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Energy/Protein Index: III. Correlation with a biochemical parameter which reflects protein nutritional imbalance

By

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To establish the usefulness of the Energy/Protein index, a study was made to assess its correlation with a biochemical parameter able to detect marginal forms of protein-energy malnutrition such as the non-essential/essential aminoacid ratio.

A simple linear regression model was proposed and tested in a sample of ninety-seven malnourished children, by means of analysis of variance. The model was satisfactory. A highly significant ($p < 0.001$) correlation coefficient of $r = 0.552$ was found.

Energy/Protein Index is a new anthropometric index described by us. It relates the logarithm transformation of the triceps skin-fold (S) and the logarithm of middle arm muscular circumference (MAMC) [1, 4.] The index shows little variability among well-nourished preschool children, and is not sex-dependent [1].

As this index relates a parameter such as the triceps skin-fold which reflects body energy reserves with another one depending on the status of protein nutrition [12, 13, 20, 27], it allows to assess the relative impairment of both factors which characterize protein-energy malnutrition (pem) thus making it possible to distinguish between the two kinds of pem, marasmus and kwashiorkor. Thus, by means of the Wellcome Trust Classification [9], we could study the behaviour of the index in four groups of malnourished children and found it possible to discriminate between mild and severe forms of marasmic pem and between these and kwashiorkor [2]. This proved true for the clinically detectable forms of pem but it remained necessary to study the ability of the index to detect marginal or subclinical forms, when just biochemical changes are present.

Protein imbalance may be detected according to its severity, by several biochemical parameters. The non-essential/essential aminoacid ratio (neaa/eaa ratio) is one of the first factors to show alterations even in

marginal cases. Although the issue is controversial, the ratio has been employed with success by many authors [5, 11, 17, 21, 23, 24, 29, 32]. Moreover, we found a significant correlation between neaa/eaa ratio and MAMC [3]. Thus, a significant correlation was expected between the E/P index and some biochemical parameters such as the neaa/eaa ratio.

Materials and Methods

Ninety-seven preschool children admitted to the Nutrition Ward at the William Soler Paediatric Hospital, Havana, with the diagnosis of protein-energy malnutrition were studied.

The diagnosis of pem was established from the weight for height deficit in a child with pondostatural retardation [28]. Reference standards for weight and arm circumference (MAC) was measured in each patient in the middle third of the left upper arm, using a fibre-glass tape. Triceps skin-fold thickness was obtained at the same site using a Harpenden skin-fold caliper with a standard pressure of 9.3 g/mm^2. All anthropometric measurements were recorded in duplicate by the same previously trained observer, and with the help of an assistant who wrote out and verified the data. The methods of measurement were as described by Jelliffe [19]. Starting from MAC and S values, MAMC was obtained according to the formula [20]

$$\text{MAMC} = \text{MAC} - \pi \times \text{S}, \qquad \text{where}$$

MAC = middle arm circumference in cm;
MAMC = middle arm muscular circumference in cm;
S = triceps skin-fold thickness in cm;
$\pi = 3.1416$

The transformation to a log scale of S according to the caliper employed is as follows [10]:

$Z = \log_{10}$ (reading in 0.1 mm $-$ 18).

The E/P index was calculated by the formula (3.5):

$$\text{E/P index} = \frac{\text{Transformed S}}{\log_{10} \text{MAMC}}$$

Simultaneously with anthropometric and clinical assessment, on admission a venous blood sample was drawn from each child. After clotting, serum was separated by centrifugation.

Paper chromatography of the serum was performed according to Whitehead [31], with some modification [6]. The ratio non essential/essential aminoacids was obtained as the quotient of the photocolorimetric reading after elution of the correspondent spots of the chromatogram. [31].

The Pearson correlation coefficient between E/P index and non-essential/essential aminoacid ratio was calculated, and a significance test for this correlation was performed. Then, a simple linear regression model was postulated, the regression parameters were calculated and the hypothesis of linearity was verified by means of an analysis of variance. The E/P index was taken as the dependent variable [8, 22, 33].

Results

The correlation coefficient estimate was $r = 0.552$ and it turned out to be highly significant at a level of $\alpha < 0.01$. The significance test was based upon $t = r\sqrt{\frac{n-2}{1-r^2}}$ which follows a t $-$ Student distribution with $n-2$ degrees of freedom.

The following ANOVA table summarizes the results of the calculations performed to test the hypothesis of linearity.

Source of variation	Sum of squares	D. F.	Means squares	Variance ratio
Within groups	3.460 768	73	0.047 408	
Regression	1.657 695	1	1.657 695	
about the regression	0.949 693	22	0.043 168	0.910 564
Total	2.607 388	23	0.113 365	

F^{22} (0.05) = 1.70

Thus, the F value was not significant and the hypothesis of a linear relationship between the two variables could not be rejected. Finally, the regression equation is

$Y = b X + a$, where

Y = E/P index

X = neaa/eaa ratio

a = 1.094 56

b = 0.206 63

Discussion

We found a close relationship between E/P index figures and neaa/eaa ratio values. High values for the E/P index corresponded to high values of the aminoacid ratio, and the results obtained showed that both the anthropometric and the biochemical parameters have a similar capacity for the detection of relative changes between energy and protein status.

The selection of neaa/eaa ratio as the biochemical parameter to be correlated was based upon the positive results obtained in a previous work, where a correlation coefficient $r = 0.486$ ($p < 0.001$) was found between this ratio and MAMC [3].

Considering the objections raised by several authors regarding the neaa/eaa ratio and the influence on its value of diet composition instead of protein status [7, 25], we tried to prevent the eventual influence of the dietary factors by taking the blood samples at the moment of admission, before any treatment had been administered. In contrast with blood sampling, anthropometric measurements are a simple task, easily performed by non-medical personnel. Moreover, calculation of the E/P index is performed by a simple mathematical formula which can be programmed in a general-purpose minicomputer, and applied to field studies for the screening of malnutrition in the community.

Several authors have attempted to quantify the magnitude of the impairment of energy and protein status, considering the study of adiposity and muscle mass at the middle third of the upper arm [13, 14, 15, 16].

Gurney and Jelliffe [15] set up a hypothesis about the possibility of classifying malnourished children in different categories of nutritional deficiencies. They developed a nom-

ogram [16] which allows the calculation of fat and muscle areas at the middle upper arm level, and had proved useful in community nutrition surveys.

Our E/P index quantifies the relative impairment of energy and protein nutritional status and therefore offers more complementary data than a study of separate measurements. The ability of the index to discriminate among different forms of malnutrition (kwashiorkor and marasmic forms of pem) and the finding of a significant linear correlation with biochemical parameters of recognized value in the detection of marginal protein malnutrition, lend to the E/P index a diagnostic value in the early detection of energy or protein imbalance.

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