Anthrop. Közl. *27*; 109—118. 1983.

SOMATOTYPING AS A TOOL FOR NUTRITIONAL ASSESSMENT IN PRESCHOOL CHILDREN

by M. Amador, C. Rodríguez and María E. Gonzáles

Higher Institute of Medical Sciences of Havana, Havana, Cuba;
Institute of Sports Medicine, Havana, Cuba

Abstract: With the purpose of testing the usefulness of somatotype determinations in nutritional assessment, an anthropometric study of a selected sample of 362 healthy children between 1.50 and 5.49 years of age (190 boys and 172 girls), was carried out, obtaining the ratings of three components of the somatotype according to the Heath and Carter's (1967) method, and the figures of E/P Index according to Amador et al. (1975).

It was observed a shift towards higher first component ratings with age in girls and a similar trend was found in boys regarding second component. In both sexes, ratings for mesomorphy were rather elevated probably due to the influence of the osseous component in the figures obtained for mesomorphy. Somatotype Dispersion Index remained within the range 1.41—2.44 except in two-year old girls in which it was 3.99.

We could demonstrate that a close relationship exists between somatotype ratings and E/P Index figures, especially between first component and E/P. These results represent a new approach to nutritional assessment, taking into account that somatotype ratings are closely related to body build and body composition.

Key words: Somatotype, Energy/Protein Index, body composition, nutritional assessment, preschool children.

Introduction

Somatotyping has been scarcely used in assessing body components and its relationships with growth and nutritional status in children at preschool age (Heath and Carter 1971, Walker 1974a, 1974b, 1978). Undoubtedly, more experience is needed concerning the application of the distribution of the three components of the somatotype at different ages considering that all three have some kind of relationship with the two tissues more affected by nutritional unbalance: fat and muscle.

Energy/Protein Index (E/P), which is the ratio between transformed triceps fatfold and the logarithm of mid-arm muscle circumference, has proved to be very useful indicator for reflecting the status of fat and muscle components of the body and their variations with nutritional disturbances (Amador et al. 1975, 1976, Amador et al. 1980, Amador et al. 1981).

Based on the reasons stated above, we considered of the greatest interest to study the peculiarities of the somatotype components in healthy and in malnourished preschool children, and the relationships existing between the figures obtained and the distribution of E/P Index with the purpose of testing the possibilities of introducing the somatotype as a new tool for a more precise diagnosis of malnutrition.

Material and Methods

A selected sample of 362 children between 1.50 and 5.49 years (190 boys and 172 girls) was obtained from those attending the Teaching Polyclinics "Louis Pasteur" and "Playa" in Havana, for periodic health surveillance. All the children belonged to the health areas of the Polyclinics. All those who came to consultation in the ten-day period of study were included; only children with chronic diseases or malformations were excluded.

The data were collected by a measuring team composed of anthropometrists and other members of the staff of the Department of Physical Development of the Institute of Sports Medicine. The official form for anthropometric assessment of that Institute was employed for recording the data. These were: 1. Name of the subject, 2. Sex, 3. Date of measurement, 4. Date of birth, 5. Decimal age, 6. Body weight, 7. Stature, 8. Humerus width (biepicondilar diameter), 9. Femur width (bicondilar diameter), 10. Flexed biceps girth, 11. Calf girth, 12. Mid-arm circumference (MAC), 13. Triceps fatfold (T), 14. Subscapular fatfold (SS), 15. Suprailiac fatfold (SI), 16. Calf fatfold (C).

Date of birth and date of recording were completely registered in year, month and day for obtaining the decimal age as described by TANNER et al. (1969). Children below 82.5 cm. of height were excluded because charts for determining the second component (mesomorphy) for shorter subjects were not available.

All measurements were done on the right hand side of the body. The general aspects of the methodology employed, including general recommendations, subject position, instruments and apparatus were those recommended by the International Biological Programme (TANNER et al. 1969), and are described elsewhere (AMADOR 1978, AMADOR, BACALLAO and FLORES 1980).

The E/P Index was calculated in each child through the expression:

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

where: TT is transformed fatfold (EDWARDS et al. 1955), TMAMC is the $\log_{10}$ of mid-arm muscle circumference, obtained according to JELLIFFE (1966).

The somatotype components were obtained according to HEATH and CARTER (1967), and ROSS, HEBBELINK and WILSON (1973). Using the somatotype plotting grid (ROSS et al. 1973), the somatotypes were plotted by the formulae:

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

where: I is the first component (endomorphy), II is the second component (mesomorphy), III is the third component (ectomorphy).

The sample was divided into groups according to decimal age and sex. Four groups for each sex were thus formed: from 1.50 to 2.49 year-old, from 2.50 to 3.49, from 3.50 to 4.49, and from 4.50 to 5.49 year-old.

Mean values and standard deviations for each component of the somatotype were calculated in each one of these eight groups.

Somatotype Dispersion Distances (SDD) were calculated in each subject (ROSS et al. 1973) according to the expression:

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

The Somatotype Dispersion Index (SDI) for each one of the groups was obtained according to the formula by Ross et al. (1973).

$$SDI = \frac{\Sigma \, SDD}{N}$$

Mean values and standard deviations for the osseous, and muscular components of the mesomorphy, and finally, for E/P Index were also calculated.

Percentile reference values for E/P were referred to those reported by us in a previous paper (AMADOR, BACALLAO and FLORES 1980).

Simple linear regressions were found between E/P Index and each one of the components of the somatotype, and also between E/P and the ratio first/second component (YAMANE 1970, DANIEL 1974).

All the statistical and computational work was performed in a Cuban-made CID-201-B minicomputer at the Center of Cybernetics Applied to Medicine of the Higher Institute of Medical Sciences of Havana.

Results

Mean values and standard deviations for each component of the somatotype, osseous and muscular components of mesomorphy and E/P Index, and SDI figures for each age group in boys and girls are shown in Tables 1 and 2.

Mean values for each sex and age group were plotted in a somatochart which appears in Figure 1.

Regression studies between E/P Index and the different components of the somatotype are summarized in Table 3. The highest correlation coefficient was found when regressing the first component with E/P. A high "r" figure was also found when regressing the ratio first/second component with E/P.

Table 1

Mean values and standard deviations for E/P Index and for different components of the somatotype, and SDI figures according to age in 190 boys*

Age group (decimal)	Somatotype Components			Mesomorphy		SDI	E/P Index
	1	2	3	OC	MC		
1.50—2.49 n = 42	*2.01* (0.54)	*5.54* (0.65)	*0.73* (0.47)	*13.47* (3.40)	*3.33* (3.01)	1.54	*1.733* (0.083)
2.50—3.49 n = 55	*1.93* (0.50)	*5.62* (0.53)	*0.82* (0.38)	*12.90* (2.86)	*3.66* (2.65)	1.41	*1.726* (0.069)
3.50—4.49 n = 58	*1.89* (0.66)	*5.78* (0.58)	*1.16* (0.68)	*12.83* (3.02)	*3.83* (2.82)	1.98	*1.656* (0.077)
4.50—5.49 n = 35	*1.71* (0.41)	*5.88* (0.84)	*1.41* (0.72)	*12.70* (3.47)	*3.17* (2.69)	2.18	*1.619* (0.091)

* Mean values in italics, standard deviations in brackets. 1 = First component (Endomorphy), 2 = Second component (Mesomorphy), 3 = Third component (Ectomorphy). OC: Osseous component of the mesomorphy; MC: Muscular component of the mesomorphy; SDI: Somatotype Dispersion Index; E/P: Energy/Protein Index.

Table 2

Mean values and standard deviations for E/P Index and for different components of the somatotype, and SDI figures according to age in 172 girls*

Age group (decimal)	Somatotype Components			Mesomorphy		SDI	E/P Index
	1	2	3	OC	MC		
1.50—2.49 n = 24	*2.21* (0.73)	*5.38* (0.82)	*0.84* (0.28)	*11.06* (4.08)	*3.12* (3.06)	3.91	*1.798* (0.082)
2.50—3.49 n = 53	*2.37* (0.75)	*5.43* (0.56)	*0.96* (0.16)	*11.60* (3.19)	*3.09* (2.24)	1.59	*1.735* (0.079)
3.50—4.49 n = 57	*2.47* (0.87)	*5.42* (0.69)	*1.05* (0.70)	*10.89* (3.41)	*3.69* (1.96)	2.44	*1.714* (0.088)
4.50—5.49 n = 38	*2.49* (0.86)	*5.48* (0.71)	*1.28* (0.33)	*11.57* (3.68)	*3.33* (2.39)	1.85	*1.699* (0.085)

* For explanation see Table 1.

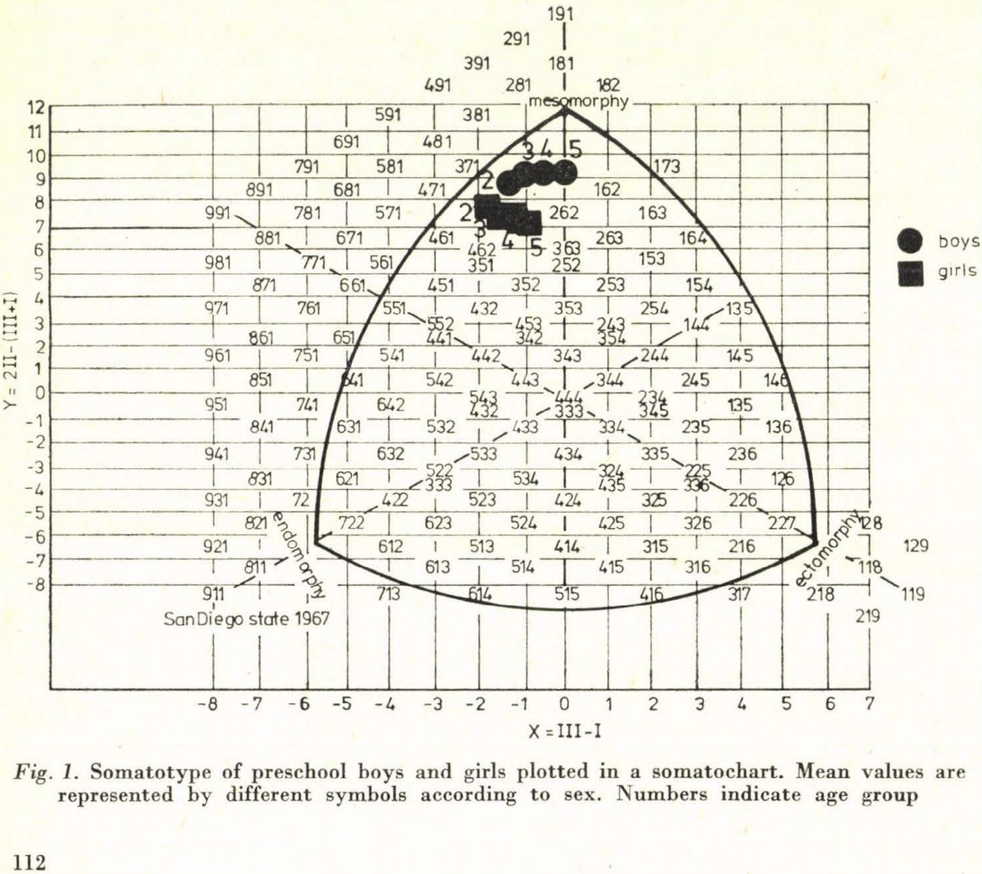

Fig. 1. **Somatotype of preschool boys and girls plotted in a somatochart. Mean values are represented by different symbols according to sex. Numbers indicate age group**

With the purpose of knowing the differences in the distribution of the somatotype components according to E/P Index values, we grouped all the subjects of each sex into three categories as follows:

— Those with E/P values under the 10 th, percentile (Lower Group);

— Those with E/P values equal to or over the 10th percentile and under the 90th percentile (Middle Group); and

— Those with E/P values equal to or over the 90th percentile (Upper Group).

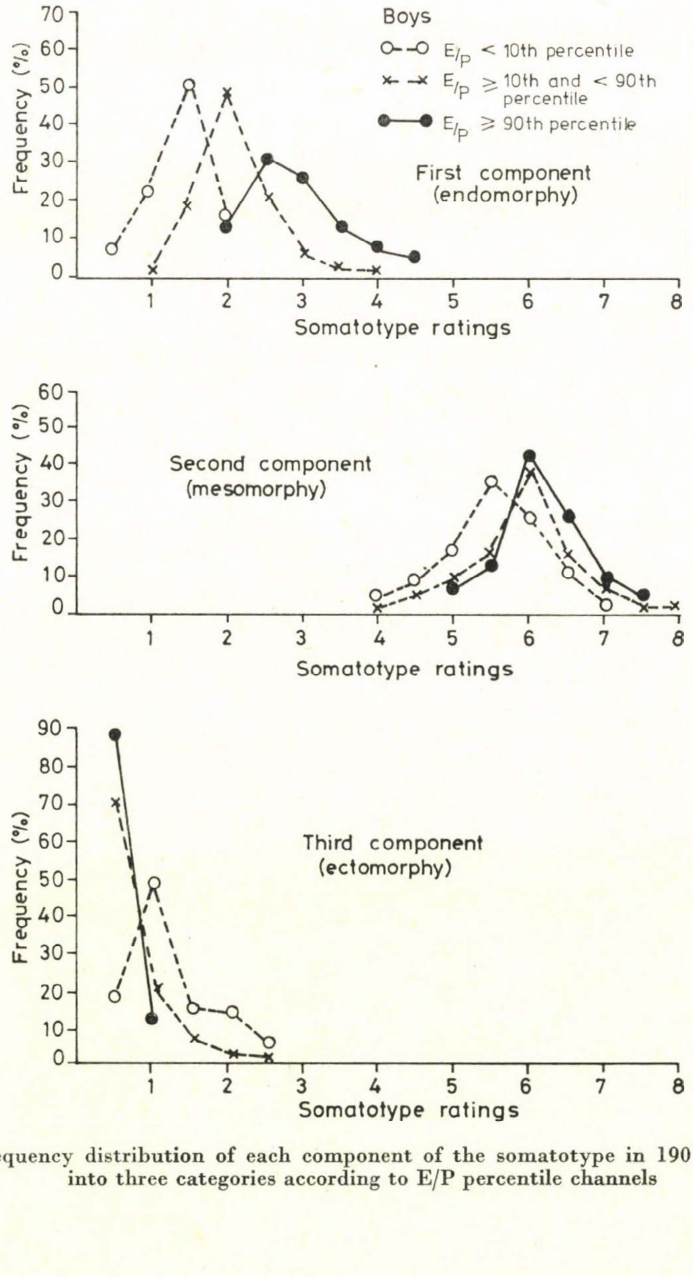

Fig. 2. Frequency distribution of each component of the somatotype in 190 boys grouped into three categories according to E/P percentile channels

Figures 2 and 3 show the frequency distribution of each component of the somatotype for each group and sex (boys and girls, respectively). In boys, as well as in girls we found a tendency towards high ratings for endomorphy in children with E/P figures in or above the 90th percentile, and the opposite situation was observed in children under the 10th percentile. These tendencies were more evident in females. For the second component, both sexes show-

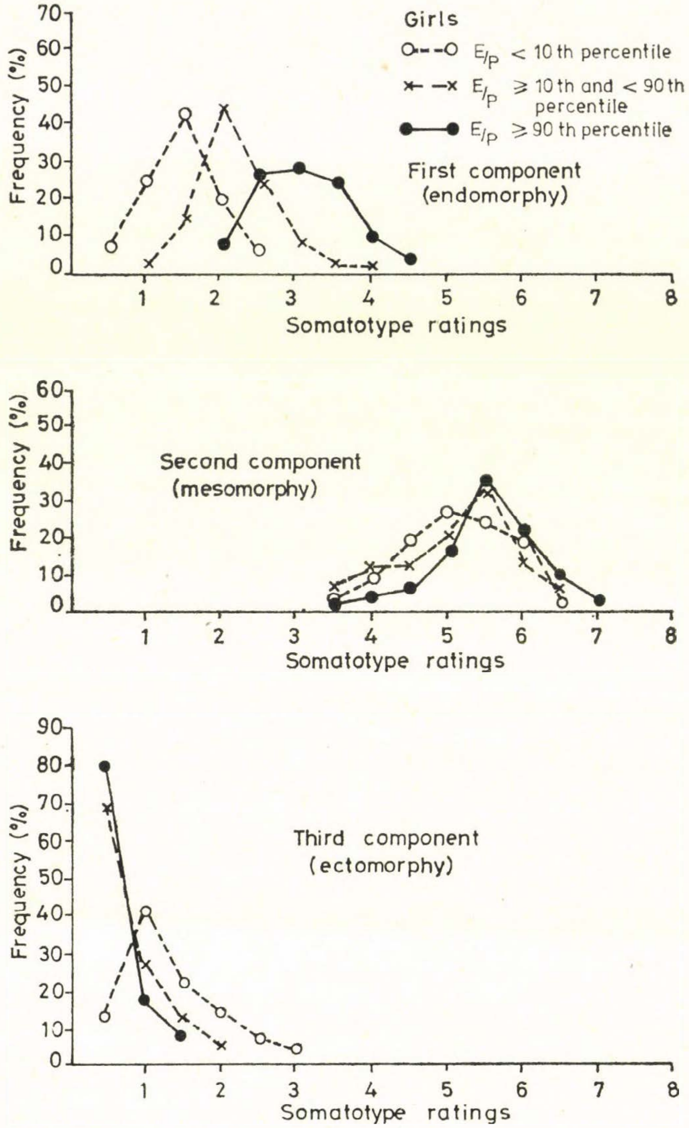

Fig. 3. Frequency distribution of each component of the somatotype in 172 girls grouped into three categories according to E/P percentile channels

Table 3

Linear regression studies relating E/P Index with somatotype components in 362 preschool children

x	y	y = bx + a		r	P
		b	a		
First component	E/P Index	0.139	1.372	0.732	< 0.001
Second component	E/P Index	—0.045	2.035	—0.451	< 0.001
Third component	E/P Index	—0.053	1.739	—0.383	< 0.001
Ratio 1st/2nd	E/P Index	0.153	1.455	0.667	< 0.001

ed a clear upward tendency in the upper groups. When observing the third component, a remarkable shift to lower ratings was observed in the Middle Groups and in the Upper ones.

Discussion

Since 1940, when SHELDON introduced the concept of somatotyping, a growing interest and a great deal of controversy has developed, encouraging many research workers to propose modifications to the original method (NOVAK 1952, PARNELL 1954, HEATH 1963, HEATH and CARTER 1966). The simple method devised by HEATH and CARTER in 1967 was a decisive approach for the introduction of somatotyping in clinical practice.

Nevertheless, few studies exist on somatotype in children, and there is a special lack in younger ones. PAŘÍZKOVÁ and CARTER (1976) considered that the validity of somatotyping in children is somewhat lower than in adults. One of the main factors supporting this criterion is that bone development, specially at the femoral condyles and humeral epicondyles influences mesomorphy yielding higher ratings than in older children, in which a greater development of muscle mass exists. In our subjects, both males and females, high ratings for the second component were found and their osseous component was particularly elevated and paid a great contribution to the observed values.

Age and sex differences in somatotype distribution were rather small in our sample, the same as reported by HEATH and CARTER (1971) in their study of Manus children, but those differences were always present. The same shift towards higher first component ratings with age in girls, was found, and similarly, a shift towards the second component was found in boys. This last finding was not clearly observed in previous studies (AMADOR 1978, AMADOR et al. 1979), but our present sample is somewhat larger, and includes the subjects previously studied. Shift tendencies described above tend to increase with age as appears in HEATH and CARTER's series (1971). PAŘÍZKOVÁ et al. (1977) in a longitudinal study of somatic and functional development of children from 3 to 6 years of age, reported small increments in circumference measurements and indicators of skeletal robusticity, and also a decline in subcutaneous fat, arriving to the conclusion that weight increments during the period of life they had studied, are represented only by lean body mass development. As mesomorphy refers to musculo-skeletal development, the increase of second component ratings observed by us agrees with those authors' findings.

Regarding the first component, PAŘÍZKOVÁ et al. (1977), found that the amount of subcutaneous fat in girls does not decrease from three to six years of age as it happens in boys. An apparent relationship between E/P Index and the somatotype distribution has come about with our work. In girls, the increase of endomorphy with age, and the stability of mesomorphy explains the fact that age trend of E/P Index is less notable than in boys, which show a more distinct trend due to the decrease with age of the first component with a simultaneous increase of the second one.

With respect to the third component, we should say that, from our point of view it has limitations because there is no rating below 1/2 for lower figures of the Ponderal Index. Thus, in an age group as the one we are dealing with, showing very low ectomorphy, the individuals tend to cluster just on the lowest ratings and there are no possibilities to establish a clear correspondence with E/P. Index.

The evidence that E/P Index values reflect not only the status of energy reserves and protein reserves but the relationship between both of them, has been put into evidence when a significant correlation could be found between E/P Index and the first and the second components of the somatotype, as in a previous paper we demonstrated a significant correlation between E/P Index and the cross sectional areas of fat and muscle at the middle third of the upper arm (AMADOR, RODRÍGUEZ and BACALLAO 1980). Of a particular importance is the significant correlation found when regressing E/P with the ratio which relates endomorphy and mesomorphy.

The negative "r" values in the regression studies of E/P with the second component, might be explained by the fact that mesomorphy is an indicator of muscle mass, which is in the denominator in E/P formula. Thus, lower figures for muscle mass correspond to higher values of E/P Index, as low figures for the second component mean a light skeletal frame and little muscle mass.

Negative "r" values were found when regressing E/P with the third component, which is given by Ponderal Index. This means that, as the ratings of this component increase, a lower weight for stature is found. Thus, the lighter the individual, the lower E/P Index figures and the higher ratings he will have. With the purpose of testing the correspondence between ectomorphy ratings and SHELDON's Ponderal Index, we made a linear regression study between E/P and Ponderal Index. The "r" value obtained (—0.371) was highly significant and very similar to that obtained regressing ectomorphy with E/P (—0,383), in magnitude and sign.

It is evident that the highest "r" values were obtained when relating fat indicators. This suggests that E/P Index has a better discriminating quality for the assessment of energy status. However, we must point out that, although the first component has been considered a good indicator of body fat, for the second component it is not exactly the same, — at least in small children — because it includes not only muscle but also bone. WILMORE (1970) found practically no relationship between the second component of HEATH and CARTER's somatotyping method and lean body weight. One of us (RODRÍGUEZ 1981), has recently applied E/P Index to boxers, and found a high correlation between this Index and the first component ($r = 0.62$) and between E/P and the percentage of body fat (r = 0.66) but no significant correlation was observed when relating E/P with the second component.

The introduction of somatotyping as a new and promisory approach to the study of nutritional status has been indorsed by our results in which we have demonstrated the close relationship existing between somatotype ratings and E/P figures. Taking into account that estimates of obesity and leanness in a population are subject to variation according to the criteria used for classification, we consider that this study contributes to support the increasing attention which is currently given to the study of body composition, and demonstrates that the search for new tools for nutritional assessment is far form being exhausted.

Acknowledgements: Our grateful acknowledgement to professors *Santos Canetti* from Teaching Polyclinic "Playa", and *Luis Córdova*, from Teaching Polyclinic "Louis Pasteur", for the facilities in obtaining the sample of preschool children.

We are also indebted to the Center of Cybernetics Applied to Medicine, especially to Lic. *Jorge Bacallao* for statistical advice.

*

A SZOMATOTIPIZÁLÁS, MINT AZ ÓVODÁSKORÚ GYERMEKEK TÁPLÁLKOZÁSÁNAK ÉRTÉKELÉSÉRE SZOLGÁLÓ ELJÁRÁS

Írta: AMADOR, M.—RODRIGUEZ, C.—GONZÁLES, M. E.

Összefoglalás

A szerzők arra a kérdésre kerestek választ, hogy vajon használható-e a szomatotipizálás a táplálkozás értékelésére. Egy 362 1,05—5,49 éves egészséges gyermekekből (190 fiú és 172 leány) álló mintán antropometriai vizsgálatot végeztek, és meghatározták a három szomatotípus komponens értékét HEATH és CARTER (1967) módszerével, valamint az E/P index értékét AMADOR és mtsai (1975) nyomán.

Az első komponens esetében a leányoknál az életkorral párhuzamosan emelkedő értékeket kaptak. Hasonló tendenciát találtak a fiúknál is, a második komponens értékeiben. A mezomorfia értékek mindkét nemnél igen magasak voltak, ami feltehetően a csont komponens hatásával magyarázható. A „Somatotype Dispersion Index" a 2 éves leányok (SDI = 3,99) kivételével az 1,41—2,42 intervallumon belül maradt.

Szoros kapcsolatot tártak fel a szomatotípus értékek és az E/P index között, s ezen belül a legjelentősebb az első komponens és az E/P index összefüggése.

A szerzők eredményeik alapján a táplálkozás értékelésének egy új megközelítési módját mutatják be, figyelembe véve, hogy a szomatotípus értékek szoros kapcsolatban vannak a testfelépítéssel és a testösszetétellel.

Received 29th October 1982.

REFERENCES

AMADOR, M. (1978): *Energy/Protein Index: A new approach for the assessment of the nutritional status.* — PhD Dissertation, Havana and Budapest.

AMADOR, M.—BACALLAO, J.—FLORES, P. (1980): Indice Energía/Proteína; nueva validación de su aplicabilidad en evaluación nutricional. — Revista Cubana de Medicina Tropical, *32:* 11—24.

AMADOR, M.—BACALLAO, J.—HERMELO, M.—FERNANDEZ, R.—TOLON, C. (1975): Indice Energía/Proteína: un nuevo aporte para la evaluación del estado de nutrición. I) Valores en ninos sanos de edad preescolar. — Revista de Investigación Clínica, *27;* 247—253.

— — — — — (1976): Indice Energía/Proteína: Su utilidad en el diagnóstico de distintas formas de mala nutrición. — Revista Cubana de Medicina Tropical, *28;* 127—132.

AMADOR, M.—RODRIGUEZ, C.—BACALLAO, J. (1979): Somatotipo en preescolares: sus relaciones con el Indice Energía/Proteína. — Res. II Congreso Internacional de Auxología, pp. 125—126. La Habana.
— — — (1980): Contribución del Indice Energía/Proteína en la evaluación de la composición corporal en preescolares. — Boletín Médico del Hospital Infantil de México, *37;* 631—644.
AMADOR, M.—GONZALEZ, M. E.—HERMELO, M. (1981): Energy/Protein Index: Its usefulness in assessing obesity. — Anthrop. Közl. *25;* 3—16.
DANIEL, W. W. (1974): *Biostatistics:* A foundation for analysis in the Health Sciences. Chapters 7,8 and 9. John Wiley & Sons, Inc. New York.
EDWARDS, D. A. W.—HAMMOND, W. H.—HEALY, M. J. R.—TANNER, J. M.—WHITEHOUSE, R. H. (1955): Design and accuracy of calipers for measuring subcutaneous tissue thickness. — Brit. J. Nutr., *9;* 133—143.
HEATH, B. H. (1963): Need for modification of somatotype methodology. — Am. J. Phys. Anthrop. *21;* 227—233.
HEATH, B. H.—CARTER, J. E. L. (1966): A comparison of somatotype methods. Am. J. Phys. Anthrop. *24;* 87—99.
— — (1967): A modified somatotype method. — Am. J. Phys. Anthrop. *27;* 57—74.
— — (1971): Growth and somatotype patterns of Manus children, territory of Papua and New Guinea: Application of a modified somatotype method to the study of growth patterns. — Am. J. Phys. Anthrop. *35;* 49—68.
JELLIFFE, D. B. (1966): Assessment of the nutritional status of the Community. — WHO, Monograph Series, No. *53.* pp. 77. Geneva.
NOVAK, Z. (1952): The somatotype of the ice hockey player. — Sport and Health., *2;* 96—101.
PAŘÍZKOVÁ, J.—ČERMÁK, J.—HORNÁ, J. (1977): Sex differences in somatic and functional characteristics of preschool children. — Hum. Biol. *59;* 437—451.
PAŘÍZKOVÁ, J.—CARTER, J. E. (1976): Influence of physical activity on stability of somatotypes in boys. — Am. J. Phys. Anthrop. *44;* 327—340.
PARNELL, R. W. (1954): Somatotyping by physical anthropometry. — Am. J. Phys. Anthrop. *12;* 209—228.
RODRIGUEZ, C. (1981): Análisis antropométrico para la caracterización del boxeador de alto• redimiento y la valoración de su estado de entrenamiento. — Res. Seminario Científico „Las Ciencias y el Desarrollo de la Cultura Física y el Deporte", La Habana, pp. 119.
ROSS, W. D.—HEBBELINCK, M.—WILSON, B. D. (1973): Somatotype in sport and the performing arts. — Medicina dello Sport., *26;* 314—326.
SHELDON, W. H.—STEVENS, S. S.—TUCKER, W. B. (1940): *The varieties of Human Physique. An introduction to constitutional psychology.* — Harper Brothers, New York.
TANNER, J. M.—HOERNAUX, J.—JARMAN, S. (1969): Growth and Physique Studies — *in* WEINER, J. S.—LOURIE, J. A. (Eds): *Human Biology. A Guide to Field Methods.* 1—76. — Blackwell Scientific Publ. Oxford, Edinburgh.
WALKER, R. N. (1974a): Standards for somatotyping children: I. The prediction of young adult height from children's growth data. — Annals of Human Biology, *1;* 149—158.
— (1974b): Standards for somatotyping children: II. The prediction of somatotyping ponderal index from children's growth data. — Annals of Human Biology, *1;* 289—299.
— (1978): Pre-school physique and late-adolescent somatotype. — Annals of Human Biology, *5;* 113—129.
WEINER, J. S.—LOURIE, J. A. (1969): *Human Biology: A guide to field methods.* — International Biological Programme, Handbook No. 9. Blackwell Scientific Publications, Oxford.
WILMORE, J. G. (1970): Validation of the first and second components of the Heath-Carter modified somatotype method. — Am. J. Phys. Anthrop. *32;* 369—374.
YAMANE, T. (1970): *Statistics: An introductory analysis.* (2nd. edition) Chapters 17 and 21. Instituto del Libro, La Habana.

Author's address: Prof. MANUEL AMADOR, MD, PhD.
Servicio de Nutrición
Hospital Pediátrico "William Soler"
San Francisco 10112, La Habana 8.
Cuba.