrations.

The correlation coefficients between the two criteria of classification and between each criterion and each biochemical parameter were calculated. A significance test based upon the approximate t distribution

for each correlation coefficient was also carried out [31].

The distribution of the sample according to three main groups of classification was also made upon a common basis. It was considered normal weight for both criteria of classification when the ratio of actual weight for expected weight was between 0.91 and 1.10; underweight, when this value was less than 0.909; and overweight, if it was over 1.10. Differences of distribution were evaluated employing the χ^2 test. Finally, a regression line was drawn between the figures of both criteria. In all cases the level of significance was established at $\alpha = 0.05$. Data were processed employing a Cuban-made minicomputer CID—201B.

Results

The results shown in Table I seem to point to a better discrimination by McLaren and Read's than by Waterlow's criterion. There was a significant difference in the proportion of underweights which was higher with the first method. No differences were found in the percentage of overweights.

Correlations were significant for all the biochemical parameters, except for total protein. The correlation coefficient was higher for McLaren and Read's criterion (Table II). There was a significant difference for ne/e ratio in plasma and for the ratio E/P for ne/e. The product $A\alpha$ too showed significant differences. The regression study revealed a linear regression between the two criteria, the r value (0.931) being highly significant (Fig. 1).

Discussion

Determination of the weight of a child in relation to the weight expected for his actual height has been widely used and recommended [20, 27]; it provides an age-independent index of the current nutritional status. A low weight for height suggests that a given child has been on an energy and/or protein deficient diet in the period immediately prior to the examination, but cannot distinguish individuals who had had malnutrition in the past.

Table I

Distribution of 184 children between 2 and 60 months of age according to two different systems of nutritional assessment

Criteria of Assessment	Weight/height		Weight for height	
	No.	per cent	No.	per cent
Overweights	32	17.4	31	16.9
"Normal" weight	100	54.8	126	68.3
Underweights	52	27.8	27	14.8
Total	184	100.0	184	100.0

$\chi^2 = 28.50$
$p < 0.001$

TABLE II

Correlation between two criteria of anthropometric nutritional assessment and some biochemical variables in 184 infants and children

Variable \ Criteria of Classification	Weight/height		Weight for height	
	r	p	r	p
Non essential/essential amino acid ratio (Plasma)	—0.499	<0.001	0.145	<0.05
Non essential/essential amino acid ratio (Erythrocytes)	0.219	<0.01	0.188	<0.05
E/P Ratio for ne/e.	0.570	<0.001	0.186	<0.05
Total amino acids (Plasma)	—0.458	<0.001	—0.480	<0.001
Total amino acids (Erythrocytes)	—0.694	<0.001	—0.490	<0.001
E/P Ratio for TAA	—0.463	<0.001	—0.505	<0.001
Albumin by Alpha globulin	0.286	<0.001	0.163	<0.01
Total Proteins	0.126	>0.05 n.s.	0.081	>0.05 n.s.

The ratio W/H measures the relative quantity of body mass for a given linear unit and is more precise if we consider that it takes into account the fact that at each age a certain weight (in g) is associated with a certain length (in cm). The weight increases with age, being about 67.5 g per cm at birth and 132.5 g/cm by 12 months of age. Thereafter it increases slowly, to 169 g/cm at 60 months. Thus, for each age the ratio is different, increasing progressively, and therefore individuals with the same height or length should have different ratios if their ages are different [22]. Length may also differ widely among healthy children of the same age due to genetic, prenatal and postnatal influences. Consequently, weight is frequently related to length without taking into account physiological or pathological variations in body composition [10].

In recent years, increasing interest has been devoted to the body components for a more accurate nutritional assessment [2, 3, 4, 6, 7, 11, 14, 21, 25]. Classifying the sample according to the ratio W/H, we found a higher proportion of underweight children than with the use of the WH criterion. This agrees with McLaren and Read's observation [24], considering that Waterlow's system tends to underestimate the problem of the detection of malnutrition. These authors, comparing a group of undernourished children according to both classifications, found that the differences increase with the severity of malnutrition, and an important num-

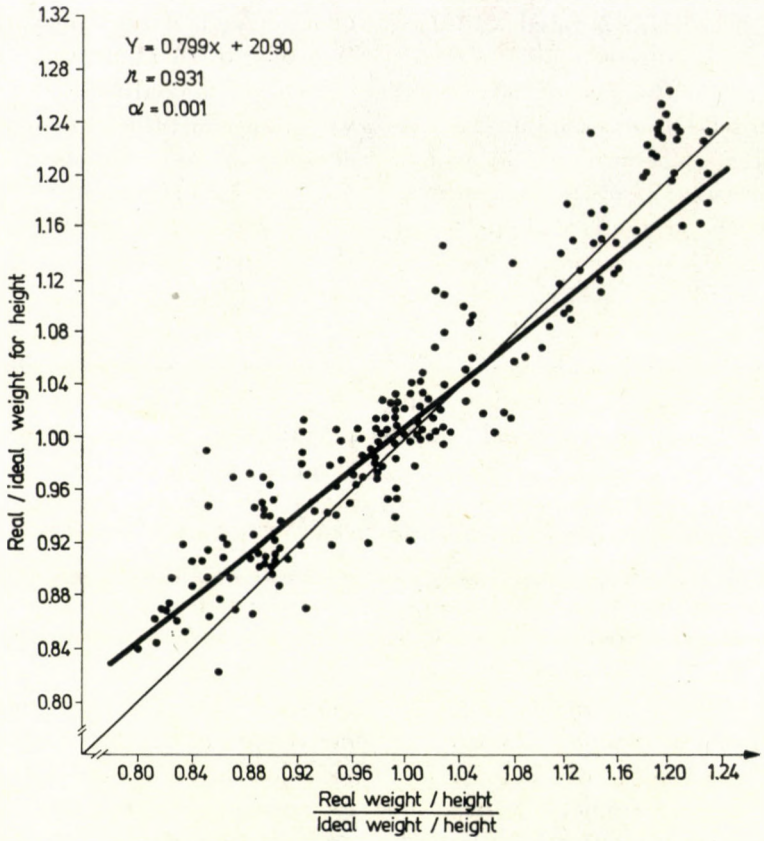

FIG. 1. Correlation between the two criteria of classification

ber of undernourished children should not be considered for Public Health actions or priorities if classified according to Waterlow's system.

This higher possibility of discrimination in McLaren and Read's system has nevertheless to be considered with caution because it includes as malnourished individuals some who actually are not malnourished, and even children classified as undernourished according to the WH criterion might be constitutionally thin and not actually undernourished.

Another important fact is that the differences between both systems are not apparent for the overweight group. The proportion of overweights according to both criteria is similar and there are no significant differences between them. The W/H criterion includes underweight children who according to WH are in the normal range. The difference could be explained on the basis of the age-dependence of W/H. According to WH, there is always a determined value of weight for a given length,

even if the child is stunted. Stunting may be the expression of a delayed biological age and, accordingly, lower figures for W/H corresponding to biological age could be found in a child with nutritional growth retardation, and not the expected (higher) ones according to his chronological age.

Thus, children who have nutritional growth retardation, even if they are not wasted, should exhibit a lower W/H ratio, and according to this criterion, should be considered undernourished.

Therefore, in this sense, McLaren and Read's criterion overestimates the problem if the degree of stunting is not taken into account. According to this criterion, nutritional dwarfism occurs if the W/H is normal i.e. above 90% and height is under 90%, but height is not a reliable indication of the present status of malnutrition and, moreover, cannot be used as a factor in its classification. According to these authors, a given height deficit may result either from a brief period of retarded growth in early childhood or from a longer retardation of growth at an older age [23].

In order to confirm this hypothesis, we analysed the 52 underweight children detected by the W/H criterion, classifying them again according to both systems, but considering their height for age instead of the chronological age for W/H. The results appear in Table III. As it is seen, no significant differences in distribution ($p > 0.05$) were found. Another important finding was that the W/H ratio is not normal for chronological age when there is a growth retardation, being only normal if a correction is made for height for age in non-wasted children.

Thus, the question arises, which of the two systems gives a better information? That which includes as underweight children those who are retarded in biological age probably on account of a compensated previous undernutrition, or that which considers underweight those children who have some degree of wasting, i.e. a low weight for height?

TABLE III

Classification of 52 infants and children considered underweight according to W/H, using height for age instead of chronological age

Criteria of Classification	W/H		W for H	
	No.	per cent	No.	per cent
"Normal" weight	23	44.2	25	48.2
Underweight	29	54.8	27	51.8
Total	52	100.0	52	100.0

$X^2 = 0.31$
$p > 0.1$ n.s.

There is no doubt that, if we want to determine current undernutrition, WH gives the more reliable information. On the other hand, body mass for a given linear dimension changes with age and this fact may affect the accuracy of WH determination because it is important to know in which children body mass has not changed as it ought to according to age.

The correlation studies between each of the criteria and several biochemical variables used for nutritional assessment showed highly significant r values, except when regressing with TP. For the ne/e ratio in plasma and erythrocytes and also for the ratio E/P for this variable and for Aα, the value of r and therefore the level of significance is higher for the ratio W/H than for WH. This closer relationship could be regarded as the expression of a better quality of W/H ratio in nutritional assessment. This difference is more significant if we consider that the W/H criterion includes children without actual undernutrition whose values for the biochemical variables are expected to be normal.

It is well known that indicators which use measurements not distinguishing body composition are not completely accurate when dealing with values near the cut-off points between normal and abnormal. Thus, the diagnosis of marginal malnutrition is still a challenge in the field of nutrition.

As a conclusion, there is a significant correlation between both systems of classification of the nutritional status, and the differences found are due to the age dependence of W/H. For assessing overweight, both criteria are similar, but there is a clear difference with underweights.

If we want to assess actual undernutrition, WH gives a figure closer to the situation, keeping in mind that there are some children who are constitutionally thin and not actually undernourished and show a low weight for height. As Waterlow's classification of undernutrition considers the degree of stunting together with the degree of wasting, children with growth retardation should also be detected and classified, and the action diagram could be applied [28] and Public Health actions could be carried out.

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