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Testing of two score systems for the diagnosis of malnutrition

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Two score systems, one for the diagnosis of obesity and another for diagnosing undernutrition were tested in thirteen overweight and seven underweight children aged five years and preliminarily classified as malnourished. These score-systems included indicators grouped into three categories, those which evaluate total body mass changes (one-point group); those which assess fatness (two-point group); and those which assess fatness and/or body composition through complex indices (three-point group). Indicators such as Energy/Protein Index, AKS Index, Somatotype ratings, and Somatotype Dispersion Distances were included in the third group and played an important role in the final score.

A subject was classified as malnourished if he reached 80% of the maximum possible score. According to these criteria, only six among the thirteen overweight children could be considered obese and none of the seven underweight ones could be classified as undernourished.

Mild or moderate overweight or underweight may be misleading and an incorrect diagnosis of either obesity or undernutrition can be made if the possibility of constitutional corpulence or thinness is not taken into account.

When clinical and anthropometric features of malnutrition are evident, the diagnosis of either obesity or undernutrition can be made easily, but the problem of identifying nutritional imbalance arises when the commonly used methods of assessment fail to establish whether changes beyond the typical ranges are due to malnutrition or correspond to constitutional peculiarities of a given individual [5] due mainly to the influence of genetic factors than to nutritional ones [16, 17].

It is well known that there is no unique criterion capable to discriminate among typical subjects those who are malnourished [5]; moreover, the estimates of obesity and leanness in a population vary with the criteria used [9, 24, 43]; and a given criterion differs in its diagnostic value according to the purpose we use it: for screening, for ascertaining the true prevalence of disease, or for use in surveillance [22]; or according to the type [39] or degree [22] of malnutrition we are assessing. Anyhow, a simple division of children into well-nourished and malnourished on the basis of a single parameter can be misleading [39]; therefore in order to achieve better results and obtain a precise diagnosis, it is necessary to combine several criteria [39].

The selection of these criteria has

to be made on the basis of several premises, considering the changes in body mass and body composition which occur as consequences of nutritional disturbances. The premises should be

1. Total body mass is increased in obesity and decreased in undernutrition.

2. Obesity is characterized by an increase in Fat Body Weight (FW).

3. Mean feature in undernutrition is the decrease of Lean Body Weight (LBW), with a more or less marked decrease of FW.

Considering these three premises, we have made an attempt to establish a score system based upon several criteria, some of them classic and others not commonly used in nutritional assessment, testing this system in two small samples of selected supposedly malnourished children.

Materials and Methods

A group of twenty supposedly malnourished children admitted with the preliminary diagnosis of obesity or undernutrition was studied. Thirteen of these children, 8 girls and 5 boys, showed mild or moderate overweight (weight for stature up to 160%); and the other seven, 4 girls and 3 boys, were slightly or moderately underweight (weight for stature not less than 75%). The children were otherwise healthy. Their age ranged from 4.2 to 5.3 years of decimal age.

Anthropometric assessment consisted in the following measurements:

1. Body Weight (BW)
2. Stature (HT)
3. Humerus Width (biepicondylar diameter)
4. Femoral Width (bicondylar diameter)
5. Upper Arm Circumference (UAC)
6. Flexed Biceps Girth (FUAC)
7. Calf Girth (CC)
8. Triceps Fatfold (T)
9. Subscapular Fatfold (SS)
10. Suprailiac Fatfold (SI)
11. Calf Fatfold (C)

Date of birth and date of recording were registered for obtaining the decimal age as described by Tanner et al [41].

All measurements were done on the right side of the body as required for somatotyping. The general aspects of the methodology employed including general recommendations, subject position, instruments and apparatus, were those recommended by the International Biologic Programme [41], and have been described elsewhere [2, 3].

Expected BW for HT (BW/HT), was obtained according to Ounsted and Simmons [31] as follows.

$$BW/HT = \frac{A}{B} 100$$

$$\text{where } A = \frac{\text{Actual BW of the subject}}{\text{Actual HT of the subject}}$$

$$\text{and } B = \frac{\text{50th percentile BW for age}}{\text{50th percentile HT for age}}$$

Expected values for BW, HT, UAC, CC and fatfolds were referred to the 50th percentile of Cuban standards [26].

Energy/Protein Index (E/P) was calculated in each child by the expression [2]:

$$E/P = \frac{TT}{TUAMC}$$

where TT is transformed T [13], TUAMC is $\log_{10}$ of upper arm muscle circumference [25].

The somatotype components were obtained according to Heath and Carter [23], and Ross et al [34]. Using the somatotype plotting grid [34], the somatotype of each subject was plotted by the formulae

$$X = III - I \text{ and } Y = 2II - (1 + III)$$

where I is the first component of endomorphy, II is the second component of mesomorphy, III is the third component of ectomorphy.

Somatotype Dispersion Distances were calculated in each subject according to the expression [34]:

$$SDD = \sqrt{3(X_1 - X_2)^2 + (Y_1 - Y_2)^2}$$

where X_1 and Y_1 represent the coordinates of a given subject, and X_2 and Y_2 are the previously reported mean reference values for age and sex [7].

Fat Body Weight (FW) was calculated by means of Dugdale and Griffiths' regression equations [12], starting from BW, HT, T and SS. Lean Body Weight (LBW) was obtained by substracting FW from BW. Body Fat percent (%BF) was obtained by the expression

$$\%BF = \frac{FW \times 100}{BW}$$

Aktiver Körpersubstanz Index (AKS) was obtained according to Wutscherk [42] as follows

$$AKS = \frac{LBW}{HT^3} 100$$

Previous reports regarding percentile distribution for E/P [3] and for FW, %BF, LBW, and AKS [8] were taken as reference.

Twelve different criteria which could be considered indicators of obesity were tested in each of the 13 overweight subjects. In order to quantify the results, we established a score system in which each criterion present in the subject received a number of points according to its quality as indicator of the nutritional status as follows.

(a) Criteria which evaluate total body mass changes obtained one point; these were

1. BW for age above 90th percentile
2. BW for HT (BW/HT) above 120%
3. UAC above 90th percentile
4. CC above 90th percentile

(b) Criteria which assess fatness from single measurements obtained two points; these were

5. Triceps fatfold above 90th percentile
6. Subscapular fatfold above 90th percentile
7. Suprailiac fatfold above 90th percentile

(c) Criteria which assess fatness and/or body composition through more complex indices obtained three points; they were

8. FW above 90th percentile
9. %BF above 90th percentile
10. E/P above 90th percentile
11. Endomorphy (1st component) ≥ 3.5 in girls and ≥ 3.0 in boys
12. SDD ≥ 6.00

According to this score, the maximum for an individual is 25 points and we established an arbitrary cut-off cumulative value of 20 (80% of the total possible) above which a subject could be classified as obese.

Fifteen different criteria which could be considered indicators of undernutrition were tested in each one of the seven underweight subjects comprising the sample. Like in overweight subjects, a similar score system was established as follows.

(a) One-point group

1. BW for age under 10th percentile
2. BW/HT under 90%
3. BW/HT under 80%
4. UAC under 10th percentile
5. CC under 10th percentile

(b) Two-point group

6. T under 10th percentile
7. SS under 10th percentile
8. SI under 10th percentile
9. FW under 10th percentile
10. %BF under 10th percentile

(c) Three-point group

11. LBW under 10th percentile
12. AKS Index under 10th percentile
13. E/P Index under 10th percentile
14. Mesomorphy (2nd component) < 4.0 (in both sexes)
15. SDD ≥ 7.00

The maximum cumulative score in this case was 30, and the 80% regarded as cut-off point was 24.

All statistical and computational work was carried out at the Centre of Cybernetics Applied to Medicine of the Higher Institute of Medical Sciences of Havana.

Table Ia

Anthropometric measurements in 13 overweight (supposedly obese) children

Subject No.	Age Sex	BW kg	HT cm	Girths, cm		Circumferences, cm			Fatfolds, mm			
				Humer	Femor	UAC	FUAC	CC	T	SS	SI	C
1	4.6	26.2	109.3	4.5	7.0	20.0	21.0	24.0	13.0	9.6	8.2	8.6
	F	(8)	(6)	(a)	(a)	(8)	(a)	(7)	(7)	(7)	(7)	(a)
2	4.8	21.0	104.2	4.3	7.0	20.6	21.3	25.1	11.6	6.1	6.2	6.9
	F	(7)	(5)	(a)	(a)	(8)	(a)	(7)	(7)	(5)	(6)	(a)
3	4.9	20.8	109.1	4.7	7.0	19.8	20.9	23.2	11.4	8.6	7.5	9.3
	F	(8)	(6)	(1)	(a)	(8)	(a)	(6)	(7)	(6)	(6)	(a)
4	4.3	20.4	107.3	4.9	7.0	19.1	20.8	24.1	11.2	7.3	8.2	8.1
	F	(7)	(6)	(a)	(a)	(7)	(a)	(7)	(7)	(5)	(7)	(a)
5	4.4	21.5	110.9	4.5	6.5	19.2	20.7	24.4	13.1	9.6	9.7	9.2
	F	(8)	(6)	(a)	(a)	(7)	(a)	(7)	(7)	(7)	(7)	(a)
6	4.2	22.2	109.6	4.5	6.8	18.6	19.6	23.7	12.6	9.8	9.6	6.2
	F	(8)	(6)	(a)	(a)	(7)	(a)	(7)	(7)	(7)	(7)	(a)
7	5.0	25.9	110.0	4.6	7.1	21.2	22.3	24.2	13.2	9.0	8.1	8.2
	F	(8)	(6)	(a)	(a)	(8)	(a)	(7)	(7)	(7)	(7)	(a)
8	5.2	23.8	110.6	4.8	7.2	21.9	22.8	24.3	12.9	9.6	7.8	7.7
	F	(8)	(6)	(a)	(a)	(8)	(a)	(7)	(7)	(7)	(6)	(a)
9	4.3	19.6	103.2	4.5	7.0	19.8	20.6	22.9	13.2	9.6	8.4	9.6
	M	(7)	(5)	(a)	(a)	(8)	(a)	(7)	(8)	(8)	(7)	(a)
10	4.4	19.1	104.2	4.6	7.2	18.6	19.2	23.1	12.1	6.2	7.1	8.4
	M	(7)	(5)	(a)	(a)	(7)	(a)	(7)	(8)	(5)	(7)	(a)
11	4.2	19.6	108.0	4.4	6.8	18.8	19.4	23.6	11.1	8.8	7.8	8.5
	M	(7)	(7)	(a)	(a)	(8)	(6)	(7)	(7)	(7)	(7)	(a)
12	5.2	21.5	108.8	4.5	6.7	18.1	18.6	22.4	11.9	7.9	7.6	7.1
	M	(7)	(5)	(a)	(a)	(7)	(a)	(5)	(7)	(7)	(7)	(a)
13	5.3	21.9	111.0	4.6	6.8	19.3	20.1	23.7	11.5	8.8	8.4	7.7
	M	(7)	(5)	(a)	(a)	(8)	(a)	(7)	(8)	(7)	(7)	(a)

BW: Body weight
HT: Stature
UAC: Upper arm circumference
FUAC: Flexed UAC
T: Triceps fatfold
SS: Subscapular fatfold
SI: Suprailiac fatfold
C: Calf fatfold

in parentheses:
percentile channels
8: >97th
7: >90th ≤97th
6: >75th ≤90th
5: >50th ≤75th
(a), Cuban standards not available.

Results

The recorded data of anthropometric measurements and calculated indices in the 13 overweight children are shown in Tables Ia and Ib. Table Ic includes an analysis of the twelve different indicators expressed above which could be regarded as criteria of obesity. According to the score-system established, only six out of the thirteen subjects accumulated twenty points or more. Subjects 1, 7 and 13 showed a score of 25, and subjects

TABLE Ib

Anthropometric indices in 13 overweight (supposedly obese) children

Subject No.	BW/HT %	FW kg	%BF	LBW kg	AKS	E/P	Somatotype components			SDD
							1st	2nd	3rd	
1	155.8	9.01 (8)	34.38 (8)	17.19 (8)	1.32 (7)	1.896 (7)	3.5	5.5	0.5	6.43
2	126.6	5.88 (6)	28.02 (6)	15.12 (6)	1.34 (7)	1.804 (6)	2.5	6.0	0.5	5.84
3	122.5	5.43 (6)	26.09 (6)	15.37 (7)	1.22 (5)	1.796 (6)	3.0	5.5	1.0	5.56
4	125.1	5.24 (6)	25.66 (5)	15.16 (6)	1.23 (5)	1.785 (6)	2.5	5.5	0.5	5.62
5	128.4	5.73 (6)	26.63 (6)	15.77 (7)	1.16 (4)	1.798 (6)	3.5	5.5	1.0	5.96
6	132.9	6.42 (7)	28.92 (6)	15.78 (7)	1.20 (5)	1.815 (6)	3.0	5.0	0.5	5.96
7	150.4	8.58 (8)	33.11 (7)	16.32 (8)	1.23 (5)	1.877 (7)	3.5	5.5	0.5	7.29
8	135.1	7.97 (8)	31.72 (7)	16.53 (8)	1.22 (5)	1.861 (7)	3.0	6.0	0.5	6.48
9	123.6	5.55 (8)	28.06 (8)	14.06 (5)	1.28 (6)	1.789 (7)	3.5	6.0	0.5	5.75
10	118.0	4.02 (7)	21.05 (7)	15.08 (5)	1.33 (7)	1.762 (6)	2.5	6.0	0.5	3.99
11	123.0	4.11 (7)	20.95 (7)	15.50 (5)	1.23 (5))	1.758 (6)	3.0	5.5	1.0	4.31
12	122,1	5.04 (8)	25.07 (8)	15.06 (5)	1.17 (4)	1.795 (7)	3.0	4.5	1.0	5.39
13	122.9	6.06 (8)	27.66 (8)	15.84 (5)	1.17 (4)	1.802 (7)	4.0	5.0	1.0	6.78

BW/HT: Body weight for stature
FW: Body weight in fat
%BF: Body fat percent
LBW: Lean body weight
AKS: AKS Index
E/P: Energy/Protein Index
SDD: Somatotype dispersion distance

in parentheses:
percentile channels
8: >97th
7: >90th ≤97th
6: >75th ≤90th
5: >50th ≤75th
4: >25th ≤50th

8, 9 and 12 exhibited scores of 20, 22 and 21 respectively.

The anthropometric measurements and indices in seven underweight children appear in Tables IIa and IIb. Table IIc includes the cumulative score of the fifteen criteria of undernutrition. None of the seven subjects studied reached a score of 24.

Figures 1 and 2 show the individual cases (boys and girls respectively) plotted in somatocharts. Each somatochart includes the mean value for age and sex as reported previously

TABLE Ic

Selected criteria for classification as obese of 13 overweight children

Criteria considered positive of obesity		Subject No.												
		1	2	3	4	5	6	7	8	9	10	11	12	13
Body Weight above 90th percentile	(1)	×	×	×	×	×	×	×	×	×	×	×	×	×
Upper Arm Circumference above 90th percentile	(1)	×	×	×	×	×	×	×	×	×	×	×	×	×
Calf Circumference above 90th percentile	(1)	×	×	—	×	×	×	×	×	×	×	×	—	×
Body Weight for Stature above 120%	(1)	×	×	×	×	×	×	×	×	×	—	×	×	×
Triceps Fatfold above 90th percentile	(2)	×	×	×	×	×	×	×	×	×	×	×	×	×
Subscapular Fatfold above 90th percentile	(2)	×	—	—	—	×	×	×	×	×	—	×	×	×
Suprailiac Fatfold above 90th percentile	(2)	×	—	—	×	×	×	×	—	×	×	×	×	×
Body Weight in Fat above 90th percentile	(3)	×	—	—	—	—	×	×	×	×	×	×	×	×
Body Fat percent above 90th percentile	(3)	×	—	—	—	—	—	×	×	×	×	×	×	×
E/P Index above 90th percentile	(3)	×	—	—	—	—	—	×	×	×	—	—	×	×
Endomorphy (1st component) ≥3.5-girls- ≥3.0-boys	(3)	×	—	—	—	×	—	×	—	×	—	×	×	×
Somatotype Dispersion Distance (SDD) ≥6.00	(3)	×	—	—	—	—	—	×	×	—	—	—	—	×
Total score		25	6	5	8	13	13	25	20	22	13	19	21	25
Classified as obese		×	—	—	—	—	—	×	×	×	—	—	×	×

Number of points given to each criterion appears in parentheses

[7], and the distribution of overweight as well as underweight subjects.

DISCUSSION

In this paper we have attempted to give answers to the practical questions what to do with those children whose parents are worried about their nutritional status, a preoccupation usually reinforced by hasty medical diagnosis of malnutrition based upon weight for age, weight for stature or similar criteria, when the children show no apparent cause of malnutrition either organic or socioeconomic; and are such children actually mal-

TABLE IIa

Anthropometric measurements in 7 underweight (supposedly undernourished) children

Subject No.	Age Sex	BW kg	HT cm	Girths, cm		Circumferences, cm			Fatfolds, mm			
				Humer.	Femor.	UAC	FUAC	CC	T	SS	SI	C
1	4.6 F	12.7 (2)	103.9 (5)	4.2 (a)	6.1 (a)	14.1 (2)	14.5 (a)	19.7 (3)	6.0 (2)	4.6 (2)	3.4 (2)	4.8 (a)
2	4.3 F	12.2 (2)	98.6 (3)	4.1 (a)	6.0 (a)	14.5 (2)	14.8 (a)	19.2 (2)	5.8 (2)	4.2 (1)	2.8 (1)	4.1 (a)
3	4.5 F	11.9 (a)	100.1 (4)	4.0 (a)	5.9 (a)	13.9 (1)	14.1 (a)	19.6 (3)	4.6 (1)	4.4 (2)	3.4 (2)	3.7 (a)
4	4.2 F	12.2 (2)	102.0 (5)	4.2 (a)	6.2 (a)	14.4 (2)	14.9 (a)	19.0 (2)	5.8 (2)	4.6 (2)	3.7 (3)	4.6 (a)
5	4.3 M	12.7 (2)	102.2 (5)	4.1 (a)	6.0 (a)	14.5 (2)	15.0 (a)	1.94 (2)	5.5 (2)	3.9 (2)	2.9 (1)	4.0 (a)
6	4.4 M	13.3 (2)	104.8 (5)	4.3 (a)	6.4 (a)	14.6 (2)	15.0 (a)	19.2 (2)	4.5 (1)	3.9 (2)	3.2 (2)	4.3 (a)
7	4.3 M	12.6 (1)	102.7 (4)	4.2 (a)	6.5 (a)	14.8 (3)	15.2 (a)	19.9 (3)	5.4 (2)	4.0 (2)	3.8 (1)	4.4 (a)

BW: Body weight
HT: Stature
UAC: Upper Arm Circumference
FUAC: Flexed UAC
T: Triceps Fatfold
SS: Subscapular Fatfold
SI: Suprailiac Fatfold
C: Calf Fatfold

in parentheses
percentile channels
1: ≤3rd
2: >3rd ≤10th
3: >10th ≤25th
4: >25th ≤50th
5: >50th ≤75th
(a), Cuban standards not available

nourished or only constitutionally heavy or thin?

The subjects we have selected for the study were otherwise healthy children. Growth and development were within the expected range for their age and sex; they had chronic disease and routine laboratory studies showed no abnormality.

Among the overweight children, the familiar incidence of overweight or "heavy constitution" was as follows

(a) Parents and one or more siblings, 2 subjects (Nos 1 and 4)

(b) Both parents, 2 subjects (Nos 5 and 8)

(c) One or more siblings, 2 subjects (Nos 7 and 13)

(d) One parent, 4 subjects (Nos 2, 3, 10 and 11)

(e) No parent or sibling, 2 subjects (Nos 9 and 12).

Thus, eleven subjects had at least one close relative with overweight or "heavy constitution". As these relatives were not examined and we have been informed only by the child's parents, it was not possible to establish which of them were actually

TABLE IIb

Anthropometric indices in 7 underweight (supposedly undernourished) children

Subject No.	BW/HT %	FW kg	%BF	LBW kg	AKS	E/P	Somatotype components			SDD
							1st	2nd	3rd	
1	78.8	0.254 (1)	2.02 (1)	12.45 (3)	1.11 (3)	1.490 (2)	1.5	4.0	4.0	7.95
2	81.5	0.882 (1)	7.22 (1)	11.32 (2)	1.18 (4)	1.450 (2)	1.5	4.5	3.0	5.41
3	76.9	0.527 (1)	4.43 (1)	11.37 (1)	1.13 (3)	1.323 (1)	1.5	4.0	3.5	6.96
4	78.7	0.301 (1)	2.47 (1)	11.90 (3)	1.12 (3)	1.455 (2)	1.5	4.0	4.0	7.95
5	80.7	0.609 (1)	4.97 (1)	12.09 (2)	1.13 (3)	1.419 (2)	1.5	4.0	3.5	6.96
6	80.9	0.421 (1)	3.16 (1)	12.88 (3)	1.12 (3)	1.277 (1)	1.5	4.5	4.0	7.07
7	79.3	0.537 (1)	4.30 (1)	12.06 (2)	1.11 (3)	1.396 (2)	1.5	4.5	3.5	6.11

BW/HT: Body Weight for Stature
FW: Body weight in fat
%BF: Body fat percent
LBW: Lean Body weight
AKS: AKS Index
E/P: Energy/Protein Index
SDD: Somatotype dispersion distance

in parentheses:
percentile channels
1: $\leq$3rd
2: $>$3rd $\leq$10th
3: $>$10th $\leq$25th
4: $>$25th $\leq$50th

obese. Nevertheless, the association of overweight in parents and siblings with overweight in the subjects studied was evident, but no differences could be detected between those overweight children we have classified as obese and those considered non-obese.

Among underweights, the information obtained from parents was less precise regarding the siblings. "Thin constitution" was present in both parents in subjects Nos 1 and 5; in one parent in subjects Nos 3, 4, 6 and 7; and subject No. 2 had no thin parents.

Though the probability of being obese or lean increases with the incidence of obesity or leanness in the kinship [20], the same familiar incidence can be expected for "heavy" or "light" constitution. Hence, unless the familiar incidence of obesity or undernutrition could fully be distinguished from the familiar incidence of heavy or light constitution, this aspect cannot be considered a reliable indicator for assessing malnutrition.

The score system was based upon criteria accepted as suitable for nutritional assessment, though some of them are not used commonly. The categorization of these criteria into three groups, each one with a different value in the score, took into

TABLE IIc

Selected criteria for classification of seven underweight children as undernourished

Criteria considered positive of undernutrition		Subject, No.						
		1	2	3	4	5	6	7
Body Weight under 10th percentile	(1)	×	×	×	×	×	×	×
Upper Arm Circumference under 10th percentile	(1)	×	×	×	×	×	×	—
Calf Circumference under 10th percentile	(1)	—	×	—	×	×	×	—
Body Weight for Stature under 90%	(1)	×	×	×	×	×	×	×
Body Weight for Stature under 80%	(1)	×	—	×	×	—	—	×
Triceps Fatfold under 10th percentile	(2)	×	×	×	×	×	×	×
Subscapular Fatfold under 10th percentile	(2)	×	×	×	×	×	×	×
Suprailiac Fatfold under 10th percentile	(2)	×	×	×	—	×	×	×
Body Weight in Fat under 10th percentile	(2)	×	×	×	×	×	×	×
Body Fat percent under 10th percentile	(2)	×	×	×	×	×	×	×
Lean Body Weight under 10th percentile	(3)	—	×	×	—	×	—	×
AKS Index under 10th percentile	(3)	—	—	—	—	—	—	—
E/P Index under 10th percentile	(3)	×	×	×	×	×	×	×
Mesomorphy (2nd component) >4.0	(3)	—	—	—	—	—	—	—
Somatotype Dispersion Distance ≥7.00	(3)	×	—	—	×	—	×	—
Total score		20	20	20	19	20	20	19
Classified as undernourished		—	—	—	—	—	—	—

Number of points given to each criterion appear in parentheses

account the possibilities of each criterion for detecting changes in body composition. Therefore, we grouped in the one-point category such measurements or indices which only appraise variations in whole body mass; the limitations of BW for age, BW/HT and UAC, had been discussed elsewhere [6, 21, 30, 36, 37]. Calf circumference has been used in the diagnosis of undernutrition as well as thigh circumference [44]. Those however accept similar limitations as UAC.

Fatfolds were grouped in the two-point category. T fatfold above the 85th centile has been considered a suitable criterion of obesity [19], but with a low correspondence with BW for age [18]. SS and SI fatfolds seem

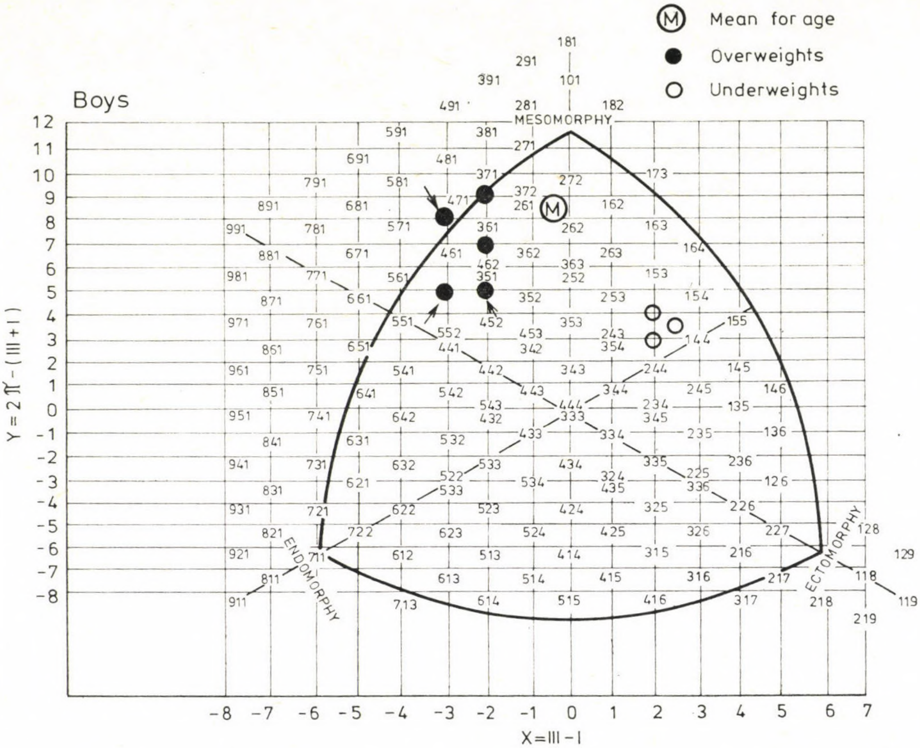

FIG. 1. Five overweight and three underweight boys were plotted in the somatochart. The mean for age and sex is included. The arrows point to the three overweight boys who were classified as obese according to the score

less sensitive to environmental changes than limb fatfolds [10]. In Cuba, Esquivel and Vassallo [15], correlating BW with fatfolds found that the highest "r" value was obtained with SS.

Though most common forms of undernutrition are accompanied by a lack of total energy which has its expression in a decrease of subcutaneous body fat, in undernutrition the decrease of LBM is the most specific feature [27, 28, 29, 36, 40].

The three-point group includes new indices.

Obesity is defined as an increase of FW, and this increase can be measured by determining %BF. The limitations of these two indicators are in the accuracy of the method employed for determining FW [12]. Our experience with Dugdale and Griffiths's regression equations [12] was fairly satisfactory and we believe that they provide a useful tool for nutritional assessment. FW as well as %BF were, however, included in the two-point group when evaluating undernutrition; the cause has been explained above: the decrease of body fat is

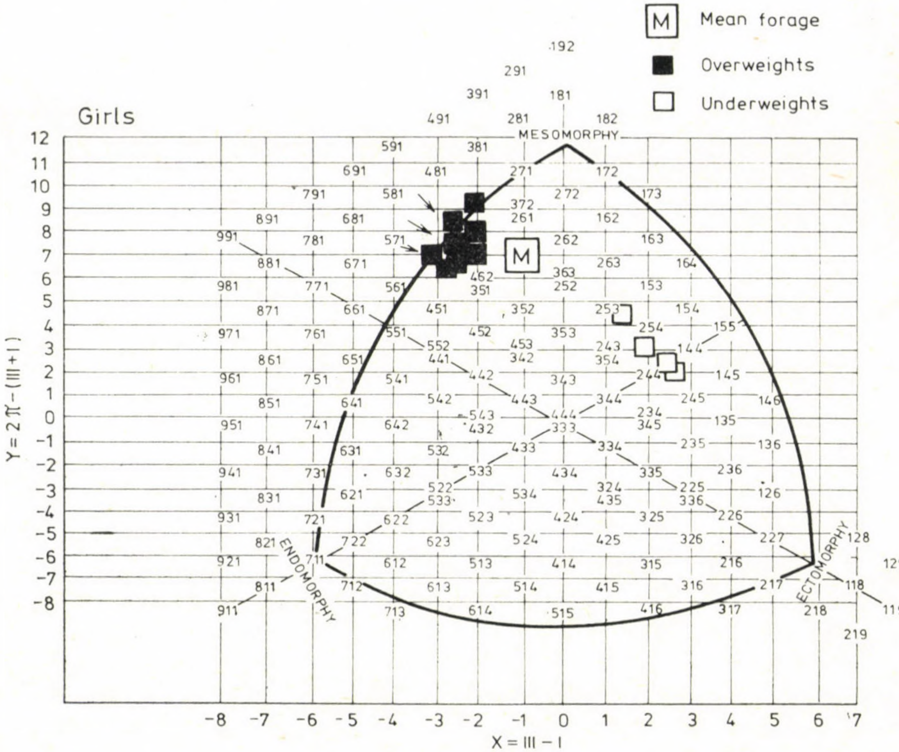

FIG. 2. Eight overweight and four underweight girls were plotted in the somatochart. The mean for age and sex is included. The arrows point to the three overweight girls who were classified as obese according to the score

not the most outstanding feature in undernutrition in contrast with the loss of LBW which rapidly increases during nutritional recovery [33].

Therefore, LBW has been included in the third category. Its only limitation is that it is greatly influenced by the stature, a fact that has been overcome by the introduction of the AKS (Aktiver Körpersubstanz-Index) [42]. This index expresses LBW in kg of fat-free mass per cm^3 of total body mass and avoids the variations determined by differences in height. Originally designed for use in athletes, the AKS has been introduced successfully in nutritional assessment of children [5, 8] with the only difference that the original description determines LBW by calculating FW by Par'zková's regression equations for ten fatfolds [32] and we obtained FW by Dugdale and Griffiths's equations for BW, HT and two fatfolds.

Somatotyping is another new method having been tested by us. Its first component measures adiposity and high ratings for endomorphy should be consistent with the diagnosis of obesity. In a previous study, the mean value for the first component in five-year old healthy children was 1.71 for boys, and 2.49 for girls [7]. This indicator was positive in four of the five children with scores of 20 or more, and only two of the eight subjects had a score under 20.

As we obtained high ratings for mesomorphy in healthy children [7], a rating of 4 (around two standard deviations below the mean; 5.88 for boys and 5.48 for girls) was considered the cut-off point. Four of the seven subjects showed a second component of 4 and none was below that figure.

The Somatotype Dispersion Distance (SDD) [34] shows how far from the means for age and sex are the somatotype ratings for a given individual. In a previous study the Somatotype Dispersion Index (SDI), which is the mean dispersion of the ratings of reference children, was 2.18 for boys, and 1.85 for girls. In the present study we established high cut-off points for SDD considering the great variations existing among individuals in body build and body constitution. In overweight subjects none below a score of 20 was beyond the cut-off point and, conversely, four of the five children classified as obese were positive for this indicator. In underweights only three subjects were positive.

The usefulness of the Energy/Protein Index in assessing obesity [4] and both main forms of undernutrition has been considered in previous reports. The only five overweight subjects with E/P above the 90th percentile were just those with a score of 20 or above. On the other hand, all subjects showed E/P figures under the 10th percentile. If we state that none of the seven subjects was undernourished, this would be contradictory to our previous statement that an E/P below the 10th percentile is an indicator of undernutrition [2, 3]. As a possible explanation, the seven subjects studied were lean, with a low degree of adiposity but conserving their fat-free mass. This means a decrease in the E/P numerator without a change in the denominator, yielding low values for the ratio. If we take the 3rd percentile of E/P as the cut-off points, only two subjects were positive by this criterion. Nevertheless, this raises the question of the discriminative value of E/P in the kind of subjects we have considered in this study.

As to the correspondence among the different indicators, in overweights the indicators of the first group were consistently coincident; in the second group SS and SI were not always coincident with T. Esquivel and Vassallo [14] reported a tendency of T to be at a higher percentile channel than BW and other fatfolds, a finding also reported by Garn et al [18]. In the third category FW, %BF and E/P were also coincident. There was no coincidence between the first component and SDD. The discriminative power of the indicators of group three was decisive in the classification of the subjects.

In underweight children, indicators of the first group were coincident but not with the same consistency. Fatfolds were coincident and this points to the high degree of leanness of the subjects. The coincidence between FW and %BF contrasted with the difference found between LBW and AKS. The circumstance that all the subjects showed an AKS Index above the 10th percentile, meaning that there was no actual impairment of LBW, was of great significance in the definition that these underweight subjects were not actually undernourished. AKS was also coincident with mesomorphy ratings showing the close relationship between the second component and fat-free mass development.

The wide range found in SDD, the same as it happened with the overweights, could be related to the underlying genetic influence in the features of body build which determine a basic somatotype. Nutritional disturbances influence the phenotype but the basic morphological patterns were comparatively stable [11, 35].

In this paper we have selected several anthropometric criteria with the purpose of establishing a quantification of different features which usually accompany malnutrition. Of course, there are many other indicators available and the present selection was made according to our own experience. The result can be improved by including new criteria or excluding some of the present ones. Though the scoring systems are always arbitrary, we followed a systematization based upon the theoretical ability of each criterion to express the variations of body components.

It is evident that the different anthropometric criteria of malnutrition may yield widely different estimations of the prevalence of malnutrition and different age-specific prevalence patterns [38]. This is also valid for individual assessment. We agree with Trowbridge [38] in that malnutrition cannot be considered a single homogeneous entity which should be measured by a given anthropometric indicator. As different indicators give different estimates of malnutrition, score systems combining several of these indicators, one for obesity and another for undernutrition, will be useful, especially when the diagnosis is doubtful.

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