

The forming of anterior-posterior spinal curvatures in young people from junior high schools and grammar schools

Kształtowanie się przednio-tylnych krzywizn kręgosłupa u uczniów z klas gimnazjalnych i licealnych

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Key words

body posture, inclinometer, Saunders norm

Abstract

Introduction: Defects of posture in children and adolescents have been frequently observed for many years. The determination of the shape and size of anterior-posterior spinal curvatures is one of the elements within the examination and assessment of body posture.

Aim: Characteristics of anterior-posterior spinal curvatures in the examined young people in reference to general Saunders norm.

Material and method: the examinations covered 117 young people (67 girls and 50 boys), aged 13–19 years old. The measurements of the size of anterior-posterior spinal curvatures were taken using an inclinometer. The children were examined under the following points: the medianus point of the sacrum bone (α angle), area intervertebralis Th₁₂–L₁ (β angle) and area intervertebralis C₇–Th₁ (γ angle). The Wolański method was applied to show the differences of individual types of body posture. The Statistica 7.0 program (-t-Student test and χ^2 test) was applied to check if statistically significant differences occurred.

Results: The differences of the statistically significant ($p < 0.05$) were stated in the γ angle amongst young people from grammar school and junior high school. The statistically significant differences were noted in the forming of thoracic kyphosis between the girls from the junior high school and the girls from the grammar school and between the boys from the junior high school and the boys from the grammar school (in both cases $p < 0.05$). The most common type of body posture for all the teenagers was of the kyphotic type (63.2%). The most frequent defect of body posture was flat lumbar lordosis (28.2%).

Conclusions: The existence of a curvature angle increase in thoracic kyphosis and angle reduction in lumbar lordosis in reference to the general Saunders norm is common in both research groups. The thoracic kyphosis is formed differently in girls and boys from grammar schools and junior high schools. It follows to form the lumbar lordosis in the correction of body posture.

Słowa kluczowe

postawa ciała, inklinometr, norma według Saundersa

Streszczenie

Wprowadzenie: W ostatnich latach obserwuje się znaczny wzrost częstości występowania wad postawy u dzieci i młodzieży. Określenie kształtu i wielkości przednio-tylnych wygięć kręgosłupa jest jednym z elementów badania i oceny postawy ciała.

Cel pracy: Charakterystyka przednio-tylnych krzywizn kręgosłupa u uczniów z klas gimnazjalnych i licealnych z Krosna w odniesieniu do ogólnej normy według Saundersa.

Materiał i metoda badań: Badaniem przekrojowym objęto 117-osobową grupę młodzieży, w tym 59 uczniów z Katolickiego Gimnazjum w Krośnie i 58 uczniów z Katolickiego Liceum Ogólnokształcącego w Krośnie. Podstawową metodą badawczą był pomiar przednio-tylnych krzywizn kręgosłupa przy użyciu inklinometru mechanicznego. Pomiaru dokonano w następujących punktach topograficznych: punkt pośrodkowy kości krzyżowej (kąt a), przestrzeń międzykręgową Th₁₂–L₁ (kąt b) i przestrzeń międzykręgową C₇–Th₁ (kąt g). Do określenia poszczególnych typów i podtypów postawy ciała badanych posłużono się typologią sylwetkową Wolańskiego. W celu analizy zebranego materiału zastosowano program Statistica 7.0 w tym test t-Studenta dla prób niezależnych oraz test niezależności Chi² (χ^2).

Wyniki: Stwierdzono statystycznie istotną różnicę ($p < 0,05$) w zakresie wartości średnich arytmetycznych kąta g między młodzieżą w wieku gimnazjalnym a licealnym oraz w ukształtowaniu kifozy piersiowej między młodzieżą gimnazjalną a licealną płci żeńskiej i analogicznie: młodzieżą gimnazjalną a licealną płci męskiej (w obu przypadkach $p < 0,05$). Nie wykazano różnic w ukształtowaniu przednio-tylnych krzywizn kręgosłupa między płcią żeńską i męską na żadnym z etapów edukacji. Najczęstszym typem postawy ciała

Authors' contribution: A – project of the study, work; B – collection of the data, information; C – statistical analysis; D – data interpretation; E – preparation of the manuscript; F – literature query; G – obtaining funds

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całej badanej młodzieży był typ kifotyczny (63,2%). U wszystkich badanych uczniów najczęstszą wadą postawy ciała była spłaszczona lordoza lędźwiowa (28,2%).

Wnioski: Występowanie zmniejszonego kąta krzywizny lordozy lędźwiowej i zwiększonego kąta krzywizny kifozy piersiowej w odniesieniu do ogólnej normy według Saundersa jest częste w obu badanych grupach. Kifoza piersiowa kształtuje się odmiennie zarówno w przypadku dziewcząt, jak i chłopców z gimnazjum i liceum. Nie występuje dymorfizm płciowy w zakresie ukształtowania kifozy piersiowej i lordozy lędźwiowej u młodzieży na obu badanych etapach edukacji. Typ kifotyczny stanowi najważniejszą cechę postawy badanej młodzieży szkolnej. W korekcji postawy ciała należy szczególnie zwrócić uwagę na kształtowanie lordozy lędźwiowej.

Introduction

The incessant and fast rate of change that occurs within the environment inhabited by contemporary man has a directly unfavourable effect upon him. Man in his adaptive mechanisms – the transformation of himself, his biological nature is unable to keep pace with the dynamism of civilizational changes the result of which is, among other things, disorders in the organs of locomotion, which, in the case of children and young people are faults in body posture. These dysfunctions treated as a manifestation of the process of evolution, limit functional possibilities and impair the organism's efficiency and therefore it follows to consider it as undesirable and through the selection of appropriate internal and external environmental factors to limit or remove their negative influence¹. In the present publication there has been undertaken an attempt at evaluating the forming of the anterior-posterior spinal curvatures in pupils from junior high schools and grammar schools on the basis of inclinometer measurements. An analysis of the frequency of default manifestations of posture allowed one to indicate those which occur the most often and which are characteristic for the period of development under study. The work may lead to an increase in the effectiveness of corrective procedures amongst those young people afflicted with deformations in body posture.

The aim of the work

The aim of the work was the evaluation of the form of the thoracal kyphosis and lumbar lordosis in relation to the general Saunders norm as well as defining the the most commonly occurring types and defects in body posture. The aim is equally the comparison of the forming of the anterior-posterior spinal curvatures in relation to sex at each of the educa-

tional stages as well as revealing an possible differences in the values of angles characterising spinal curvature at the sagittal plane between young people of junior high school age and those at grammar school.

As a consequence of the tests conducted the aim of the work gave rise to the following research questions:

1. What is the thoracal kyphosis and lumbar lordosis in relation to the general Saunders norm and does sexual dimorphism appear in the forming of the above mentioned curvature at each of the stages of education examined?
2. What are the differences in the values of curvature angles at the sagittal plane amongst young people of junior high school and grammar school age?
3. How are the sizes of the angle of thoracal kyphosis and lumbar lordosis formed as a result of the educational stage of the youth examined and do differences in the values of the angles of spinal curvatures at the sagittal plane occur between girls from junior high schools and grammar school girls as well as between boys from junior high school and grammar school?
4. What type of body posture occurs the most often in both groups?
5. What body posture defects occur the most often in both groups?

Research materials and methods

Research materials

Cross-sectional studies covered 117 young people, including 59 pupils of the Catholic Junior High School in Krosno and 58 pupils of the Catholic Grammar School in Krosno. The age of the junior high school pupils examined was between 13 and 15 years of age, while the age range for the grammar school pupils was 16-19. The average age of the pupils from junior high school was 13.85, while

the average age for the grammar school pupils was 17.12. The tests were conducted in 2007 with participation agreement having been obtained from the pupils themselves as well as their parents and the headmaster of the above mentioned schools following a detailed explanation of the scope and aims of the tests.

Test methods

The basic test method was the measurement of the anterior-posterior spinal curvatures by means of a 'SUUNTO' mechanical inclinometer. Measurements were conducted in the morning in heated appropriately lit premises. The person examined stood in a free position in a spot indicated by the researcher in such a way that the toes were in a single line, with the feet positioned to the width of the hips. The measuring was conducted in the following topographic points: the central point of the sacral bone (angle α), the intervertebral space Th₁₂-L₁ (angle β) and the intervertebral space C₇-Th₁ (angle γ), with an exactness up to 2°. The means of conducting measurement with the mechanical inclinometer is presented in Diagram 1.

With the aim of avoiding a measurement error, prior to measuring a dermatograph was used to mark the measurement points on the body of each testee: spinous C₇, the thoracal-lumbar transition, the line linking the lower aspects of the posterior superior iliac spines. The inclinometer was placed in a base position before each measurement (reset in relation to the vertical) while the results are read off perpendicular to the device.

With the aim of characterizing the anterior-posterior spinal curvatures the results obtained were compared with the general Saunders norms² (Table 1).

The individual types and subtypes of body posture of the testees were defined according to Wolański's silhouette typology³.

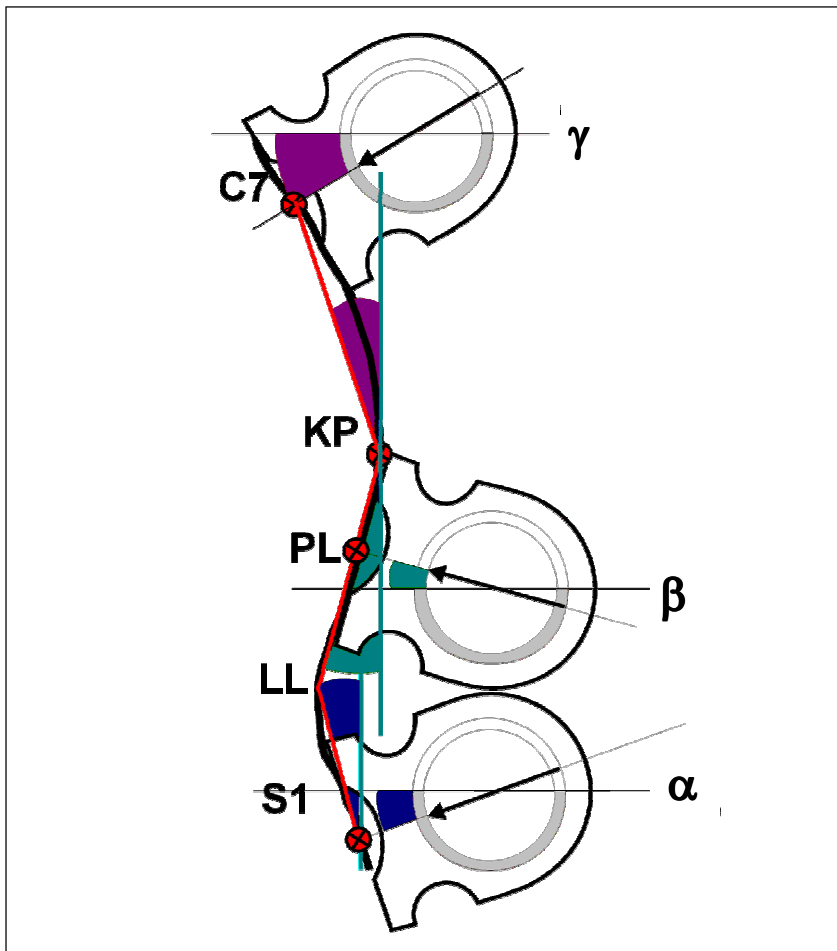


Diagram 1
The manner of performing anterior-posterior spinal curvatures measurement with the use of a mechanical inclinometer

Table 1

General Saunders norms	
Measurement	Saunders norm
Lombar sacral angle (angle α)	15–30°
Curvature of the lombar lordosis (angle α + angle β)	30–40°
Curvature of the thoracal kyphosis (angle β + angle γ)	30–40°

A balanced posture (R) was taken to be one in which the difference in angles between the thoracal curvature and the lumbar was contained in a division from 0 to 5°. In connection with which the following subtypes were isolated:

- R I – where the difference between Th and L is from 0 to 2°
- R II – where the difference between Th and L is from 3 to 4°
- R III – where the difference between Th and L is 5°.

A kyphotic type (K) was taken to be one where the angle of thoracal cur-

vature is greater than the angle of lumbar curvature by over 5°. In connection with which the following subtypes were isolated:

- K I – norm (6–10°)
- K II – slight deviation from the norm (11–15°)
- K III – significant deviation from the norm (16–20° and above).

A lordotic type of posture (L) was taken to be one in which the angle of lumbar curvature is greater than the angle of thoracal curvature by over 5°. In connection with which the following subtypes were isolated:

- L I – norm (6–10°)
- L II – slight deviation from the norm (11–15°)
- L III – significant deviation from the norm (16–20° and above).

Statistical methods applied

The program Statistica 7.0 was used with the aim of analysing the collected material. The standard deviation (s), and the coefficient of variability (v) were calculated by the arithmetic mean.

In order to check the conformity of the test with the normal distribution the Kolmogorow-Smirnov index was used. With the aim of showing statistically the significant differences in the values of the angles α , β , γ between the groups tested the t-Student test was applied for the independent date. With the aim of assessing the independence between the magnitude of the lumbar lordosis angle as well as of the thoracal kyphosis in young people at both educational stages as equally between the females from the grammar school and analogically the boys from the junior high school and grammar school, as well as between the females and males at each educational stage the independence test χ^2 (χ^2) was used. The values of statistics for $p < 0,05$ were considered statistically significant. Besides which the following principles were adopted to evaluate test probability:

- $p < 0.001$ – the appearance of a really very high statistically significant dependence (***)
- $0.001 \leq p < 0.01$ – the appearance of a really high statistically significant dependence (**)
- $0,01 \leq p < 0,05$ – the appearance of a statistically significant dependence (*).

Analysis of results

Table 2 contains the number and percentage of the values of the defining angles: the arrangement of the sacral bone, curvature of the lumbar lordosis as well as curvature of the thoracal kyphosis in relation to the general Saunders norm. The tests showed that the value of the angle α in around 70.9% is located within the boundaries of a norm that is 15-30. The value of the angle of curvature of the lumbar lordosis (angle $\alpha + \beta$) fitting within the borders of the norm was

Table 2

Numerical and percentage statement of the angle values describing anterior-posterior spinal curvature in relation to accepted standards						
Category	Angle α		Curvature of the Lombar lordosis (angle α + angle β)		Curvature of the thoracal kyphosis (angle β + angle γ)	
	N	%	N	%	N	%
Norm	83	70.94	53	45.30	57	48.72
Pathology	34	29.06	64	54.70	60	51.28
In total	117	100.00	117	100.00	117	100.00

Table 3

Comparision of the forming of anterior-posterior spinal curvatures between females and males during each period of education								
Feature	Girls		Boys		In total		χ^2	p
	N	%	N	%	N	%		
Junior High School								
Magnitude of thoracal kyphosis								
Norm	13	46.43	16	51.61	29	49.15	0.158	0.923
Decrease	8	28.57	8	25.81	16	27.12		
Increase	7	25.00	7	22.58	14	23.73		
In total	28	100.00	31	100.00	59	100.00		
Grammar School								
Magnitude of thoracal kyphosis								
Norm	21	53.85	11	57.89	30	51.72	0.531	0.766
Decrease	1	2.56	0	0.00	1	1.72		
Increase	17	43.59	8	42.11	25	43.10		
In total	39	100.00	19	100.00	58	100.00		
Junior High School								
Magnitude of lumbar lordosis								
Norm	14	50.00	11	35.48	25	42.37	2.126	0.345
Decrease	12	42.86	19	61.29	31	52.54		
Increase	2	7.14	1	3.23	3	5.08		
In total	28	100.00	31	100.00	59	100.00		
Grammar School								
Magnitude of lumbar lordosis								
Norm	25	64.10	4	21.05	29	50.00	8.400	0.014
Decrease	11	28.21	14	73.68	25	43.10		
Increase	3	7.69	1	5.25	4	6.90		
In total	39	100.00	19	100.00	58	100.00		

noted as being 45.3% of the pupils. From the data concerning the value of the angle of thoracal kyphosis (angle β + γ) it results that the percentage of pupils for whom the values of this angle fit within the boundaries of the norm was very close to the percentage of pupils amongst whom pathology was confirmed for the results were relatively 48.7% and 51.3% (Table 2).

An analysis of the test χ^2 did not display statistically significant differences in the forming of thoracal kyphosis and lumbar lordosis amongst girls and boys from junior high school and girls and boys from grammar school (Table 3).

Analysis of the material assembled was conducted in association with a comparison of the forming of the an-

teriorposterior spinal curvatures in the groups researched: junior high school and grammar school. In Table 4 and Diagram 2 there is presented a comparison of the values of the angles defining the spinal curvature on the sagittal plane amongst the groups tested in relation to Saunders norm. From this data it results that the value of the angle α , in both groups is close

Table 4

Comparison of the angle values describing anterior-posterior spinal curvature amongst young people from junior high school and grammar school

Category		Angle α		Lumbar lordosis curvature (angle α + angle β)		Thoracal kyphosis curvature (angle β + angle γ)	
		N	%	N	%	N	%
Junior high school	Norm	43	72.88	24	40.68	30	50.85
	Pathology	16	27.12	35	59.32	29	49.15
Grammar school	Norm	40	68.96	29	50.00	27	46.55
	Pathology	18	31.03	29	50.00	31	53.44

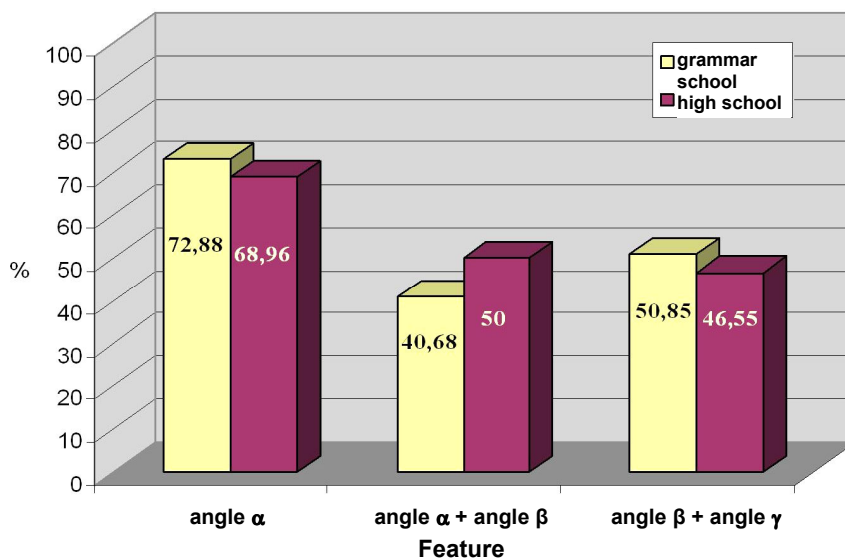


Diagram 2

Forming of norm-adhering spinal curvature in young people from junior high school and grammar school in relation to accepted standards

to each other and on the whole is located within the division of the generally accepted norm.

In the case of the angle of lumbar lordosis curvature, only 40.7% of the results of the junior high school pupils tests and 50% of the tests of young people from grammar schools were within the boundaries of the norm. In moving on to an analysis of the results concerning the angle of thoracal kyphosis curvature, it follows to state that in the case of 50.8% of junior high school pupils the values of the angle $\beta + \gamma$ were within norm boundaries. Amongst the remaining 49.1% the sum of the angles β and γ assumed irregular values. In the grammar school the situation presented itself oppositely, where the regular values were noted amongst 46.5% of the pupils while pathological cases were noted in 53.4% (Table 4, Diagram 2).

With the aim of showing whether there existed a statistically significance difference in the values of the angles defining spinal curvature in the sagittal plane amongst young people of junior high school and grammar school age the t-Student test was applied for independent tests. On the basis of the analysis of the values of the t-Student test a statistically significant difference in the range of the average arithmetical values of the α angle amongst young people of junior high and grammar school age ($p < 0,05$); in the case of the angles α and β there was not confirmed any statistically significant differences (Table 5).

In Table 6 is located the data on the subject of the forming of the magnitude of the angle of the thoracal kyphosis and lumbar lordosis depending on the educational stage of the young people concerned. The correct forming of

the thoracal kyphosis is more often noted amongst young people of grammar school age (55,2%) than amongst the pupils of junior high school (49.1%). The shallowing of the thoracal kyphosis occurred more often amongst the pupils of junior high school than amongst those of grammar school (27.1%) with its deepening amongst grammar school pupils (43.1%). The statistical gravity concerns the mentioned differences of the magnitude of the angle of the thoracal kyphosis amongst junior high school pupils and those of grammar schools appeared at the highest assumed level $p < 0,001$. In the case of the magnitude of the angle of the lumbar lordosis statistically significant differences were not noted between young people from junior high and grammar school (Table 6).

In Table 7 is presented a comparison of the values of the angles of spinal curvatures in the sagittal plane between girls from junior high school and those from grammar school as well as between boys from junior high and boys from grammar school. The statistically significant differences concerned the forming of the thoracal kyphosis and occurred both amongst girls as well as boys in both cases at a level of $p < 0,05$. There was not noted any statistically significant differences in the forming of the lumbar lordosis between female junior high school pupils and those from grammar school as equally between boys from junior high and grammar school (Table 7).

In Table 8 are presented the percentage of young people with a kyphotic type, equivalent as well as lordotic in numbers and percentages. It results from these data that the most common type of body posture for the entire group of young people tested was the kyphotic type (63.2%). The equivalent type appeared in second place where it

Table 5

Characteristics of the mean arithmetical values, standard deviation, the variation coefficient for α , β , γ angles and the t-Student test coefficient values amongst young people from junior high school and grammar school								
Category	Junior high school			Grammar school			t-Student test	p
	mean	SD	V	mean	SD	V		
Angle α	18.23	5.61	30.76	19.76	6.76	34.25	-1.313	0.19
Angle β	10.13	5.07	50.06	10.55	4.83	45.86	-1.366	0.17
Angle γ	25.79	8.21	31.84	28.86	6.90	23.93	-2.323*	0.02

*p<0.05

Table 6

Comparision of the magnitude of the angle of thoracal kyphosis and the lumbar lordosis in the researched population in relation to the period of education								
	Junior high school		Grammar school		In total		χ^2	p
	N	%	N	%	N	%		
Magnitude of thoracal kyphosis								
Norm	29	49.15	32	55.17	59	50.43	16.478	0.0002***
Decrease	16	27.12	1	1.71	19	16.24		
Increase	14	23.73	25	43.10	39	33.33		
In total	59	100.00	58	100.00	117	100.00		
Magnitude of lumber lordosis								
Norm	25	42.37	29	50.00	54	46.15	1.073	0.584
Decrease	31	52.54	25	43.10	56	47.86		
Increase	3	5.08	5	8.62	8	6.84		
In total	59	100.00	58	100.00	117	100.00		

***p < 0.001

was confirmed amongst 27.3% of those tested, while lordotic occurred the least often in a mere 9.4% of those examined (Table 8).

Comparing the types of posture for young people from junior high and grammar school one may state that the dominant type of body posture is that of the kyphotic type. Amongst grammar school pupils with a kyphotic type of body posture the greatest percentage comprised pupils with a noticeable deviation from the norm (27.6%). Among the majority of junior high school pupils, however, the kyphotic posture was maintained in a norm of 25.4%. The lordotic type occurred the least often, though more often amongst junior high school pupils (13.6%). Amongst a decisive majority of junior high school pupils with posture of the lordotic type it was confirmed that the lumbar lordosis was within the norm (Table 9).

In Table 10 the characteristics of the defects in posture dependent on

the forming of spinal curvatures in the sagittal plane are presented: decreased thoracal kyphosis, concave back, curved back, flattened lumbar lordosis, flat back, rounded-concave back and the correct form of spinal curvatures. One may state that the most commonly occurring amongst all the pupils tested was flattening of spinal curvature in the lumbar section (28.2%). Rounded shoulders occurred in 18.8% of those tested. Comparing the results of the pupils from the junior high school and those from the grammar it follows to state that in both groups the decisively dominant defect was flattening of the lumbar lordosis. Amongst the junior high pupils a significant percentage had flat backs in both sections (18.6%), which in the grammar school pupils was not observed. In all the pupils a problem with back curvaceousness in the thoracic section. Amongst the grammar school pupils the percentage was 22.4 while for the junior high – 15.2%. 17.2% of

grammar school pupils had confirmed the incidence of total kyphosis, i.e. twice the number noted in junior high pupils (6.8%). It follows to emphasise that a significant percentage of pupils were characterised by a correct form of spinal curvature (Table 10).

Discussion

The body posture of man has a topic of interest for many areas of science and practices for a long time. Attempts have been made depending on the possibilities available to diagnose the state of posture. Various methods have been employed – from the simplest examinations to specialist apparatus and measurement instruments. Despite the preparation of many methods and means of testing the problem of evaluating the posture of the human body has yet to be totally solved⁴.

The frequency of the incidence and degree of advancement of the body posture defects of 2124 boys in Cra-

Table 7**Comparison of the magnitude of the angles of anterior-posterior spinal curvature amongst girls from junior high school and girls from grammar school and amongst boys from junior high school and boys from grammar school**

Feature	Junior high school		Grammar school		In total		χ^2	p
	N	%	N	%	N	%		
Girls								
Magnitude of thoracal kyphosis								
Norm	13	46.43	21	53.85	34	50.75	9.955	0.006**
Decrease	8	28.57	1	2.56	9	13.43		
Increase	7	25.00	17	43.59	24	35.82		
In total	28	100.00	39	100.00	67	100.00		
Boys								
Magnitude of thoracal kyphosis								
Norm	16	51.61	11	57.89	25	50.00	6.486	0.039*
Decrease	8	25.81	0	0.00	10	20.00		
Increase	7	22.58	8	42.11	15	30.00		
In total	31	100.00	19	100.00	50	100.00		
Girls								
Magnitude of lumbar lordosis								
Nom	14	50.00	25	64.10	39	58.21	1.582	0.453
Decrease	12	42.86	11	28.21	23	34.33		
Increase	2	7.14	3	7.69	5	7.46		
In total	28	100.00	39	100.00	67	100.00		
Boys								
Magnitude of lumbar lordosis								
Norm	25	64.10	4	21.05	29	50.00	1.214	0.544
Decrease	11	28.21	14	73.68	25	43.10		
Increase	3	7.69	1	5.25	4	6.90		
In total	39	100.00	19	100.00	58	100.00		

*p < 0.05; **p < 0.01

Table 8**Frequency of individual types of body posture occurrence in the young people examined with reference to the whole material**

Type of body posture	Number of persons (total)	%
Kyphotic	74	63.25
Balanced	32	27.35
Lordotic	11	9.40

cow was studied by Suder et al⁵. The evaluation of the body's posture was carried out by the authors by means of the Stobiecka somatoscopic method incorporating the modifications of Chrzanowska. The tests showed that the frequency of spinal defects in the sagittal plane increases with age to 11-12 years of old, while the worst posture is affirmed between 11 and 13 years of

age. Intensified lumbar lordosis occurs much more frequently than intensified thoracal kyphosis. The flattening of the thoracal kyphosis occurred in 2% of the boys tested. In turn Kania-Gudzio et al⁶, according to Kasperczyk, tested the posture of children aged 7-15 in Poznan. This was achieved by a method of awarding points. In the case of 74 boys aged 13-15, within 16.2%

of them the authors confirmed increased thoracal kyphosis, in 28.3% reduced thoracal kyphosis, while increased lumbar lordosis for 17.6%. Prętkiewicz-Abacjew⁷ analysed the shape of spinal curvatures in the sagittal plane and the angle of anteversion of the pelvis based on testing conducted through the help of a special device and Wiles compasses, and the types of body posture defined by Wolański. From the author's tests it results that during the period of pubescence there occurrence of irregularities in body posture in the sagittal plane is more often than before this period with which the inclination of the spine did not have a more varied arrangement because the average values for each analysed angle for both of the sexes were similar. Amongst prepubescent boys there was ob-

Table 9

Types of body posture in the young people examined from junior high school and grammar school

Type of body posture		Junior high school		Grammar school	
		N	%	N	%
Kyphotic	K I	15	25.4	9	15.5
	K II	9	15.2	12	20.7
	K III	13	22.0	16	27.6
	In total	37	62.6	37	63.6
Balanced	R I	9	15.3	8	13.8
	R II	5	8.5	10	17.2
	R III	0	0	0	0
	In total	14	23.6	18	31.0
Lordotic	L I	7	11.9	2	3.5
	L II	1	1.7	1	1.7
	L III	0	0	0	0
	In total	8	13.6	3	5.2

Table 10

Characteristics of the stated body postures defects as a whole and in both of the researched groups separately

Posture defect	In total		Junior high school		Grammar school	
	N	%	N	%	N	%
Flattened thoracal kyphosis	7	5.98	5	8.47	2	3.45
Concave back	3	2.56	2	3.39	1	1.72
Curved back	22	18.80	9	15.25	13	22.41
Flattened lumbar lordosis	33	28.20	17	28.81	16	27.59
Flat back	11	9.40	11	18.64	0	0
Correct/ regular spinal curvature	24	20.51	10	16.95	14	24.14
Total kyphosis	14	11.96	4	6.78	10	17.24
Curved concave back	3	2.56	1	1.69	2	3.45

served that most often there appeared a large angle of thoracal inclination of the upper section of the spine. Almost a half of the girls tested possessed also a large angle of inclination though the value of the mean of this angle corresponded to the division of the average angles. Besides which amongst prepubescent boys the value of the mean inclination for the above section of the spine was greater than amongst the girls and the difference was statistically significant. In the case of the angle of curvature of the lumbar lordosis in the prepubescent period the most numerous were small angles of spinal inclination in the thoracolumbar section both for girls and boys. Besides a half of the boys and

girls during puberty were characterised by large angles of inclination of the lumbosacral section. Body postures evaluated by the above given method were in the case of prepubescent boys the most often balanced, less often lordotic and least of all kyphotic. During puberty they were mainly balanced and less often kyphotic. Of note is the common manifestation amongst boys of the III balanced types and the I kyphotic as well as the absence of II and III kyphotic postures. Amongst girls there also appeared often during this period balanced and kyphotic postures. The author emphasises that the change in the morphological conditions occurring during the period of puberty, disturbs feeling and posture

habit, therefore the body posture in this period demands the particular attention of doctors, parents and P.E. teachers who should take care that worsening of posture that occurs during this period should not become an established pattern⁷. Walicka-Cupry et al.⁸ by means of an inclinometer have researched the shape of spinal curvature in ten-year-old children. A comparison of the results with the Saunders norms showed a flattening of spinal curvatures in the lumbar section and/or thoracal section of the spine amongst the majority of the children tested. The authors claimed a predominance of balanced types within the tested group.

According to Kutzner-Kozińska et al.⁹ the age division of 6 to 10 is characterised by flattened thoracal kyphosis, protruding abdomen and clear lumbar lordosis and consequently features of lordotic posture. Śliwa et al.¹⁰ on the basis of the results of tests conducted through the application of the Posturometer-S, conducted an evaluation of the entire curve of the spine as well as of individual sections and their mutual positioning and shape, an evaluation of the position of the pelvis in the sagittal plane and its possible influence on the shape of the lumbar lordosis. The authors described a frequent irregular formation of the lumbar lordosis in the form of shallowing, flattening or inversion, which in the case of flattening or inversion could indicate excessive extension and weakening of the back muscles in the lumbar section and hip-lumbar section. Besides which the authors showed that inversion of the lumbar lordosis caused among 10% of those tested total kyphosis, which characterised the significant mobility observed in attempts at elongation which created the conditions for pathological stretching and loosening of the muscular-ligament apparatus¹⁰.

The differences in the test results of various authors is more than likely connected with the large time period that has elapsed between the various pieces of research cited as well as the application of various methods and instruments for measurement.

The results of our research indicate the diversity of the magnitude of spinal curvatures both in the lumbar section as equally in the thoracal in both of the groups of young people. It is possible to observe the tendency

affirmed by Śliwa's research¹⁰, where amongst the majority of the pupils tested there was affirmed a frequent manifestation of intensified thoracic kyphosis and flattening of spinal curvature in the lumbar section. Flattened lumbar lordosis appears far more often than intensified anterior spinal curvature both in the junior high school group and that from the grammar school. The reverse is the case, however, with thoracic curvature. In both groups an increase in thoracic kyphosis occurs much more often than its flattening. An increasingly observed problem for young people is total kyphosis, the percentage of which is not yet as significant amongst the junior high school group as it is in the grammar school group (correspondingly 6.8% and 17.2%). One may conjecture that the increase in the frequency of kyphosis cases amongst the grammar school group is the result of the increasing influence of being in a sedentary position enhances the intensification of thoracic kyphosis and the shallowing of lumbar lordosis. In our research there was not observed, on any of the educational levels, the appearance of gender dimorphism in the forming of spinal curvatures in the sagittal plane, something that is convergent with the results of Prędkiewicz-Abacjew⁷. Besides which our research showed a statistically significant difference in the values of the arithmetical averages of the γ angle amongst young people from junior high and grammar school; therefore it also follows to state that the inclination of the spine in the thoracic section is the most important feature differentiating the research groups in relation to the forming of anterior-posterior spinal curvatures. In addition it was observed that 18.6% of junior high school pupils had flat backs while for those at grammar school this type of deformation was not noted. The least often met defect in body posture in the sagittal plane in both of the groups was rounded-concave and concave backs. It follows to emphasise that a significant percentage (20.5%) constituted pupils with a correct shape of spinal curvatures.

The inclinometer used in tests is a small, convenient and cheap instrument for measurement. It may be used everywhere which enhances the diagnostic process and measurement accessibility. The high level of reliability

and usefulness of this method in clinical tests has been confirmed by many authors Saur¹¹, Kuźdżał et al¹², Walicka-Cupryś et al.^{8, 13}. The scientific reports, together with the results of our research, point to the need for the diagnosis and development of programmes of remedial procedures with the aim of limiting the frequency with which deviations from the correct shape of the spine, within the sagittal plane, occur as well as the narrowing down of correction to pathological states. In addition there exists the necessity of develop age norms for the average variability of spinal curvatures in the sagittal plane. The inclinometer may constitute a useful device in the objective and non-invasive evaluation of spinal geometry.

Conclusions

1. Both in the junior high school group as in the grammar school group the kyphotic type of body posture is decisively the most common. In relation to Saunders norms it may be stated that there occurs an increased angle of thoracic kyphosis curvature and a reduced angle of lumbar lordosis curvature.
2. On the basis of compared values of spinal curvature in the sagittal plane amongst young people of junior high and grammar school age there was observed a tendency amongst the grammar school pupils for excessive kyphoticization of the thoracic section of the spine.
3. Gender dimorphism was not observed in the forming of thoracic kyphosis and lumbar lordosis in young people of the age 13-15 and amongst young people aged 16 and 19.
4. Statistically significant differences were noted in the magnitudes of the angles of thoracic kyphosis between junior high school girls and girls from grammar school as well as between junior high school boys and those from grammar school. Lumbar lordosis, however, develops in a similar way for both junior high school and grammar school pupils of both sexes.
5. The kyphotic type occurs the most often in both junior high school and grammar school pupils and consequently one may consider it as the most characteristic feature of body posture for the whole group of

school pupils tested.

6. The frequent occurrence of flattened lumbar lordosis in both junior high school pupils and grammar school pupils indicates that in correction of body posture it follows to pay attention to this irregularity in body posture.

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