PARAMORPHIC AND DYSMORPHIC CHANGES OF THE THORAX AND OF THE THORACIC SPINE IN SECONDARY SCHOOL PUPILS

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Abstract:

On a sample of 290 15-16 year old secondary school pupils from Split, who were divided, by gender and by education degree, into four subsets, a set of nine relevant indices for the assessment of postural deviations was used to determine the paramorphic and dysmorphic changes in the thorax and in the thoracic spine on one hand, any possible differences between the subjects as regards gender and education level on the other. The obtained results allow the following conclusions to be drawn.

The secondary school boys and girls are characterised by a very small percentage of correct body posture. Paramorphic changes of the thorax as well as the paramorphic changes in the thoracic spine are relatively frequent, which can also be said for dysmorphisms. As regards gender, the paramorphic changes of the thorax are more frequent in secondary school girls, whereas the dysmorphic changes are more frequent in secondary school boys. It was evident that the paramorphic postural changes decreased with the increase in education level. This decrease was more expressed in boys.

The results of discriminant analyses pointed to the fact that the secondary school boys differred from their female peers in the space of the analysed indices of paramorphic and dysmorphic changes in the thorax and in the thoracic spine. The asymmetry of the pectoral muscles, the kyphotic spine and keel chest were more frequent in secondary school boys, whereas scoliosis was more frequent in secondary school girls.

It is necessary to implement such a system of physical exercising that would have an expressed antiparamorphic effect in order to prevent and suppress this large-scale occurrence in children at their developmental age.

Key words: *paramorphic and dysmorphic postural changes, discriminant analyses*

PARAMORPHISCHE UND DYSMORPHISCHE ÄNDERUNGEN VOM THORAX UND VON DER BRUSTWIRBELSÄULE BEI MITTELSCHÜLERN

Zusammenfassung:

Neun relevante Indexe für die Bewertung von Haltungsschäden wurden verwendet, um bei 290 15-16jährigen Mittelschülern aus Split, die laut deren Geschlecht und Ausbildungsstufe in vier Gruppen geteilt wurden, sowohl die paramorphischen und dysmorphischen Änderungen vom Thorax und von der Brustwirbelsäule einerseits, als auch die möglichen Unterschiede zwischen den Probanden, bezüglich deren Geschlecht und Ausbildungsstufe andererseits, festzustellen. Die Ergebnisse erlauben die folgenden Schlussfolgerungen.

Die MittelschülerInnen wurden von einem sehr niedrigen Prozent der regelmäßigen Körperhaltung charakterisiert. Sowohl die paramorphischen Änderungen vom Thorax als auch die paramorphischen Änderungen von der Brustwirbelsäule sind relativ häufig, und das gilt auch für die Dysmorphismen. Bezüglich des Geschlechts, die paramorphischen Änderungen vom Thorax sind häufiger bei den Mittelschülerinnen, und die dysmorphischen Änderungen bei den Mittelschülern. Es ist offensichtlich, dass sich die Anzahl von paramorphischen Haltungsänderungen in der höheren Ausbildungsstufe vermindert. Diese Verminderung ist bei den Mittelschülern mehr ausgeprägt.

Die Ergebnisse der Diskriminanzanalyse zeigten, dass sich, laut der Indexe der paramorphischen und dysmorphischen Änderungen vom Thorax und von der Brustwirbelsäule, die Mittelschüler und die Mittelschülerinnen voneinander unterschieden. Die Asymmetrie von Brustmuskeln, die kyphotische Wirbelsäule und *pectus carinatum* waren häufiger bei den Mittelschülern, und Skoliosis bei den Mittelschülerinnen.

Es ist notwendig, ein solches System von Körperübungen zu gestalten, das einen ausgeprägten antiparamorphischen Effekt haben würde, um diesem häufigen Phänomen vorzubeugen und es zu bekämpfen bei Kindern in deren Entwicklungsphase.

Schlüsselwörter: *paramorphische und dysmorphische Haltungsschäden, Diskriminanzanalysen*

Introduction

Although the back is a very strong structure and although it can bear heavy loads, the increasing number of people of different age categories and of different occupations suffer, due to their indifference or ignorance, from various disorders and traumatic states that can cause acute or permanent impairments of the thorax and the spine.

Paramorphic changes of the thorax and the spine have a significant incidence rate in the population of primary school children (Willner, 1984; Kalafatić, 1978; Dieck, Kelsey, Goel, Panjabi, Walter & Laprade, 1985; Lončar-Dušek, Pećina & Prebeg, 1991; Kosinac, 1992; Kosinac, Bižaca & Kučić, 2002; Kosinac & Bižaca, 2002). While growing, the organism corrects one portion of postural deviations by itself (self-correction) (Miniskin, 1971; Niderstrat, 1975). This natural capacity of the organism is somewhat less efficient in the so-called 'high-risk' children. If a paramorphic curvature continues to persist for a long time during the phase of intensified growth and if it is accompanied by various environmental conditions (long systematic school-related tasks, pedagogic discipline, decrease in motor activity, heavy static loads, frequent periods of fatigue and exhaustion, etc.), slowly but inevitably it transforms into recognisable types of dysmorphism with possible multiple consequences and significantly decreased therapeutic effects (Antropova & Koljcova, 1986; Ciammaroni, 1988; Lončar-Dušek, Pećina & Prebeg, 1983; Kosinac, 1994, 2002; Tribastone, 1994).

The longer lasting postural disorders are more frequent in boys and girls in upper forms (Antropova & Koljcova, 1986; Musafija & Radoničić, 1980; Kosinac, 1992, 1994, 2002; Negrini, A. & Negrini, S., 1991). The changes are located in the superior, middle and inferior parts of the thorax and the thoracic spine. Since growth and formation of the chest are not completed by the age of 14, various adverse effects can frequently distort the correct posture. If the correct attitude of the body is constantly distorted, morphological changes of the spine occur, in particular, the asymmetry of intervertebral discs and the asymmetry of the bodies of vertebrae. Due to the increased pressure in one or the other segment, the growth of the intervertebral discs and the growth of the bodies of vertebrae in this portion of the spine are slowed down, whereas, simultaneously, the portion of the spine that is not under pressure grows more intensively, which leads to pathological changes. The growth of vertebrae is not balanced – it is periodic and results in increased growth of the lumbar vertebrae in comparison to the thoracic vertebrae. Thus, in the period between three to fourteen years of age, the length of the bodies of the thoracic vertebrae is increased two times, the length of the bodies of the lumbar vertebrae 2.2 times, whereas the width of the bodies of the thoracic vertebrae is increased 1.5 times and the width of the bodies of the lumbar vertebrae 2 times.

The growth of intervertebral discs unfolds in a different way. In ten-year-old children their height in the thorax is increased two times and in the lumbar portion 1.5 times. After the age of 10, growth intensity is decreased, which is obviously connected with the onset of secondary ossification - formation of apophyses (Antropova & Koljcova, 1986).

From the kinesiological and morphological point of view, the evolution of postural deviations in 15-16 year old children can be the subject of interest for at least three reasons: 1) the existence of correlation between growth (increase in height), ossification and the occurrence of paramorphic and dysmorphic changes of the thorax and of the thoracic spine (Kalafatić, 1978; Musafija & Radoničić, 1980; Lončar-Dušek et al, 1983; Kosinac, 2002; Tribastone, 1994, etc.); 2) the occurrence of paramorphic and dysmorphic changes of the thorax and the thoracic spine is followed not only by morphological changes, but also by functional changes in the respiratory system (Kkosinac, 1999); 3) possible therapeutic intervention by means of kinesiological stimulation aimed at the final part of the process of morphological formation of thoracic posture at the age of 15 and 16 years is not irrelevant (Antropova & Koljcova, 1986; Becchetti, 1982; Edelmann, 1995; Kosinac, 1999; Kosinac & Bižaca, 2002).

Taking into account the psychophysical susceptibility of the organism to all kinds of overload during puberty, as well as taking into account the fact that the thoracic skeleton is not completely formed by the age of 14, it was purposeful to assume that a specific and variable occurrence of paramorphic and dysmorphic changes of the thorax and of the thoracic spine was to be expected during further growth and maturation of 15-16 year olds, both with regard to age and with regard to education level. The task of this study was to investigate the correlation between growth and postural changes – this 'parallelism' in children at their developmental age.

In the light of these considerations and searching for quality answers regarding this issue, the basic aim of this study was to determine the incidence of paramorphic and dysmorphic postural changes and to determine the possible differences

between the pupils with regard to their gender and education level in the space of some relevant indices of paramorphic and dysmorphic changes of the thorax and of the thoracic spine.

In compliance with the aim and the hypotheses set, it is expected that the obtained results in this study will have a two-fold value: first, the cognitive value regarding the possible influence on the transfer of perceptions dealing with the etiology and pathogenesis of the paramorphic and dysmorphic changes in the young, and secondly, the practical value which will support the viewpoints that emphasise the necessity of regular physical exercise and participation in a selected sport activity that has an expressed antiparamorphic influence as the most natural efficient agent in the prevention and control of paramorphic postural changes.

Methods

This investigation was carried out on a sample of 290 subjects (140 secondary school girls and 150 secondary school boys) from four high schools in Split. The pupils were between 15 and 16 years of age and they were divided in four subsamples, by gender and by education level. The physical examination of the subjects was carried out according to the procedures as described by Palmer and Epler (1998) regarding the postural assessment, and according to the criteria set by Leskaz (1981) and Tribastone (1994) regarding the physical examinations of the locomotor system. For this purpose a set of nine relevant indices that point to the paramorphic and dysmorphic chages of the thorax and of the thoracic spine was employed. These indices were as follows: shoulder asymmetry (ASIRAM), scapular asymmetry (ASILOP), pectoral muscles asymmetry (ASIPRM), asymmetry of Lorenz' angle (ASILOK), asymmetry of the epigastric triangle (ASIEPT), *pectus carinatum* (PECCAR), *pectus excavatum* (PECEXA), thoracic scoliosis (THSKOL) and thoracic kyphosis (THKIFO).

In compliance with the aim of the research, the data were processed by means of descriptive statistics. The occurrence frequency (F) of paramorphic and dysmorphic types of the thorax and of the thoracic spine was recorded and the corresponding percentages were calculated. The basic statistical parameters of indicators were determined – arithmetic means ($\bar{x}$) and standard deviations (SD) – for each sample. The significance of differences between the groups by individual indices was tested by the analysis of variance and the differences between the sets were identified by means of a canonical discriminant analysis.

Results

The incidence rate of paramorphic and dysmorphic changes of the thorax and of the thoracic spine in secondary school boys and girls (*in British English:* fourth- and fifth-formers) from Split is presented in Tables 1 and 2.

The results of physical examination of the thorax and of the thoracic spine in the sample of young adolescents from Split allow the following observations: the paramorphic postural changes in secondary school pupils are relatively frequent; however, the same does not apply to the dysmorphic changes; a somewhat higher percentage of paramorphic changes in secondary school girls than in secondary school boys was evident (about 10%). Dysmorphic changes appeared to be more frequent in boys.

The differences within the groups of the same gender and of the different education level allow the following observations: in female second-formers a slight increase in the incidence of paramorphic and dysmorphic changes of the thorax and of the thoracic spine was identified, whereas the incidence of these changes in boys decreased.

Table 1. Frequency and percentage of deformities by gender and by education level

	All secondary school girls		All secondary school boys		Female first--formers		Female second--formers		Male first--formers		Male second--formers	
With deformity	115	82.1	117	78.0	57	81.4	58	82.9	62	82.7	55	73.3
Without any deformity	25	17.9	33	22.0	13	18.6	12	17.1	13	17.3	20	26.7
I. degree deformity	64	45.7	54	36.0	34	48.6	30	42.9	23	30.7	31	41.3
II. degree deformity	42	30.0	51	34.0	21	30.0	21	30.0	32	42.7	19	25.3
III. degree deformity	9	6.4	12	8.0	2	2.9	7	10.0	7	9.3	5	6.7
	140		**150**		**70**		**70**		**75**		**75**	

The analysis of Table 2 makes it possible to say that various paramorphic postural changes are more frequent than the dysmorphic ones. As for gender, it was found that paramorphic and dysmorphic changes are slightly more frequent in secondary school boys. The increase in education level results in a decrease of paramorphic postural changes and is somewhat more expressed in boys. are, on average, to a larger extent characterised by postural disorders. However, the results of the F test show that the subjects differred significantly primarily in the indices *shoulder asymmetry, thoracic scoliosis, thoracic kyphosis*, and in the indices *pectus excavatum* and *pectus carinatum*. Therefore, the results of the analysis of variance also lead to the conclusion that the groups of pupils

Table 2. Frequency and percentage of indicators of paramorphic and dysmorphic changes of the thorax and of the thoracic spine by gender and by education level

	All secondary school girls		All secondary school boys		Female first--formers		Female second--formers		Male first--formers		Male second--formers	
Variables	**F**	**%**	**F**	**%**	**F**	**%**	**F**	**%**	**F**	**%**	**F**	**%**
ASIRAM	35	25.0	32	21.3	20	28.6	15	21.4	17	22.7	15	20.0
ASILOP	74	58.2	78	52.0	34	48.6	40	57.1	43	57.3	35	46.7
ASIPRM	28	20.0	76	50.7	17	24.3	11	15.7	44	58.7	32	42.7
ASILOK	63	45.0	58	38.7	32	45.7	31	44.3	36	48.0	22	29.3
ASIEPT	67	47.9	76	50.7	34	48.6	33	47.1	38	50.7	38	50.7
PECCAR	17	12.3	37	24.7	8	11.4	9	12.9	19	25.4	18	24.0
PECEXA	8	5.7	18	12.0	3	4.3	5	7.4	7	9.3	11	14.7
THSKOL	61	43.6	35	23.3	30	42.9	31	44.3	19	25.3	16	11.3
THKIFO	26	18.6	67	44.7	10	14.3	16	22.9	41	45.7	26	34.7
	N = 140		**N = 150**		**N = 70**		**N = 70**		**N = 75**		**N = 75**	

Legend: ASIRAM – shoulder asymmetry, ASILOP – scapular asymmetry, ASIPRM – pectoral muscles asymmetry, ASILOK – asymmetry of Lorenz' angle, ASIEPT – asymmetry of the epigastric triangle, PECCAR – *pectus carinatum,* PECEXA – *pectus excavatum,* THSKOL – thoracic scoliosis, THKIFO – thoracic kyphosis

The data presented in Table 3 make it possible to state the following: secondary school boys realised, on average, higher values in most analysed indices of paramorphic and dysmorphic postural changes. The exceptions were the following indices: thoracic scoliosis (THSKOL), asymmetry of the epigastric triangle (ASIEPT) and the asymmetry of Lorenz' angle (ASILOK) in which the girls attained higher values than their male peers. Consequently, it may be concluded that the boys – these groups being defined in the way as in this investigation – differ significantly from one another in the space of some indices of paramorphic and dysmorphic changes of the thorax and of the thoracic spine. The relations between average values and standard deviations lead to the conclusion that the female first-formers represent a more homogeneous group compared to the female second-formers, whereas with boys the situation is reversed.

Table 3. Basic statistical parameters: arithmetic means ($\bar{x}$), standard deviation (SD), F test and the level of statistical significance (p) – secondary school girls: first-, second- formers, secondary school boys: first-, second-formers

Variable	$\bar{x}_{g1}$	SD_{g1}	$\bar{x}_{g2}$	SD_{g2}	$\bar{x}_{b1}$	SD_{b1}	$\bar{x}_{b2}$	SD_{b2}	**F test**	**p**
ASIRAM	.26	.48	.19	.52	.29	.53	.24	.60	.33	.57
ASILOP	.56	.69	.81	.89	.85	.94	.69	.95	.54	.46
ASIPRM	.28	.53	.17	.47	.73	.74	.56	.73	22.05	**.00**
ASILOK	.54	.66	.65	.83	.59	.70	.34	.69	1.72	.19
ASIEPIT	.54	.66	.69	.89	.78	.89	.66	.80	1.01	.32
PECCAR	.17	.54	.19	.48	.34	.69	.39	.77	5.04	**.03**
PECEXA	.02	.14	.07	.33	.20	.64	.20	.48	7.10	**.01**
THSKOL	.54	.86	.78	.96	.36	.64	.27	.55	11.07	**.00**
THKIFO	.22	.54	.44	.79	.80	.92	.44	.73	7.68	**.01**

Legend: ASIRAM – shoulder asymmetry, ASILOP – scapular asymmetry, ASIPRM – pectoral muscles asymmetry, ASILOK – asymmetry of Lorenz' angle, ASIEPT – asymmetry of the epigastric triangle, PECCAR – *pectus carinatum,* PECEXA – *pectus excavatum,* THSKOL – thoracic scoliosis, THKIFO – thoracic kyphosis, $\bar{x}_{g1}$ - arithmetic mean for the first-form secondary school girls, SD_{g1} - standard deviation for the first-form secondary school girls, $\bar{x}_{g2}$ - arithmetic mean for the second-form secondary school girls, SD_{g2} - standard deviation for the second-form secondary school girls, $\bar{x}_{b1}$ - arithmetic mean for the first-form secondary school boys, SD_{b1} - standard deviation for the first-form secondary school boys, $\bar{x}_{b2}$ - arithmetic mean for the second-form secondary school boys, SD_{b2} - standard deviation for the second-form secondary school boys

The results of discriminant analyses (Tables 4 and 5) also show that the groups of secondary school girls and secondary school boys differ significantly from one another in the space of the analysed indices of paramorphic and dysmorphic changes of the thorax and of the thoracic spine. These differences may be interpreted on the basis of one significant discriminant variable. The first discriminant variable significantly separates the girls from the boys.

Table 4. Multivariate analysis of variance (MANOVA)

MANOVA	Wilks' λ	Rao's R	df_1	df_2	p
	.27	35.57	20	269	0.00

Legend: df_1 – degrees of freedom for the secondary school first formers, df_2 – degrees of freedom for the secondary school second formers, p – level of significance

Discussion

In general, the postural asymmetry of the thorax and of the thoracic spine shows certain regularities and it is recognizable, both with regard to gender and with regard to education level. Table 1 makes it evident that a very small percentage of secondary school girls (18%) and boys (22%) from the first and the second form of secondary schools from Split are characterised by correct posture. As many as 82% of secondary school girls and 78% of secondary school boys are characterised by some type of paramorphic and dysmorphic postural changes. The obtained indices carry a strong message that is directed, above all, towards those individuals or social institutions that are, in any way, responsible for the regular growth, development and health of young people.

Table 5. The values of discriminant function parameters

Discriminant function	eigenvalue	Canoni R	Wilks' λ	$\bar{x}$	df	p
1	**.36**	**.51**	**.68**	**108.29**	**27**	**.000**
2	.05	.23	.93	21.57	16	.158
3	.02	.15	.98	6.47	7	.486

Legend: $\bar{x}$ – arithmetic mean, df – degrees of freedom, p – level of significance

The second and the third discriminant variable were extracted (Table 6) that did point to some differences within the groups of girls and boys, however, these differences were not significant, so that, congruently, their interpretation is irrelevant.

Table 6. Correlation of variables with the discriminant variable and centroids

Variable	DF1	DF2	DF3
ASIRAM	.05	-.02	.13
ASILOP	-.17	-.27	-.40
ASIPRM	**-.62**	-.17	.33
ASILOK	.04	-.60	.04
PECCAR	**-.27**	.11	-.02
PECEXA	-.16	.17	-.30
EPIGTR	-.11	-.30	-.25
THSKOL	**.41**	-.47	-.07
THKIFO	**-.52**	-.48	-.47

Legend: ASIRAM – shoulder asymmetry, ASILOP – scapular asymmetry, ASIPRM – pectoral muscles asymmetry, ASILOK – asymmetry of Lorenz' angle, ASIEPT – asymmetry of the epigastric triangle, PECCAR – *pectus carinatum,* PECEXA – *pectus excavatum,* THSKOL – thoracic scoliosis, THKIFO – thorasic kyphosis

As for gender, the following can be said: scapular asymmetry, the asymmetry of Lorenz' angle and the asymmetry of the shoulders are more frequent in girls. On the other hand, in boys, the asymmetry of the epigastric triangle and the asymmetry of the pectoral muscles are somewhat more frequent. Further analysis of Table 1 leads to the following conclusion: the increase in education level results in a decrease of the percentage of postural asymmetry both in secondary school girls and in secondary school boys, the decrease being more expressed in boys. This may be attributed to the varying dynamics of changes of some thoracic segments. It is well known that the length of the thorax increases faster than its transverse and its anteroposterior diameters. It is also well known that the development of the thorax is not completed by the age of 14. Simultaneously with its growth the process of morphological formation continues. The hereditary influence that regards physical constitution, as well as the influence of environmental factors (bad sitting position, bad lying position, carrying a heavy school-bag, fatigue) are not irrelevant.

From the point of view of time dynamics (education level), there exists a recognizable regularity in the process of morphological postural transformation – one should be acquainted with this regularity and it should be taken into account, namely, it can be of significant diagnostic and kinesitherapeutic importance.

Paramorphic changes occurred in 49% female first-formers, whereas this number was by 6% lower in the female second-formers. The situation is reversed with boys, namely, the number of paramorphic postural changes increased from 31% in first-formers to 41% in second-formers. The recorded postural changes expressed by different percentages and opposite directions with regard to gender and education level can very probably be explained by the varying dynamics of growth and of the morphological formation of certain thoracic segments and segments of the thoracic spine; however, they can also be explained by the hereditary influence that relates to physical constitution and by the influence of environmental factors that are frequently neglected. One good thing exists, fortunately, in this general picture. A high percentage of pupils with paramorphic changes of the thorax and of the thoracic spine can, from the clinical, as well as from the diagnostic point of view, be depicted as functional cases, i.e. as paramorphic changes characterised by the initial disruption of the static-dynamic postural relations. In children, the thoracic area must be examined and monitored due to the possible occurrence of rib prominence, which is usually connected with scoliosis.

Scapular asymmetry is the most frequent disorder of the shoulder girdle (58% in secondary school girls vs. 52% in secondary school boys). The excessive abduction or adduction of one or both shoulder-blades was assessed by measuring the distance between the thoracic spine and the border of the scapula. The most frequently recorded types of scapular displacement in subjects were as follows. **Winged scapulae** *(scapulae alatae)* were recorded either as a separate paramorphism or as a paramorphism occurring together with a bent back. The muscles responsible for this occurrence are the trapezius muscle and the rhomboid muscles. Their hypotonic state decreases the possibility of fixation of shoulder-blades to the thorax and the hypertonia of antagonists that act in opposition to another muscle, i.e. they draw the shoulder-blade towards the thorax, thus causing imbalance. **Elevated scapula** (scapulae are of uneven height) is the result of scoliosis that can, due to the curvature of the spine, limit the descent of a scapula. It may also occur as the result of the posterior convexity of the thoracic spine (kyphosis). This is the so-called 'unexpected' or paradoxical scapula characterised by being placed heigher than the other scapula. The term **abducted scapulae** denotes the scapulae that have moved away from the midline of the thoracic vertebrae. The causes are the tightness of the serratus anterior muscle, and the elongation of the rhomboid and middle trapezius muscles. Another phenomenon is referred to as **adducted scapulae** - the scapulae are drawn closer to the midline of the thoracic vertebrae. The causes are shortened rhomboid muscles and the elongated pectoralis major and minor muscles.

Scapular asymmetry frequently occurs together with shoulder asymmetry, i.e. the asymmetry of the borders of the upper trapezius muscle. The height of both shoulders must be approximately equal, however, the dominance of one upper extremity may moderately affect the symmetry. The evident hypertrophy of one side of the body may be a sign of the dominance of one upper extremity, whereas the atrophy of one upper trapezius muscle may occur as the result of pathology or of the nonutilization. The most frequent paramorphic shapes of shoulders are as follows. The term **dropped shoulder** denotes an occurrence implying that one shoulder is depressed below the level of the other. The causes are the dominance of one arm (the dominant shoulder is lower), short lateral trunk muscles, high and adducted hip joint and the tightness of the rhomboid and the latissimus dorsi muscles. The term **elevated shoulder** implies that one shoulder is higher than the other. This is a somewhat more rare occurrence in the young of this age. The most frequent causes are the tightness in the upper trapezius and levator scapulae muscles on one side, possible hypertrophy on the dominant side, elongated and weak lower trapezius and pectoralis minor muscles, and scoliosis of the thoracic vetebrae. **Medial rotation of the shoulder** – medial epicondyle of the humerus is directed posteriorly. The causes are joint limitation in lateral rotation and the tightness of the medial rotator muscles.

The asymmetry of the epigastric triangle is relatively frequent in pupils of this age. The cause of this deformity is associated with rickets, unequal morphological formation of the thorax and with the family-specific anomaly frequently accompanied by other deformities (scoliosis, kyphosis, kyphoscoliosis, expressed funnel chest, etc). It is assumed that kinesiological activities (water sports) that strongly stimulate respiratory functions have an antiparamorphic effect on the morphological formation of the thorax and are recommended to

the so-called 'high-risk' children as the preventive and remedial means.

As expected, the incidence of dysmorphic changes in the subjects of this age is significantly lower, however, not irrelevant, especially when we are talking about minor dysmorphic changes (II. degree deformities). It is evident that the dysmorphic postural changes (II. degree deformities) have similar incidence among the female first- and second-formers (about 30%), which was not the case with secondary school boys, because in male second-formers an obvious decrease of 18% with regard to the male first-formers occurred.

Keel chest (*pectus carinatum*) was found in about 12% of the young adolescents. This percentage doubled in boys (24.7%). It is interesting to compare the data obtained in this investigation with the data collected during the physical examinations of schoolchildren and the young at the School Polyclinic in Spilt (1990). This comparison makes it possible to conclude the following: today, the incidence of pupils suffering from keel chest is significantly higher than it was the case with their peers in 1990 (10.4%), which can be explained by large postbellum migrations of people, the way of life, diet regimen, but also by the influence of environmental factors. The causes of this deformity are: deformation of ribs and sternum, elongation of *m. rectus abdominis* and taut superior intercostal muscles.

More severe dysmorphic changes of the thorax and the thoracic spine are, on the whole, rather rare (about 3% of female first-formers and 7% of female second-formers). However, in male first-formers the percentage of these cases is 15%, and in male second-formers it decreases to 11%. In general, it can be said that both the minor dysmorphic changes (30-34%) and the real dysmorphisms (6-8%) are to some extent more frequent in secondary school boys.

Although **funnel chest** (*pectus excavatum*) is a deformity that was not so frequent in subjects in this investigation (6% in girls and 12% in boys), this does not mean that the interest of the medical profession and of kinesitherapists for this deformity should be less. On the contrary, funnel chest usually results in the obstruction of the upper respiratory tract, thus decreasing the capacity for work on the one hand and in increasing the susceptibility to pulmonary infections on the other. The most frequent causes of funnel chest are: tightness of upper abdominal, shoulder adductor, pectoralis minor and intercostal muscles, bony deformities of sternum and ribs, stretched thoracic extensors and middle and lower trapezius muscles. Breathing exercises supplemented by swimming and underwater diving are a very efficient preventive and remedial means in the initial phase of the development of funnel chest.

In three cases the so-called **barrel chest** – the increased total anteroposterior diameter of the rib cage - was identified. The causes of this deformity are: respiratory difficulties, stretched intercostal and anterior chest muscles and tightness of scapular adductor muscles.

The postural image is supplemented by a significant physiological posterior convexity of the thoracic spine in the sagittal plane. The increased kyphotic curvature of the spine is very frequent in young adolescents (45%) with the tendency of further increase with respect to education level. Shoulders that fall anterior to the plumb line are termed **rounded shoulders** – the anomaly relating to the attitude of the body and frequently associated with excessive thoracic kyphosis and forward head. The increased posterior convexity of the spine in the sagittal plane causes compression of the intervertebral discs anteriorly, the elongation of thoracic extensors, the elongation of middle and lower trapezius muscles and of posterior ligaments and the tightness of anterior longitudinal ligament, the tightness of the upper abdominal and anterior chest muscles. The kyphotic curvature of the thorax is usually the result of the weakness of the thoracic spine extensor musculature, the middle trapezius muscle and of the weakness of the rhomboid muscles on the one hand, and of the tightness of intercostal muscles, of the pectoralis major and minor and of the subscapular muscles on the other.

Due to its frequency, to the characteristics of the developmental age, the influence of mechanical factors and stress, the localisation and characteristic changes and the possibilities of therapeutic effects, kyphosis occurring in young people deserves the special attention of kinesiologists and experts in biomechanics. Recent research studies have shown that in adults the pathological processes in the spine develop precisely on the site of the largest curvature of the thoracic spine (Tribastone, 1994). On the other hand, kyphosis occurring in the inferior segment of the thoracic spine is characteristic in juvenile life period. This finding throws doubt on those considerations and opinions that consider the overload to which the spine is exposed to be the primary cause of kyphosis (Ruszkowski and associates, 1986.). It seems that Dürrigl's (1972) attitude that starts from the necessity to search for the initial anticipated signs in the thoracic or in the thoracolumbar spine – the typical sign of the onset of juvenile kyphosis - was abandoned too early. From the kinesi-

therapeutic point of view this opinion is completely acceptible, because the real path of the therapeutic success continues from an early diagnosis, through early therapeutic treatment and procedures, through early participation in those sport activities that have an expressed antiparamorphic effect. Otherwise, in the next developmental phase (after the age of 14) functional kyphosis develops rather quickly into the final clinical picture of the persisting dorsal kyphosis with decreased prospects of expected therapeutic effects. It should not be forgotten that kyphotic posture develops more frequently into kyphosis than scoliotic posture into scoliosis, and that kyphotic spine can be corrected more quickly by applying the appropriate kinesitherapeutic procedures than the scoliotic spine.

Lateral deviations in the normally vertical line of the spine are more frequent in secondary school girls (about 43%) than in boys (23%). Such a high percentage of scoliotic spine occurrences in girls was rather unexpected and therefore alarming. By comparing the results of the previous investigations conducted by Kosinac (1992, 1994) and Kosinac and Bižaca (2002) on a sample of final-form primary school pupils from Split, a certain 'parallelism' of the increase of the percentage of girls with scoliotic spine and the education level was found. Namely, in 13 year old boys an almost equal percentage of scoliotic spine occurrences was found (17%). The percentage of primary school eight-formers (girls and boys) in whom this anomaly was identified increased to approximately 38% and in secondary school female first- and second-formers to 43%. Evident are the specific differences by gender and by education level between the subjects. The percentage of girls suffering from lateral deviations in the vertical line of the spine increases with the increase in their education level, whereas in boys the situation is reversed. As for scoliosis identified in the girls in this investigation we most frequently talk about the so-called minor scoliosis characterised by spine deviations up to 30° according to Cobb. In such cases, orthopaedic treatment is not necessary, and this is why these cases are the subject of interest of kinesiologists and kinesitherapists.

Functional scoliosis is caused by an imbalance of muscles due to an aberration in posture or due to a disease, and it rarely progresses. The assessment of the lateral curvature is possible by applying a relatively 'simple' method that demands that the subjects bend their trunk forward. The curvature that is straightened by bending the trunk forwards is called functional scoliosis, whereas the curvature that is not straightened in the forward bend of the trunk is called structural scoliosis. Lateral deviations are characterised by the spinuos processes of the vertebrae (*p. spinosus vertebrarum*) deviating laterally from the vertical line of the spine. Asymmetric shoulders and pelvis are a usual occurrence in scoliosis. The causes are the shortened muscles on one side of the trunk, the elongated contralateral muscles of the trunk, the compressing of the spine on the concave side, structural changes in the ribs or the spine, unequal length of legs, pelvic incline and disorders occurring in internal organs.

The program of dealing with this type of scoliosis should be based on breathing exercises, recruitment and strengthening of the musculature, stretching and relaxation of the muscles and participation in those sport activities that have an expressed antiparamorphic effect (volleyball, swimming, badminton, horeback riding, skiing, dancing, etc.). Due to its high incidence, scoliotic spine in pupils should be dealt with in those situations in which this problem is frequent and significant, namely, the school. This is the reason why physical education classes should be structured in such a way that they should contain preventive and antiparamorphic components, thus making physical exercising prevent and suppress this large-scale occurrence in the young. A question remains how to improve bad posture while it is still at the level of a bad habit and has not assumed the signs of a deformity. An equally important question is to what extent and how this problem is dealt with at schools.

Since dicriminant analyses produced identical results at various levels, the problem of discriminating between the groups defined in the described way will be presented as a whole with regard to the methods applied. The results of discriminant analyses (Tables 4 and 5) show only one significant discriminant variable that discriminates between the subjects as regards their gender and education level in the space of the analysed paramorphic and dysmorphic changes of the thorax and the thoracic spine. The first discriminant variable significantly differentiates between the secondary school girls and the secondary school boys. Its structure is such that it points to significant differentiation between gender groups in four pathological indices. The negative direction of the first discriminant variable with regard to the size of the centroids (Table 5) is such that it can be assumed that the boys with more expressed indices of the asymmetry of pectoral muscles, a larger physiological posterior convexity of the spine in the sagittal plane and a higher incidence of keel chest (*pectus carinatum*) are to be found on the

negative pole, whereas the girls who are characterised by a laterally deviating spine are to be found on the positive pole.

The obtained results clearly show that it is necessary to devise an efficient system of preventive and remedial measures in order to suppress this large scale occurrence in children and in the young. Such opinions that consider it possible for postural anomalies to diminish by growth are not sufficiently convincing, at least when we talk about the so-called 'high-risk' children. It is, therefore, important to emphasise the unexplored possibilities of the school (physical education classes, sport activity participation at school, etc.) and of parents in supporting the idea of permanent physical exercise and sport participation as the most natural methods in preventing and suppressing paramorphic and dysmorphic changes of the locomotor system.

Conclusion

The set of 9 relevant indices for the assessment of postural deviations was applied on the sample of 290 15 and 16 year old secondary school pupils from Split who were divided in to four groups by their gender and education level. The aim of the research was to identify the paramorphic and dysmorphic changes in the thorax and the thoracic spine and any differences that might occur between the groups defined in the described way.

The conducted statistical analyses allow the following conclusions to be drawn:

- Paramorphic changes of the thorax and the thoracic spine are rather frequent in young adolescents. The same holds true for dysmorphic changes.
- Paramorphic postural changes are more frequent in secondary school girls, whereas dysmorphic changes of the thorax and thoracic spine are more frequent in secondary school boys.
- As for the incidence of paramorphic postural changes within the same gender group but of different education level it was found that in older secondary school girls (16 years of age) a slight increase of paramorphic and dysmorphic changes of the thorax and the thoracic spine is noticeable, whereas in secondary school boys the direction of changes in relation to education level is reversed.
- The asymmetry of shoulder-blades, of the epigastric triangle and of Lorenz' angle are the most frequent indicators of postural deviations, and their causes are associated with a weakness of the muscles on one side of the body, with a dominance of one upper extremity or as a phenomenon accompanying other deformities (kyphosis, scoliosis, keel chest, or funnel chest).
- A relatively significant percentage of deformities of the sternum and the corresponding ribs (keel chest 25%) deserve serious kinesiological and kinesitherapeutical attention because of the possibilty of an upper respiratory tract obstruction that may result in the decrease of the capacity to work.
- Kyphotic spine in young adolescents is so frequent that it causes increasing concern of medical doctors and kinesiologists. In contrast to kyphotic spine, scoliotic spine is a somewhat more rare occurrence, however, it is more frequent in female adolescents. Due to the variety of possible psychological, somatic and sociological consequences, as well as due to the difficulty of its correction, it represents a special medical and kinesiological problem.
- By means of discriminant procedures one discriminant variable was extracted that differentiated between the secondary school boys and the secondary school girls in such a way that the boys with the more expressed indications of kyphotic spine, the asymmetry of pestoral muscles and the higher incidence of keel chest can be found on one pole, and the girls suffering from scoliotic spine on the other.

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PARAMORFIČNE I DISMORFIČNE PROMJENE PRSNOGA KOŠA I TORAKALNE KRALJEŠNICE U SREDNJOŠKOLACA

Sažetak

Uvod

Paramorfične promjene prsnoga koša i kralješnice čine znatnu incidenciju u populaciji djece osnovnih škola. Rastom, organizam sam, svojom snagom i sazrijevanjem ispravlja dio otklona posture (držanja tijela) – samokorekcija. Ta prirodna mogućnost nešto je slabije djelotvorna u tzv. "rizične" djece. Dapače, ako je paramorfično iskrivljenje u fazi pojačanog rasta već prisutno i potpomognuto raznim ambijentalnim uvjetima, transformira se polako i neizbježno u prepoznatljive oblike disformizma s mogućim višestrukim posljedicama i znatno umanjenim terapeutskim učincima.

Osnovni cilj ovog ispitivanja jest utvrditi zastupljenost paramorfičnih i dismorfičnih promjena posture te utvrditi eventualne razlike između učenika različitog spola i stupnja obrazovanja u prostoru nekih relevantnih indikatora paramorfičnih i dismorfičnih promjena prsnoga koša i torakalne kralješnice.

Metode

Ispitivanje je izvršeno na uzorku od 290 ispitanika (140 učenica i 150 učenika) četiriju gimnazija u Splitu, životne dobi od 15 do 16 godina, podijeljenih u četiri poduzorka s obzirom na spolnu pripadnost i razinu obrazovanja. Somatski pregled ispitanika učinjen je prema postupcima Palmera i Eplera (1998) o procjeni posture, kriterijima Leskaza (1981) i Tribastonea (1994) o sistematskim pregledima sustava za kretanje.

U tu svrhu primijenjen je skup od 9 revalantnih indikatora koji ukazuju na paramorfične i dismorfične promjene prsnoga koša i kralješnice. To su sljedeći indikatori: simetrija ramena (SIMRAM), simetrija lopatica (SIMLOP), simetrija prsnih mišića (SIMPRM), simetrija Lorenzova kuta (SIMLOK), simetrija epigastričnog kuta rebara (EPUGKU), izbočena prsa (PECCAR), ljevkasta prsa (PECEXA), torakalna skolioza (THSKOL) i torakalna kifoza (THKIFO).

Podaci su obrađeni metodom deskriptivne statistike: zabilježene su frekvencije (F) i izračunati su pripadajući postoci (%). Utvrđeni su osnovni statistički parametri analiziranih indikatora ($\bar{x}$, SD) za svaki uzorak. Značajnost razlika između skupina u pojedinim indikatorima testirana je analizom varijance, a razlike između skupina ustvrđene se metodom kanoničke diskriminacijske analize.

Rezultati i rasprava

Rezultati somatskog pregleda prsnoga koša i torakalne kralješnice na uzorku srednjoškolaca dozvoljavaju sljedeće konstatacije: paramorfične promjene posture u srednjoškolaca relativno su česta pojava, dok se to ne može reći i za dismorfične promjene; evidentan je nešto veći postotak paramorfičnih promjena u učenica (oko 10% u odnosu na učenike). Suprotno tome, dismorfične promjene posture češća su karakteristika učenika.

Razlike unutar skupina iste spolne pripadnosti, a različite razine obrazovanja dozvoljavaju ustanovljenje: u učenica druge godine uočljiv je lagani porast paramorfičnih i dismorfičnih promjena na prsnom košu i torakalnoj kralješnici, dok je u učenika evidentan suprotan smjer, tj. pad. S povišenjem stupnja obrazovanja postaje evidentan pad paramorfičnih promjena posture, koji je u učenika nešto jače izražen.

Općenito, asimetrija posture poprsja i torakalne kralješnice pokazuje određenu zakonitost i prepoznatljivost, kako s obzirom na spolnu pripadnost, tako i s obzirom na stupanj obrazovanja. Utvrđeno je da vrlo mali postotak učenica (18%) i učenika (22%) nižih razreda srednje škole karakterizira pravilno tjelesno držanje, odnosno čak 82% učenica i 78% učenika karakterizira neki od oblika paramorfičnih i dismorfičnih promjena posture. Ako se u obzir uzme spolna pripadnost, moguće je konstatirati: asimetrija lopatica, Lorenzova trokuta i ramena češća je karakteristika u učenica. Učenike, pak, karakterizira nešto veća nazočnost asimetrije epigastričnoga kuta i prsnih mišića. S povišenjem stupnja obrazovanja opada postotak asimetrije posture i u učenica i u učenika, s time da je taj pad izraženiji u učenika. To se može pripisati neujednačenoj dinamici promjena pojedinih segmenata prsnoga koša.

S gledišta vremenske dinamike (stupnja obrazovanja) prepoznatljiva je jedna pravilnost u procesu morfološke transformacije posture koju treba poznavati i uvažavati jer ona može biti važna s aspekta dijagnostike i kineziterapije. Naime, paramorfične promjene u učenica prve godine zastupljene su s oko 49%, da bi u učenica druge godine pokazale tendenciju pada za oko 6%. U učenika imamo obratan smjer,

tj. porast paramorfičnih promjena posture u učenika prvog razreda sa 31% na 41% u drugom razredu. Takve promjene na posturi vrlo se vjerojatno mogu objasniti neujednačenom dinamikom rasta i morfološkog oblikovanja pojedinih segmenata prsnoga koša i torakalne kralješnice, ali i nasljedno-konstitucijskim utjecajem, kao i utjecajem ambijentalnih čimbenika koji se često zanemaruju.

Kao što je bilo i očekivati, zastupljenost dismorfičnih promjena u ispitanika ove životne dobi znatno je manja, ali ne i zanemariva. Zamjetljivo je da su dismorfične promjene posture (deformiteti II. stupnja) podjednako zastupljeni u učenica prve i druge godine (oko 30%), za razliku od učenika druge godine u kojih je evidentiran pad za oko 18% u odnosu na učenika prve godine. Zanimljivo je zamijetiti da je nazočnost izbočenih prsa (*pectus carrinatum*) u mlađih adolescenta oko 12%, dok je taj postotak u srednjoškolaca udvostručen (24.7%).

Kifotično zakrivljena kralješnica vrlo je česta pojava u naših ispitanika (45%) s tendencijom porasta s obzirom na razinu obrazovanja. Postranične devijacije kralješnice češća su karakteristika u učenica (oko 43%) nego u učenika (23%). Program re-edukacije ovih skolioza trebao bi se zasnivati na: aplikaciji respiratorne kineziterapije, mobilizaciji i jačanju muskulature, istezanju i opuštanju tonusa mišića i participaciji sportskih aktivnosti s naglašenim antiparamorfičnim djelovanjem.

Prva i jedina diskriminacijska varijabla značajno odvaja učenice od učenika tako da su na jednom polu učenici s pojačanim indikatorima asimetrije prsnih mišića i fiziološkim iskrivljenjem kralješnice u sagitalnoj ravni prema natrag i češćim izbočenim prsima, dok su na drugom polu učenice koje karakterizira postranično iskrivljena kralješnica.

Zaključak

Provedene statističke i diskriminacijske analize dozvoljavaju sljedeće zaključke: paramorfične promjene prsnoga koša i torakalne kralješnice u mlađih srednjoškolaca relativno su česta pojava, dok se to ne može tvrditi i za dismorfične promjene; paramorfične promjene posture češća su karakteristika u učenica, dok su dismorfične promjene na prsnom košu i torakalnoj kralješnici češća karakteristika u učenika. U učenica starije životne dobi uočljiv je lagani porast otklona posture, dok je u učenika evidentan suprotan smjer, tj. pad.

Diskriminacijskim postupcima ekstrahirana je jedna značajna diskriminacijska varijabla koja odvaja učenice od učenika tako da su na jednom polu učenici s povećanim indikacijama kifotično iskrivljene kralješnice, asimetrijom prsnih mišića te češćim izbočenim prsima, dok su na drugom polu učenice sa skoliotično iskrivljenom kralješnicom.