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RELATION BETWEEN ANTHROPOMETRIC SOMATOTYPE AND MOTOR PERFORMANCE IN PREPUBESCENT AND PUBESCENT CZECH CHILDREN

ABSTRACT: The aim of this study was to find the relations between the components of anthropometric somatotype and motor performance in boys and girls (8–9 and 12–13 years old) with considerably above-average and considerably below-average total score of the test battery UNIFITTEST. The representative sample which participated in the motor performance test consisted of 253 boys and 267 girls aged 8–9.99, 247 boys and 262 girls aged 12–13.99. For analysis of the results of selected samples (17 to 25 children), non-parametric statistical methods were used. We have found out a significant positive relation between ectomorphy and the level of motor performance and on the contrary significant negative relation between endomorphy as well as mesomorphy and the level of motor performance of pubescent boys and girls. Then we recorded a significantly lower variability of the results of somatotype components in the high motor efficient group than in the low motor efficient one. The samples of boys and girls with a high motor performance corresponded to their somatotypes (mesomorphic ectomorphy and ectomorphic mesomorphy with low level of endomorphy dominated) and on the contrary boys and girls with a low motor performance were difficult to characterize.

KEY WORDS: Anthropometric somatotype – Prepubescent – Pubescent – Motor performance

INTRODUCTION

During the ontogenesis, motor development as part of the development of the whole organism, has its individual characteristics and uneven pace. To simplify the whole matter we can define two basic sources of inter-individual variability in motor performance: biogenetic determination of an individual and the influences and conditions of the individual's environment. These two sources cause, among others, that there is a great variability in individual motor performances with a series of individuals different from common population. Available literary sources do not provide complete information about individuals with extreme values of motor performance (especially about individuals with extremely low values) because most of the analysed researches focused on average, popular tendencies in motor performance.

In the framework of our research (Suchomel 2000) focused on characteristics of school-aged individuals with low (significantly below-average) and high (significantly above-average) level of basic motor performance, we studied the relation between somatotype and motor performance. In the submitted contribution we present our findings.

A lot of researches focused on methods of determination of somatotype have been done by various authors (Hippokrates; Hallé and the French School with Rostan and Sigaud; De Giovanni and the Italian School with Viola; the German School with Kretschmer and Conrad; Škerlj with Brožek and Hunt; Lindegård; Sheldon and his followers Parnell, Heath, Carter and Howells; Tanner; in the Czech Republic Blažek; Greil and Baudisch and many others), the survey of which was published by Bok (1972), Greil, Baudisch (1994). We found the method according to Heath and Carter (Heath, Carter 1967, Carter 1975) the most suitable for the purpose of our research. Recently, this method has been the most widespread method of determining the so-called anthropometric somatotype, it seems well elaborated and acceptable for physical education research (Bok 1972).

The authors of the method followed up the works of Sheldon *et al.* (1940) that had introduced the term somatotype of an individual and defined it as a relation of morphological components expressed by three figures. These figures describe three basic components of human stature: endomorphy, mesomorphy and ectomorphy. As the results of published findings dealing with relations of the components of somatotype of school-aged boys and girls show, there is mostly a significantly negative relation of endomorphy and mesomorphy to ectomorphy, and a significantly positive relation of mesomorphy to endomorphy, which is even more typical for girls and women (Štěpnička *et al.* 1976, 1987, Netolická 1991, Riegerová 1994). As for the relation between somatotype and biological age, the results have shown that high values of the ectomorphic component signal later maturity, on the other hand individuals with lower relative length of body segments mature earlier. Accelerated boys are, within the generally understood somatotype, more endomorphic, with lower mesomorphy and a tendency to medium types. Boys with average biological age are significantly mesomorphic and have athletic figure, retarded boys are rather ectomorphic, with significantly lower endomorphy up to the age of 17 (Riegerová 1994).

Somatotype describes the momentary morphological state of an individual. Different somatotypes have different morphological predispositions to physical activity and their reactions to physical activity are different, too. To a certain extent, according to the morphenotype, we can predict the level of motor performance since the child's lower school age. Apart from other neurophysiological and psychological factors, suitable somatotype, especially the dominance of the mesomorphic component, is one of the conditions of excellent performance at various sports (Riegerová, Vodička 1992, Riegerová 1994).

The relation between somatotype and motor performance has been studied by a series of Czech experts. At first, the subjects of studies were top sportsmen in some disciplines (Štěpnička 1977). After that, research dealing with children population of pre-pubescent and pubescent age followed (Štěpnička *et al.* 1976, 1987, Bursová 1990a, 1990b, Chytráčková 1990, 1995, Netolická 1991, Riegerová 1984, Riegerová, Vodička 1992). Summarizing the results of the studies mentioned above we can state that the relation of the individual components of somatotype to motor performance is rather ambiguous. The value of the ectomorphic component was usually either in a positive relation to the performances in motor performance tests or there was no evident relation between them. No significant relation between mesomorphy and the results of the children in motor performance tests was proved. In most cases, the endomorphic component had a significantly negative relation to the results of the children in motor performance tests. The best results in the tests were reached by ectomorphic mesomorphs while the worst results were reached by endomorphs, with no inter-sexual differences.

From the point of view of our work, Bursová (1990b) published an interesting analysis of the somatic characteristics of selected motorically considerably above-average and motorically considerably below-average boys. Unfortunately, the results of this research cannot be fully used due to quite a low number of participants (7 motorically above-average and 9 motorically below-average boys of different ages). In the conclusions, the author stated that the motorically above-average individuals, as for their somatic characteristics, showed a significant similarity. The selected individuals were characteristic by ectomorphic mesomorphy or mesomorphic ectomorphy, with very low endomorphy. On the contrary, the significantly below-average individuals did not show any tendency which would unambiguously characterize their somatic profile.

At present, school-aged children can be divided into categories of somatotypes according to their motor performance suggested by Štěpnička *et al.* (1976) and into 5 categories marked A to E adapted by Chytráčková (1990). The best results in the motor performance tests were reached by boys and girls from the D category (with dominant ectomorphy) and the B category (with dominant mesomorphy). On the contrary, the worst results were reached by boys and girls from the C category (endomorphs), or, if these were absent in the measured samples, children from the A category (especially endomorphic mesomorphs and medium somatotypes – Netolická 1991, Chytráčková 1995).

The aim of our study was to determine the relation between anthropometric somatotype and motor performance of school-aged boys and girls (8–9 and 12–13 years old) who have considerably above-average and considerably below-average total score of the test battery UNIFITTEST (6–60) (Měkota, Kovář *et al.* 1995). Analysing the published findings, we came to the hypothesis that the ectomorphic component of somatotype will be in a positive relation to motor performance while the endomorphic component will be in a negative relation to motor performance. We also suppose that we will find a closer relation in the samples with high motor performance than in the samples with low motor performance.

METHODS

Method of selecting subjects

In the framework of our research, we decided to use the standardized test battery of UNIFITEST (6–60) for evaluation of basic motor performance of school-aged children. For pre-pubescent and pubescent individuals, it contains four motor tests: standing broad jump, sit-ups 60 seconds, endurance shuttle run (20 m) or 12-minute run, and shuttle run 4×10 m. The total score of the test battery is expressed by the sum of four point (sten) values (the extent is 4–40 points, the theoretical average value is 22 points and the standard deviation is 5 stens – Měkota, Kovář *et al.* 1995).

The representative sample which participated in the motor performance test consisted of 253 boys and 267 girls aged 8–9.99, 247 boys and 262 girls aged 12–13.99. All of them come from the Liberec region, the Czech Republic. No children having any health limitation or attending specialized sport schools were included in the representative sample. On the basis of all participants' results, we selected:

a) individuals with a low motor performance; their total test scores were over 1.5 standard deviation below the average value (14 points and less) – four samples contained 19–25 children;
b) individuals with a high motor performance; their total test scores were over 1.5 standard deviation above the average value (30 points and more) – four samples contained 17–23 children.

Methods of data analysis

To determine the anthropometric somatotype we used a modified Sheldon method according to Heath, Carter (1967). The chosen typological technique is relatively reliable, by means of determining the mesomorphic component it tries to determine the proportion of active body mass and it is applied in most researches focused on the somatotype (Štěpnička *et al.* 1976). The advantage of this method is that it works with anthropometric data, which are easy to measure. The diagram of somatotypes in the form of so-called somatograph (Sheldon graph) provides easy and fast orientation in the dispersion of the result values. The selected method can be successfully used for both children and adult people of both sexes, and the somatotype is rather stable since approximately 8 years of age (Malina, Bouchard 1991). Since this method has been sufficiently described in original literature (Heath, Carter 1967, Carter 1975) and in Czech literature (Štěpnička *et al.* 1979, Bláha *et al.* 1986, Riegerová, Ulbrichová 1998) too, we do not find it necessary to describe it in detail. Data of the three basic components of somatotype (endomorphy, mesomorphy and ectomorphy) were processed with the use of software ANTROPO version 98.1 (author Pavel Bláha – ANTROBLA, 1998), with the accuracy of measurement 0.1 point.

It is rather disputable whether the method according to Heath and Carter (1967) is possible to use for obese children. On the basis of their research of obese boys and girls Bláha, Lisá (1994), for example, find this method unsuitable for determining the somatotype of obese individuals. This is mainly because of the method of determining the mesomorphic component (the result values are too high and do not correspond to reality) and the ectomorphic component (the result values are negative). Some authors also oppose to the method of determining the endomorphic component, which, as they suppose, may not express the fat component objectively in children age groups due to high variability of fat spread (Carter 1975, Bláha *et al.* 1986). This is the reason why they use correction of the calculation of the endomorphic component for boys and girls from 8 to 14 years of age. The correctional coefficient corrects the sum of three skinfolds (Carter 1975, Bláha *et al.* 1986), the corrected values of endomorphy are then approximately 0.5 points higher than the uncorrected ones (Kopřiva, Čechovský 1990).

Because of the size and the way of their selection, we used so-called boxplots to project basic descriptive characteristics of selected samples graphically. A boxplot is a graph the span of which is equal to 50 percent of all the cases and in which the median value is presented. We used Kruskal-Wallis test with subsequent pair comparison for testing the significance of the difference of the result values of our samples (McElroy 1979). The calculated medians of somatotype components of the selected samples were compared with normative data according to Bláha *et al.* (1986). It was done via so-called normalized indices (= NI). The calculated NI values were entered into graphical grids, so-called somatic profiles.

To assess somatotypes of the selected samples, we classified median somatotypes into 13 categories according to the dominance of the individual components and their correlation (Carter 1975, Štěpnička *et al.* 1979, Riegerová, Ulbrichová 1998). The dispersion of the somatotypes was assessed through visual comparison of the points in somatographs. We analyzed the dispersion of somatotypes by means of:

a) associating somatotypes in five categories according to motor performance (Štěpnička *et al.* 1976, Chytráčková 1990);
b) calculating the indices of somatotype dispersion: in two-dimensional expression SDI (Ross , Wilson 1973) and in three-dimensional expression SAM (Duquet, Hebbelinck 1977), in homogenous samples, SDI usually ranges between 1.87 and 2.57 units (Ross *et al.* 1977);
c) calculating so-called I-index (Ross *et al.* 1977) and the distance of median somatotypes: in two-dimension expression SDD (Ross, Wilson 1973) and in three-dimension expression SAM (Duquet, Hebbelinck 1977).

Mathematical-statistical data processing was done using the software of S-PLUS version 4.0 (Data Analysis Products Division, Math Soft, Inc., Seattle, Washington, U.S.A., 1997).

RESULTS AND DISCUSSION

Legend – abbreviations used in this chapter: Y = pre-pubescent (younger) individuals (aged 8–9); O = pubescent (older) individuals (aged 12–13); B = boys; G = girls;

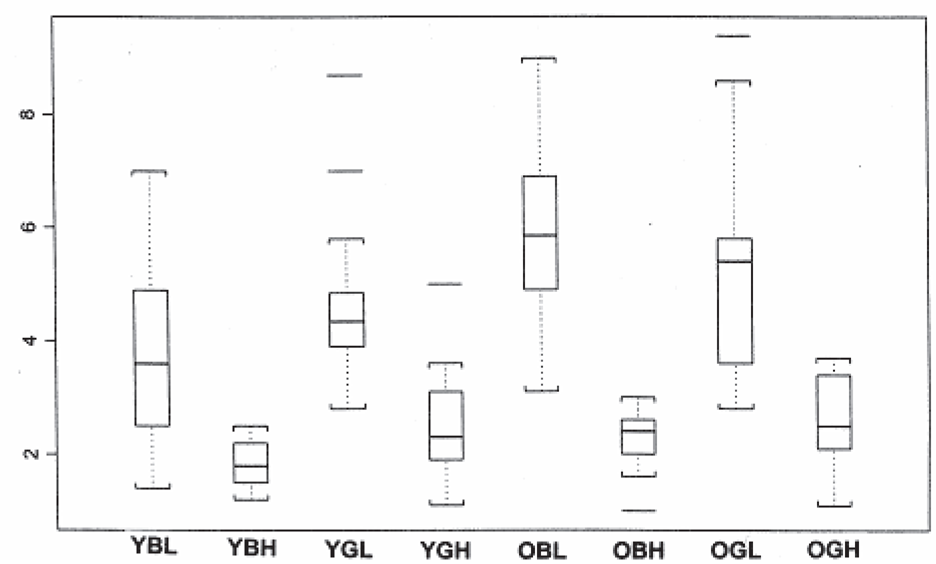

FIGURE 1. Boxplot of endomorphy (points). Y = pre-pubescent individuals; O = pubescent individuals; B = boys; G = girls; L = low level of motor performance; H = high level of motor performance.

H = high level of motor performance; L = low level of motor performance; K-W test = the Kruskal-Wallis test; $\chi^2_{0,01;7}$ = chi square (the 0.01 significance level; 7 degrees of freedom).

In the boxplots (*Figure 1–3*) we can see the result values of the L and H samples in particular components of somatotype. Assessing the result values of endomorphy (*Figure 1*), we can see that there is a significant tendency towards a high variability of the values in the L sample. On the other hand, we did not find any significant differences between the values in the H samples, particularly in the male samples. The graph clearly shows that there are logically significant differences in the endomorphic component between the samples of different ages, sexes and levels of motor performance. In all cases, higher values were recorded in the L samples. The differences mentioned above were statistically confirmed by the result of the K-W test (110.04 > $\chi^2_{0,01;7}$), at the 0.01 significance level.

Subsequently, we used the K-W test to compare result values of the selected samples in pairs (*Table 1*). It shows that in both age categories there were statistically significant differences between boy and girl samples with different level of motor performance – 0.01 level of significance, with the exception of 0.05 level of significance between the YGL and YGH samples.

The boxplot of mesomorphy (*Figure 2*) shows a great variability of results in the L samples. The YGL sample with its low interquartile range seems to be a certain exception, on the other hand there are four remote values.

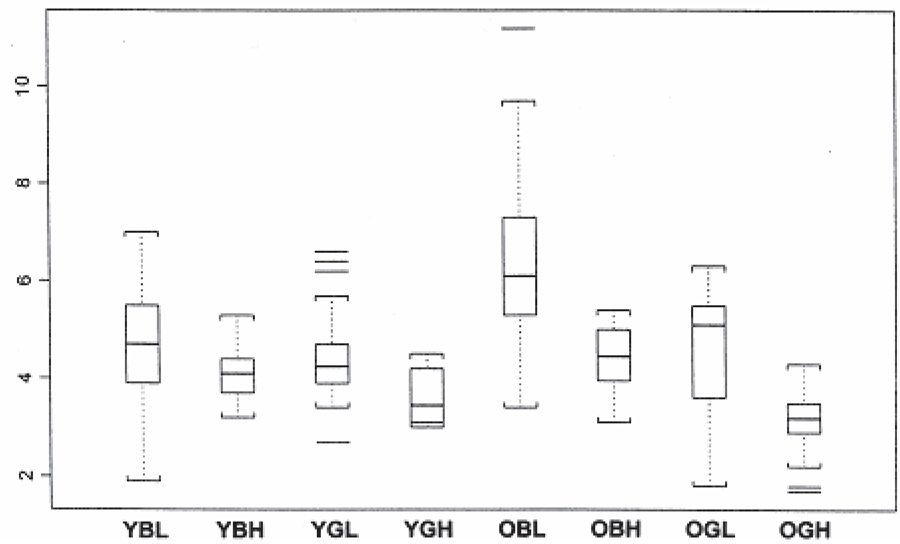

FIGURE 2. Boxplot of mesomorphy (points). Y = pre-pubescent individuals; O = pubescent individuals; B = boys; G = girls; L = low level of motor performance; H = high level of motor performance.

TABLE 1. Pair comparison of results of endomorphy (the Kruskal-Wallis test). Y = pre-pubescent individuals; O = pubescent individuals; B = boys; G = girls; L = low level of motor performance; H = high level of motor performance; levels of statistical significance: *** = 0.01, ** = 0.05, * = 0.10.

	YBL	YBH	YGL	YGH	OBL	OBH	OGL
YBL							
YBH	***						
YGL		***					
YGH			**				
OBL		***		***			
OBH			***		***		
OGL		***		***		***	
OGH			*		***		***

TABLE 2. Pair comparison of results of mesomorphy (the Kruskal-Wallis test). Y = pre-pubescent individuals; O = pubescent individuals; B = boys; G = girls; L = low level of motor performance; H = high level of motor performance; levels of statistical significance: *** = 0.01, ** = 0.05, * = 0.10.

	YBL	YBH	YGL	YGH	OBL	OBH	OGL
YBL							
YBH							
YGL							
YGH							
OBL		***	**	***			
OBH							
OGL							
OGH	**		*		***	**	**

In all cases, comparing samples of the same age and sex and different motor performance, we recorded higher values of the mesomorphic component in the L samples, which is a surprise. In the pre-prepubescent samples, we do not find these differences between the L and H individuals logically significant. On the other side, in the pubescent samples, there are logically significant differences between the respective median values in relation to the different levels of motor performance (the boys' difference is 1.65 points; the girls' difference is 1.9 points). The differences mentioned above were verified by means of the K-W test and subsequent pair comparison of the values in the selected sample (*Table 2*). Calculation of the K-W test (64.13 > $\chi^2_{0,01;7}$) confirmed statistically significant differences between the samples at the 0.01 level and resulted in rejecting the hypothesis of correspondence of the values of the mesomorphic component of the samples.

The high values of the mesomorphic component in the L samples are a question to be discussed. Generally, the mesomorphic component is considered a predisposition to high sports performance, which was not fully confirmed by the results mentioned above. The contradiction could be caused by using the method of determining so-called anthropometric somatotype of obese children (in our case approximately one third of the pubescent L samples). This problem was mentioned in the work by Bláha, Lisá (1994); when we determine the mesomorphic component of obese children, the recorded values are too high and do not correspond to reality. We can agree with the above, because, in the frame of our research, we found out similar contradictions between the visual characteristics of the individuals (round proportions, short limbs, great amount of fat) and the calculated values of mesomorphy exceeding 5 points. So the problem probably lies in the method of determining somatotype, which calculates the mesomorphic component from width and circumference parameters that are high above average in the case of obese children.

According to the table of pair comparison of the results of mesomorphy (*Table 2*), we can see that while the above mentioned logically significant difference between the OGL and OGH samples was statistically confirmed at the 0.05 level of significance, any logically significant difference between the OBL and OBH samples was not statistically confirmed. We think it is due to a great variability of the

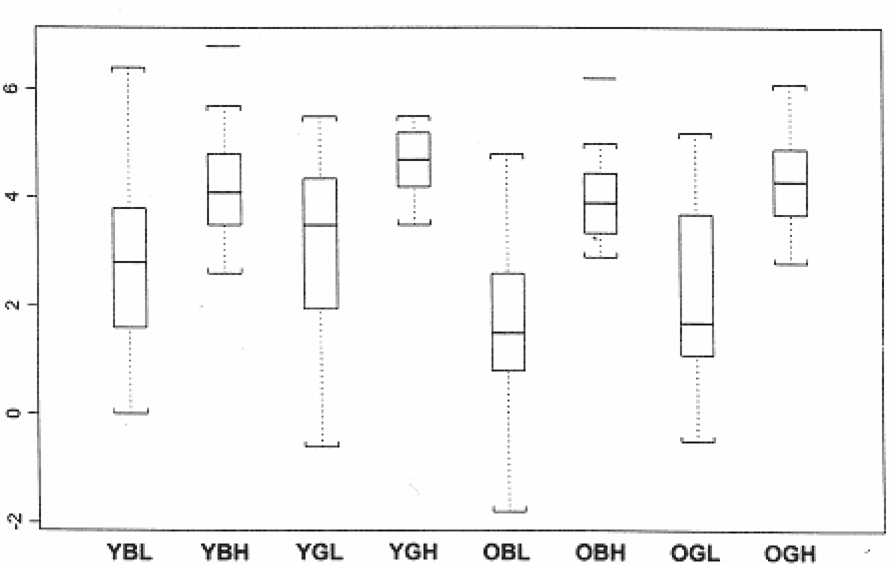

FIGURE 3. Boxplot of ectomorphy (points). Y = pre-pubescent individuals; O = pubescent individuals; B = boys; G = girls; L = low level of motor performance; H = high level of motor performance.

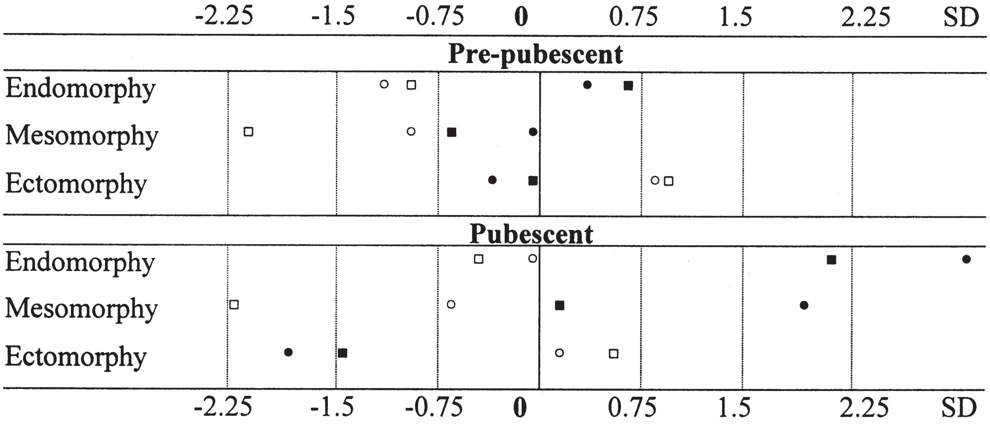

FIGURE 4. Normalized indices of somatotype components medians of samples with low and high level of motor performance. ● = boys with low motor performance; ❍ = boys with high motor performance; ■ = girls with low motor performance; ❑ = girls with high motor performance; SD = standard deviation.

values, especially in the OBL sample, and to quite a small number of participants in the samples. In view of the results of our work we find this difference logically significant.

Within the somatic profile (*Figure 4*), by means of the NI, we compared the calculated medians of the components of the somatotype in the N and H samples with the normative data of Czech population published by Bláha *et al.* (1986). The profile shows that there are significant differences between the NI values of the endomorphic component in the Land H samples and also that in both performance categories this value increases with the age of individuals. As for the mesomorphic component, we found significant differences in the values between the samples of different sex and different level of motor performance, especially in the pubescent samples. In the L samples, the values of the NI tend to increase with the age. The ectomorphic component has shown differences between the values of the NI in the L and H samples, especially in the pubescent samples. The older the individuals are, the lower values of the NI they have.

The basic idea of the somatotype is its understanding as a complex in which one of its components is relatively dominant. That was why we used the calculated medians of the individual components to determine median somatotypes of the selected samples. We found the following median somatotypes: the YBL sample 3.50–4.75–2.80; the YBH sample 1.75–4.10–4.10; the YGL sample 4.30–4.30–3.30; the YGH sample 2.40–3.50–4.70; the OBL sample 6.10–6.15–1.50; the OBH sample 2.60–4.45–3.95; the OGL sample 5.75–5.10–1.70 and the OGH sample 2.70–3.20–4.30. In the somatograph (*Figure 5*) the median somatotypes of the measured samples are divided into 13 categories according to dominance of the components and their correlation (Carter 1975).

In the graph of median somatotypes (*Figure 5*) we can see that generally the somatotypes of the L samples are

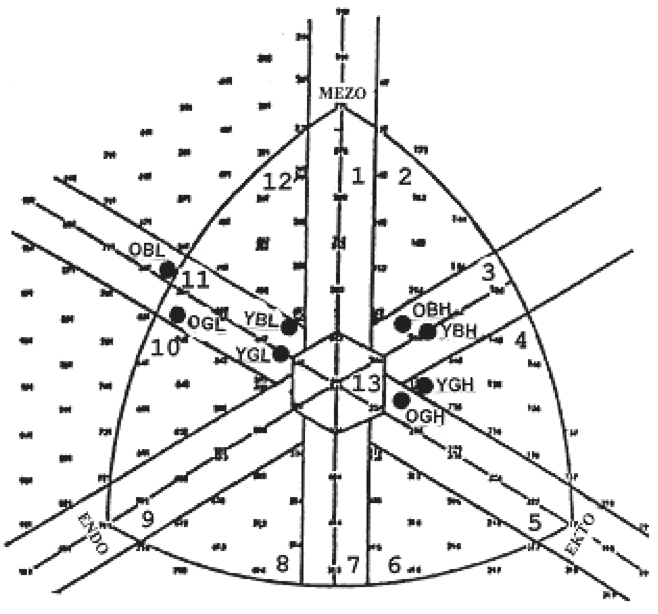

FIGURE 5. Median somatotypes of selected samples – categories in accordance with Carter (1975). Y = pre-pubescent individuals; O = pubescent individuals; B = boys; G = girls; L = low level of motor performance; H = high level of motor performance.

TABLE 3. Pair comparison of results of ectomorphy (the Kruskal-Wallis test). Y = pre-pubescent individuals; O = pubescent individuals; B = boys; G = girls; L = low level of motor performance; H = high level of motor performance; levels of statistical significance: *** = 0.01, ** = 0.05, * = 0.10.

	YBL	YBH	YGL	YGH	OBL	OBH	OGL
YBL							
YBH							
YGL							
YGH	**						
OBL		***		***			
OBH					***		
OGL				***			
OGH					***		**

situated in the left half of the somatograph, in its mesomorphic-endomorphic part, and the somatotypes of the H samples in its right half, in the ectomorphic-mesomorphic part. The higher the age of the individuals and the lower the motor performance of the samples are, the more they move in the endomorphic-mesomorphic direction. Using the categories described by Carter (1975), the median somatotypes of the YBH and OBH samples belong to the category of mesomorphs-ectomorphs, the median somatotypes of the YGH sample to the neighbouring category of mesomorphic ectomorphs and the median somatotype of the OGH sample to the category of balanced ectomorphs. The median somatotypes of the L samples belong to the category of mesomorphs-endomorphs in all the cases.

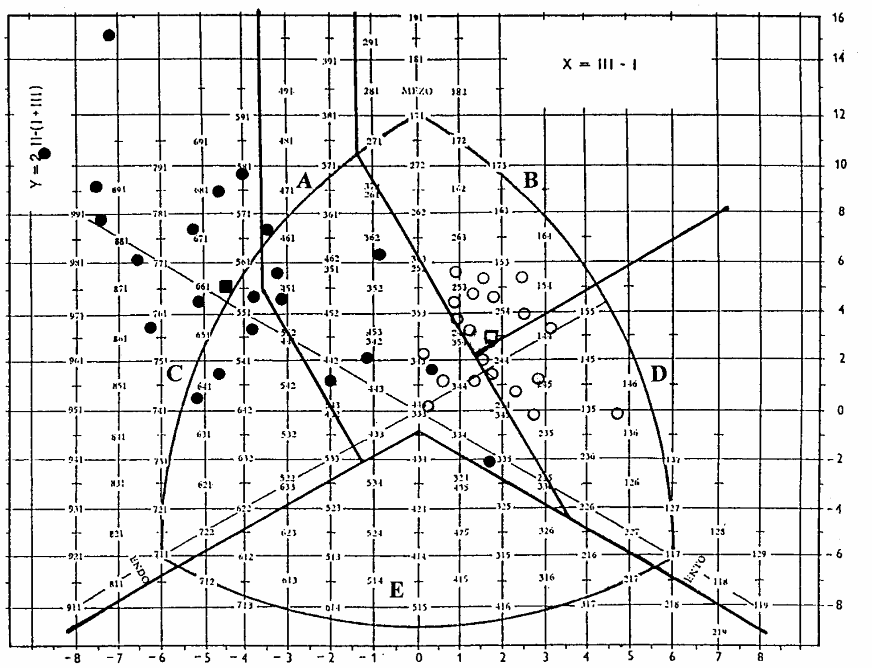

FIGURE 6. Somatotypes of pubescent boys – categories in accordance with motor performance (A – E). ● = boys with low motor performance; ❍ = boys with high motor performance; ■ = median somatotype of boys with low motor performance; ❑ = median somatotype of boys with high motor performance.

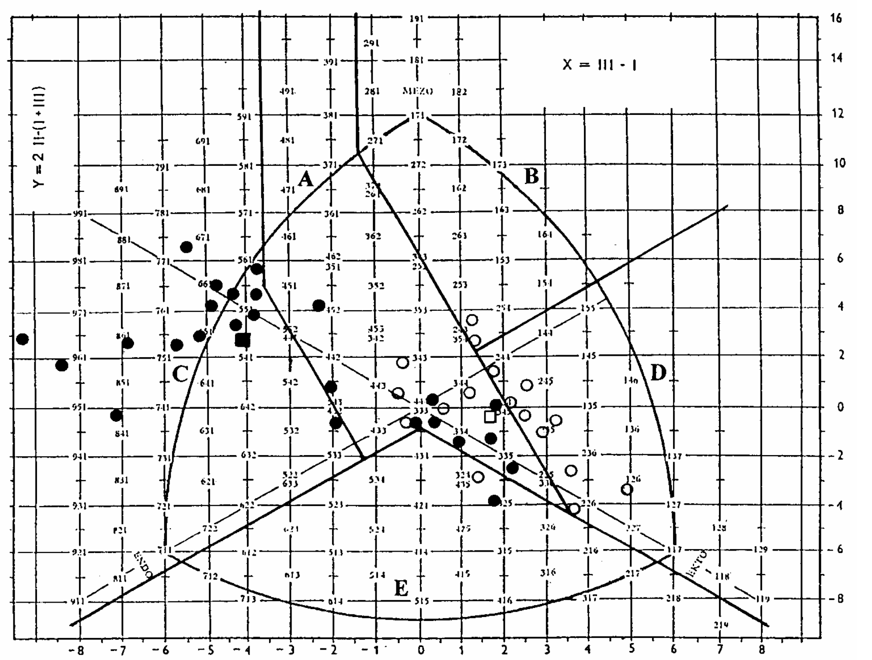

FIGURE 7. Somatotypes of pubescent girls – categories in accordance with motor performance (A – E). ● = girls with low motor performance; ❍ = girls with high motor performance; ■ = median somatotype of girls with low motor performance; ❑ = median somatotype of girls with high motor performance.

TABLE 4. Results of SDI and SAM. Y = pre-pubescent individuals; O = pubescent individuals; B = boys; G = girls; L = low level of motor performance; H = high level of motor performance.

	YBL	YBH	YGL	YGH	OBL	OBH	OGL	OGH
SDI	5.08	2.11	4.05	2.19	5.42	2.33	6.20	2.98
SAM	2.19	0.95	1.89	1.04	2.35	1.05	2.48	1.30

The somatotypes of all pubescent boys and girls (*Figures 6* and *7*) are shown in two somatographs, divided in five categories according to motor performance (Chytráčková 1990). Analysing the dispersion of the somatotypes of the H and L individuals in the categories according to motor performance we can state that in the male pubescent H sample, there are more individuals belonging to the B category, while in the female sample slim individuals belonging to the D category prevail. Low level of motor performance in the pubescent samples is characteristic for obese boys and girls belonging to the C category, sometimes to the A category. A minimum number of the measured individuals belong to the E category. The results approximately correspond with the findings of Chytráčková (1990) and Netolická (1991).

The somatographs above have clearly shown great differences in the dispersion of the somatotypes between the L and H samples. In order to analyse the dispersion of the somatotypes in detail, we calculated indices of the somatotype dispersion, expressed by the SDI index in two-dimensional expression, and by the SAM index in three-dimensional expression (*Table 4*).

Analysing the dispersion of the somatotypes in the somatographs and the results of the SDI and SAM, we found out that in all the cases the result values were more homogenous in the H samples (the SDI from 2.11 to 2.98; the SAM from 0.95 to 1.30) than in the L samples (the SDI from 4.05 to 6.20; the SAM from 1.89 to 2.48). In both performance samples, the result values were more homogenous in the prepubescent samples of both sexes than in the pubescent samples. With regard to the SDI range determined by Ross *et al.* (1977), we can, with the exception of pubescent girls, speak about homogenous selected H samples.

Assessing the result values of the I-index (possible range 0–100), we can clearly see that there is very little coincidence of somatotype dispersion of samples of the same age, sex and different motor performance (I-indices 4.12–16.67). The lowest value was found in the group of pubescent boys and the highest value in the group of pubescent girls. Great differences in somatotype dispersion between the L and H samples are identically documented by means of calculated distances between median somatotypes in two-dimension expression the SDD (from 5.71 to 11.42) and in three-dimensional expression the SAD (from 2.41 to 4.74). The distances are considered big; SDD = 1, or SAD = 0.5 means one of the components has changed by 0.5 points (Bok, Tlapáková 1982).

TABLE 5. Results of I-index, SDD a SAD. L = low level of motor performance; H = high level of motor performance.

<table>
<tr><th rowspan="2">Age</th><th rowspan="2">Characteristic</th><th colspan="2">Boys</th><th colspan="2">Girls</th></tr>
<tr><th>L</th><th>H</th><th>L</th><th>H</th></tr>
<tr><td rowspan="3">Prepubescent</td><td>I-index</td><td colspan="2">16.65</td><td colspan="2">14.57</td></tr>
<tr><td>SDD</td><td colspan="2">5.71</td><td colspan="2">6.47</td></tr>
<tr><td>SAD</td><td colspan="2">2.41</td><td colspan="2">2.61</td></tr>
<tr><td rowspan="3">Pubescent</td><td>I-index</td><td colspan="2">4.12</td><td colspan="2">16.67</td></tr>
<tr><td>SDD</td><td colspan="2">11.42</td><td colspan="2">9.15</td></tr>
<tr><td>SAD</td><td colspan="2">4.74</td><td colspan="2">3.75</td></tr>
</table>

CONCLUSIONS

On the basis of the determined somatotypes, we can claim that in the samples with low and high level of motor performance the recorded relation of ectomorphy to the level of motor performance was significantly positive, while the relation of endomorphy and mesomorphy to the level of motor performance was significantly negative in all pubescent samples and, as for endomorphy, also in male prepubescent samples. Analysis of the somatotype dispersion has shown that there is a closer relation of body built to high level of motor performance than to low level of motor performance because in all cases the results were more homogenous in the samples with high motor performance. These samples were somatically very similar, characterized by mesomorphic ectomorphy or ectomorphic mesomorphy with low level of endomorphy. On the contrary, the samples with low level of motor performance were difficult to characterize due to high values of the indices of the somatotype dispersion and a significant variability of the values of individual somatotype components. In these samples, mesomorphs-endomorphs, endomorphic mesomorphs and medium somatotypes slightly prevailed. The results confirmed the necessity of somatic parameter determination in the selection of sports talented children. On the other side they showed a tendency to ambiguous relation between the basic somatic characteristics and the low level of motor performance. Finally, on the basis of our findings, we confirm our hypothesis.

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