Volume 46(1-2):61-65, 2002
Acta Biologica Szegediensis
http://www.sci.u-szeged.hu/ABS

SYMPOSIUM

Growth type and motor performance in schoolboys – an international comparison[+]

János Mészáros, Lee Chee Pheng, András Tatár, Petra Zsidegh, János Mohácsi, Róbert Frenkl*

Faculty of Physical Education and Sport Sciences, Semmelweis University, Budapest, Hungary

ABSTRACT The aim of the present study was to compare the growth type of 10-13-year-old non-athletic children living in different geographical regions, namely in Cyprus, Egypt, Hungary and Malaysia. Altogether 2,050 volunteer youngsters with less than 25% body fat content were investigated. Body build was estimated by the metric and plastic indices (Conrad 1963), and their cardiorespiratory endurance was assessed by the time of a 1,200 m run. The Hungarian boys were the tallest, and the Egyptians were the smallest, consistently. However, no consistent differences could be observed between the body mass means. The Hungarian boys could be characterised by the most negative metric index means, and the Cypriots were the most picnomorphs. Excluding the significant height differences from the variability of plastic index the consistent differences have disappeared. The most negative metric index means were found at 12 years of age in the Chinese, Cypriot and Egyptian samples, and the average metric indices have become greater consistently at the 13-year-old boys. The mean trend of growth type indices in Hungarian subjects has indicated a significant decrease in accordance with the data published earlier. By the cardiorespiratory endurance the subjects can be divided in two groups. Significantly better performances refer to the Cypriot and Hungarian subjects. The growth type indices introduced by Conrad (1963) sensitively reveal the slight differences in body built and physique resulting from ethnic differences, various physical activity, etc. **Acta Biol Szeged 46(1-2):61-65 (2002)**

KEY WORDS

metric and plastic indices
1,200 m run
10-13-year-old boys

Anthropometric techniques (for instance, calculation of somatotype components, growth type indices, comparison with the dimensions and parameters of unisex human phantom) for the estimation of physique and body built can be evaluated as relatively new methods.

The Conrad's growth type indices for the description of physique and bone-muscle development (Conrad 1963) are more often used in kinanthropometry. The early publications have come from German (Tittel and Wutscherk 1972) and Hungarian (Szmodis et al. 1976) working groups. The results of Szmodis and co-workers (1976) and Mészáros and associates (1981) proved that successive age group means of metric index (the linearity character of physique) for boys between 7 and 18 years describe a significant second power tendency with peak linearity at 13 years of age both in athletic and non-athletic individuals. In respect of motor functions it was proved repeatedly that the greater bone-muscle development refers to better motor performance and conversely (Mészáros and Szmodis 1977; Szabó and Mészáros 1980; Mohácsi and Mészáros 1986). Unfortunately, no data are available of the growth type characteristics of children and adolescents living in other countries. The only publication in this respect belongs to Othman (2001) who investigated Arabic children.

The aim of the present study was to compare the growth type of 10-13-year-old non-athletic children living in different geographical regions, namely in Cyprus, Egypt, Hungary and Malaysia.

Subjects and Methods

Kinanthropometric data collection was carried out in healthy volunteer boys belonging to the middle socio-economic class in all the four countries. Frequency distribution of the subjects by age and nationality can be seen in Table 1.

The Cypriot boys were the inhabitants of Nicosia and the suburbs of the capital. The Cypriot sample contains only Cypriot-Greek individuals. The Egyptian children were living in Banha city (all of them had Arabic origin) in the northeastern part of the country. This settlement is the capital of Banha County with about 2 million inhabitants. The Hungarian sample contains only a population of children from Budapest and adolescents with Europid origin. Malaysian boys were living in Ipoh (the capital of Perak State) in North Malaysia. The ratio of the three dominant nationalities (Chinese, Indian and Malay) in this settlement is approximately 30-30%. Only children with Chinese origin (both

Accepted March 1, 2002
*Corresponding author. E-mail: meszaros@mte.hupe.hu
[+]Dedicated to Professor Gyula Farkas on the occasion of his 70th birthday.

Table 1. Frequency distribution of the subjects by age and nationality.

Age	Chinese	Cypriot	Egyptian	Hungarian	Total
9.51-10.50	109	116	128	160	523
10.51-11.50	107	101	114	169	501
11.51-12.50	116	102	115	175	508
12.51-13.50	110	105	113	180	518
Total 2,050					

parents and grandparents are Chinese) were enrolled into the investigation.

Five physical education (PE) classes were held within 10 days; however, marked differences can be observed between the general content of physical education of the different countries.

Relative body fat content was estimated by the method of Parízková (1961). Since the growth type indices of fat and obese individuals are significantly different than those of the normal ones (Farkas et al. 1999), children with body fat content greater than 25.0% were excluded from this comparison. In this manner, the mean relative body fat content ranges between 16-19% with relative standard deviations of 25%.

Metric and plastic indices were calculated by 6 body dimensions using the equations of Szmodis and associates (1976). The necessary dimensions are: height, shoulder width, chest width and depth, lower arm girth and hand circumference. In taking body dimensions the IBP suggestions (Weiner and Lourie 1969) were observed. All the children were investigated by the working group, girths, width and skinfold thicknesses by the same individual.

Metric index relates the chest width to the chest depth and is corrected by the actually measured stature. At first look, the index is one of the descriptions of the roundness of the chest, however, following its validation the calculated parameter is characteristic for the roundness or linearity of the whole body (Szmodis et al. 1976).

The metric index for boys and males can be calculated as follows:

$$MIX = 0.16\ (CHD - 0.26BH + 0.80CHW - 2.61)$$
$$R = 0.999$$

where: MIX = metric index, CHD = chest depth (cm), BH = height (cm), CHW = chest width (cm), R = multiplied correlation coefficient indicating the congruence between the nomographic and calculated values.

Strongly negative values refer to the leptomorphic (linear) body built, the slightly negative ones to the athletic physique, and the positive ones to the picnomorph constitution.

Plastic index is the arithmetic sum of three body dimensions and it is characteristic for the absolute bone-muscle development.

Plastic index = shoulder width + lower arm girth + hand circumference.

By the numeric values of these two indices a right-angle co-ordinate system can be created, where the vertical axis is scaled by the metric index and the horizontal one refers to the plastic index. The metromorph-normoplastic body built is located at the centre of the co-ordinate system. The upper-left quarter contains the leptomorph but hypoplastic individuals, the upper-right quarter refers to the leptomorph-hyperplastic body built. The lower-left area is characteristic for the picnomorph-hypoplastic constitution, and the lower-right quarter contains the picnomorph-hyperplastic physique variants. The vertical axis is suggested to be positioned to the level of the respective and representative plastic index average in children.

To eliminate the obvious and significant effects of height differences, relative body mass and plastic index were also calculated. Relative measurement = variable x 0.01stature^{-1}.

Cardiorespiratory endurance was estimated by the time of a 1,200 m run. Execution: following the roles of track and field athletics. Reading accuracy was 0.1 s.

Differences between age group means and standard deviations were analysed by F-test following one way ANOVA at 5% level of random error.

Results

Descriptive and comparative statistics for height, body mass and height-related body mass can be seen in Tables 2-4. The Hungarian boys were the tallest (Table 2) in all the four age groups, and the Egyptians were the smallest consistently; however, the differences between the Chinese, Cypriot and Egyptian means were occasionally also significant. The

Table 2. Descriptive and comparative statistics for height (cm).

Group	Chinese		Cypriot		Egyptian		Hungarian		
Age	Mean	SD	Mean	SD	Mean	SD	Mean	SD	P
10	136.52	6.00	137.90	5.86	133.91	7.83	140.31	6.54	<5%
11	141.95	7.23	143.81	6.91	140.77	6.20	146.88	6.74	<5%
12	147.37	8.28	149.04	7.27	146.37	7.14	152.42	6.22	<5%
13	154.06	7.58	157.84	7.67	151.02	7.54	158.02	6.42	<5%

SD = standard deviation, <5% = difference between the means is significant at 5% level of random error.

Table 3. Descriptive and comparative statistics for body mass (kg).

Group	Chinese		Cypriot		Egyptian		Hungarian		
Age	Mean	SD	Mean	SD	Mean	SD	Mean	SD	P
10	30.15	5.42	31.89	4.66	32.01	6.46	34.32	5.23	<5%
11	35.38	6.81	37.50	5.92	35.81	7.35	40.87	5.41	<5%
12	40.04	6.59	42.00	6.68	38.77	7.40	45.96	7.43	<5%
13	43.81	7.38	48.13	8.75	43.76	8.66	48.49	7.53	<5%

SD = standard deviation, <5% = differences between the means is significant at 5% level of random error.

Table 4. Descriptive and comparative statistics for relative body mass (kg x cm^{-1}).

Group	Chinese		Cypriot		Egyptian		Hungarian		
Age	Mean	SD	Mean	SD	Mean	SD	Mean	SD	P
10	22.08	3.97	23.13	3.38	23.90	4.82	24.46	3.73	<5%
11	24.92	4.80	26.08	4.12	25.44	5.22	27.83	3.68	<5%
12	27.16	4.47	28.18	4.48	26.49	5.06	30.15	4.87	<5%
13	28.44	4.79	30.49	5.54	28.98	5.73	30.68	5.03	<5%

SD = standard deviation, <5% = difference between the means is significant at 5% level of random error.

Table 5. Descriptive and comparative statistics for metric index (cm).

Group	Chinese		Cypriot		Egyptian		Hungarian		
Age	Mean	SD	Mean	SD	Mean	SD	Mean	SD	P
10	-1.41	0.27	-1.32	0.23	-1.38	0.30	-1.58	0.32	<5%
11	-1.46	0.28	-1.39	0.24	-1.43	0.31	-1.63	0.31	<5%
12	-1.52	0.34	-1.45	0.26	-1.55	0.30	-1.69	0.34	<5%
13	-1.50	0.29	-1.43	0.30	-1.53	0.32	-1.72	0.32	<5%

SD = standard deviation, <5% = difference between the means is significant at 5% level of random error.

standard deviations were similar in the four nations, and no mean dependent variabilities were found. The decreasing rank order of mean height is Hungarian, Cypriot, Chinese and Egyptian in all the four age groups.

Differences between the body mass means were also significant. The Hungarian children were the heaviest consistently considering the absolute and relative meanings as well (Table 3 and 4). The average body masses of the Chinese, Cypriot, and Egyptian boys were very similar. The only exception was the significantly greater mean of the 13-year-old boys (48.1 vs. 43.8 kg).

Tables 5 and 6 contain the means and standard deviations of growth type indices. The Hungarian boys could be characterised by the most negative metric index means from all the four age groups. However, the most linear (leptomorph) body built refers to greater bone-muscle development that is indicated by the plastic index means. By the increasing linearity component (metric index) of the growth type the rank order is: Hungarian, Chinese, Egyptian and Cypriot. It does not coincide with the trend that has been represented by the height means. The differences between the average growth type indices of Chinese and Egyptian boys were not significant at 5% level of random error in these samples.

Excluding the significant height differences from the variability of plastic index (Table 7), the consistent differences mentioned earlier disappear. At last the 10-year-old Egyptian boys and the 12-year-old Chinese adolescents had significantly greater relative plastic index than those of the remaining three averages in the respective age groups.

Another interesting observation is the timing of peak linearity (the most negative metric index within one nation). The most negative metric index means were found at 12 years of age in the Chinese, Cypriot and Egyptian samples, and the average metric indices have become greater (less negative) consistently at the 13-year-old boys. The mean trend described by the growth type indices of the investigated Hungarian subjects has indicated a significant linear decrease in accordance with the earlier published data (Szmodis et al. 1976; Mészáros et al. 1981; Mészáros and Mohácsi 1987).

By the cardiorespiratory endurance (estimated by the running time of a 1,200 m distance) our subjects can be divided in two groups (Table 8). Significantly better performances refer to the Cypriot and Hungarian subjects, and the longer times (slower running speed) to the Chinese and Egyptian samples, though the standard deviations around the means were very similar. By the evaluation of PE teachers

Table 6. Descriptive and comparative statistics for plastic index (cm).

Group	Chinese		Cypriot		Egyptian		Hungarian		
Age	Mean	SD	Mean	SD	Mean	SD	Mean	SD	P
10	63.18	2.94	65.03	3.59	65.21	5.31	66.69	3.73	<5%
11	66.29	4.32	67.99	3.55	67.03	4.36	68.31	3.89	<5%
12	70.78	4.76	70.24	4.29	69.01	4.26	70.97	3.73	<5%
13	72.91	4.42	73.77	5.18	71.49	5.56	74.18	4.53	<5%

SD = standard deviation, <5% = difference between the means is significant at 5% level of random error.

Table 7. Descriptive and comparative statistics for relative plastic index.

Group	Chinese		Cypriot		Egyptian		Hungarian		
Age	Mean	SD	Mean	SD	Mean	SD	Mean	SD	P
10	46.28	2.15	47.15	2.60	48.69	3.96	47.53	2.40	<5%
11	46.69	3.04	47.28	2.47	47.62	3.09	46.51	2.65	NS
12	48.03	3.23	47.12	2.88	47.15	2.91	46.56	2.45	<5%
13	47.32	2.87	46.98	3.28	47.34	3.68	46.94	2.87	NS

SD = standard deviation, <5% = difference between the means is significant at 5% level of random error, NS = difference between the means is not significant.

Table 8. Descriptive and comparative statistics for 1200 m run (s).

Group	Chinese		Cypriot		Egyptian		Hungarian		
Age	Mean	SD	Mean	SD	Mean	SD	Mean	SD	P
10	402.9	34.8	362.6	38.6	409.1	48.5	380.1	46.3	<5%
11	399.2	40.6	359.9	37.8	419.2	51.1	369.6	42.4	<5%
12	395.1	39.3	356.3	39.6	392.6	45.9	359.8	35.2	<5%
13	389.9	39.6	351.7	41.9	389.3	46.4	348.7	34.7	<5%

SD = standard deviation, <5% = difference between the means is significant at 5% level of random error.

the above mentioned weaker performances cannot be qualified as real running.

Discussion

The simplest explanation would be that the observed differences have arisen from the various ethnicity. Though the investigated subjects are living in three continents in different geographical and cultural regions, this explanation alone is rather stuff.

The lifestyle, elementary habits and habitual physical activity strongly correlate with body mass (especially with relative body mass) and cardiorespiratory endurance, but these environmental effects do not influence on stature and physique, if the biologically necessary nutrients are continuously consumed. Though our subjects were not fat or obese (one of the grouping criteria was the body fat content being less than 25%), they cannot be qualified as lean pupils. The basic function of physical education in Egypt and Malaysia is to ensure some physical activity between the theoretical classes. The improvement of different basic abilities like endurance, speed, strength, etc., and motor learning does not belong to its tasks.

For the consistent height and physique differences we only have theoretical explanations. Anthropologically, the two European samples are closer to each other than the Egyptian to the Chinese. Consequently, or accidentally, the Europids were the tallest, however, the mean differences between the metric index means of the Cypriot and Hungarian samples were the largest. In spite of the similar height their body proportions and physique were significantly different. The Cypriot society is a relatively closed one with a short breeding radius (the Turkish-Greek marriage was exceptional), and following the civil war this isolation has increased. In Hungary the immigration, the effects of heterosis seem to be continuous during the past centuries. The more linear body built and the taller stature could be related to these effects.

The morphological differences between the Chinese and Arabic samples were very moderate in spite of the more than 11 thousand km geographic distance, since they are closest to the Equator. In our opinion the marked differences would be more obvious than the similarities, nevertheless, both the Malaysian-Chinese and the Egyptian communities are biologically more closed (religion and traditions) than the

Cypriot society. The respective results could be evaluated as sampling error, since about 100 children per age groups were investigated, but this frequency was enough to ensure the morphological variability in the other two possible comparisons. Excluding the possible effects of sampling, no definitive explanations could be given for the observed similarities.

The break point in the age-related trend of metric index relates to the time of biological maturation (Szmodis et al. 1976). The earlier break point (at 12 years of age) of the Chinese, Cypriot and Egyptian boys may indicate their earlier maturation. Since there are close similarities in the socio-economic position (consequently, the living standards of our subjects), pediatric care, caloric intake (only the amount, but not the quality of nutrients) and habitual physical activity, etc., of our subjects, the most obvious explanation is the relationship between the timing of maturations and the ratio of sunny hours, which is markedly greater in Cyprus, Egypt and Malaysia than in Hungary.

In conclusion, the metric and plastic indices (Conrad 1963) sensitively reveal the slight differences in body built and physique resulting from ethnic differences, various physical activity, etc.

References

Conrad K (1963) Der Konstitutionstypus. Springer Verlag, Berlin.

Farkas A, Frenkl R, Mészáros J, Mohácsi J (1999) A study on BMI in children: The connection with body composition variables. Pediatric Exercise Science 11:258-259.

Mészáros J, Szmodis I (1977) Indices of physique and motor performance in pupils attending schools with a special physical education curriculum. In Eiben OG, ed., Growth and development; physique. Symposium on Human Biology. Vol. 20. Akadémiai Kiadó, Budapest, 253-261.

Mészáros J, Szmodis I, Mohácsi J, Frenkl R (1981) A nemzedéki változás és a gyermekkori fejlődés kérdései az 1970-es években végzett keresztmetszeti vizsgálat alapján. Biológia 29:165-200.

Mészáros J, Mohácsi J (1987) The growth type of 7 to 18-years-old schoolchildren in Hungary. 13th School of Biological Anthropology, Abstracts, Zagreb, 22.

Othman M (2001) A testi felépítés, a testösszetétel és a fizikai teljesítményjellemzõk vizsgálata 10-13 éves fiúknál (in Hungarian). Ph.D. Thesis, Semmelweis University, Budapest.

Parízková J (1961) Total body fat and skinfold thickness in children. Metabolism 10:974-807.

Szabó T, Mészáros J (1980) Relationship of bone age, physical development and athletic performance. Anthrop Közl 24:263-267.

Szmodis I, Mészáros J, Szabó T (1976) Alkati és működési mutatók kapcsolata gyermek-, serdülő- és ifjúkorban. Testnevelés- és Sportegészségügyi Szemle 17:255-272.

Tittel K, Wutscherk H (1972) Sportanthropometrie. JA Barth, Leipzig.

Weiner JES, Lourie JA (Eds.) (1969) Human Biology. A Guide to Field Methods. IBP Handbook, No. 9. Blackwell Scientific Publishers, Oxford.