MROZKOWIAK Mirosław. The effect of the length, angle, height, and depth of lumbar lordosis on selected features of thoracic spine. Journal of Education, Health and Sport. 2023;19(1):105-118. eISSN 2391-8306.
http://dx.doi.org/10.12775/JEHS.2023.19.01.011
https://apcz.umk.pl/JEHS/article/view/39434
https://zenodo.org/record/8339807

The journal has had 40 points in Ministry of Education and Science of Poland parametric evaluation. Annex to the announcement of the Minister of Education and Science of 17.07.2023 No. 32318. Has a Journal's Unique Identifier: 201159. Scientific disciplines assigned: Physical Culture Sciences (Field of Medical sciences and health sciences); Health Sciences (Field of Medical Sciences and Health Sciences).
Punkty Ministerialne z 2019 - aktualny rok 40 punktów. Załącznik do komunikatu Ministra Edukacji i Nauki z dnia 17.07.2023 Lp. 32318. Posiada Unikatowy Identyfikator Czasopisma: 201159.
Przypisane dyscypliny naukowe: Nauki o kulturze fizycznej (Dziedzina nauk medycznych i nauk o zdrowiu); Nauki o zdrowiu (Dziedzina nauk medycznych i nauk o zdrowiu).

The authors declare that there is no conflict of interests regarding the publication of this paper.
Received: 17.08.2023. Revised: 24.08.2023. Accepted: 06.09.2023. Published: 23.09.2023.

The effect of the length, angle, height, and depth of lumbar lordosis on selected features of thoracic spine

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The research was financed from internal funds.

Summary

The purpose of this study was to demonstrate the significant effect of the values of the angle, depth, height, and length of lumbar lordosis on selected features of the thoracic spine. Material and Methods. The study was carried out in a group of 2,361 children aged 7 to 15 years, in 6 semiannual consecutive editions. This allowed to record 16,608 observations of 31 features describing posture by photogrammetric method.

Results. The following influential features like angle, depth, heights, and lengths of lumbar lordosis were selected for multiple regression analysis with selection of a subset of the optimal set of variables.

Conclusions

The presented statistical analysis shows the mutual influence of the values of the selected characteristics. The study showed no independent feature, however, the degree of influence varied. This demonstrates the interrelatedness of the different spinal segments.

Corrective actions that change the value of one postural trait force the change of others in a positive or negative way.

Keywords: projection moiré, features of spine and pelvis

1. Introduction

Body posture during the developmental period undergoes constant changes. The greatest dynamics of these changes are observed in the first year of a child's life. It is determined, to a large extent, by successive (alternating) flexion and extension stages. Following, thoracic kyphosis, cervical lordosis, lumbar lordosis are gradually modulated. The latter appears the latest around 12th month of age and is an obvious expression of the spatial adaptation of the human body system to the upright position [1, 2]. Its appearance has a modifying effect on the shape of the thoracic kyphosis. There is a significant lability of physiological curvatures throughout early childhood. A full stabilization of cervical lordosis occurs around age of 7. The lumbar lordosis begins to deepen gradually from about 3-8 years of age, and it gets its final shape at about 10-12 years of age. The individually variable development of posture is influenced by phylogenetic and genetic factors as well as epigenetic factors. Nowadays, because of visible changes in the quality of life, they seem to have an increasing negative impact. The development of posturogenesis may also be determined by certain dimorphic variations in skeletal structure [3]. Studies [4] on the angles of physiological curvatures of the adult spine have determined their values (according to Humprey) as cervical lordosis is 18 degrees, thoracic kyphosis is 42 degrees, lumbar lordosis is 80 degrees, and sacral kyphosis is125 degrees. Our own research made it possible to determine the angular and linear values of lumbar lordosis specific for age and gender by photogrammetric method. In individuals of both sexes, the average values of the angle of lordosis, the depth, length and height of thoracic kyphosis and lumbar lordosis are parallel to one another in the age of 7 - 15 years, and the angle of kyphosis up to 13 years. At the same time, the values of the angle of lordosis are higher than those of kyphosis, and the depths, lengths and heights are lower. In the case of kyphosis, in girls and boys up to age 13, the angle increases and then decreases its value. The angle of lordosis, in girls and boys until the age of

10, decreases its value, and further successively increases. The depth of both curvatures successively decreases until the age of 14 and increases in the following year. The length and height decrease until 10 years of age, in 10 and 12 years of age it stabilizes and further increases. The most intense changes in the values of all features occur in the period from 8 to 10 and from 12 to 14 years of age. Only features like DCK%, Wc, Mc in the period from 10 to 12 years show high dynamics of changes. The periods of the most intensive increases in the values of the studied traits in individuals of both sexes coincide, with different values [3].

The purpose of the study was to demonstrate the significant effect of the values of the length, angle, height, and depth of lumbar lordosis on selected features of the thoracic spine.

2. Research material and methods

The study of posture was conducted in randomly selected kindergartens and schools of Warmian-Masurian and Pomeranian regions. There were 46.84% of boys (1,106 subjects) and 53.15% of girls (1,255 subjects) participated in the study. The preponderance of girls was 149 people, which makes 6.31%. The respondents were recruited 69.97% (1,652 people) from urban environment, 52.11% girls (861 people) and 47.88% boys (791 people), and from rural environment 55.57% girls (394 people), and 44.42% boys (315 people), tab 1. In total, the study was conducted in a population of 2,361 children aged 7 to 15 years, in 6 semiannual consecutive editions allowed to record 16,608 observations.

Tab. 1. The number of observations in the age and sex categories

	Number of observations		
Age (years)	Sex		Total (N)
	K	M	
7	610	597	1207
8	1341	1255	2596
9	1839	1677	3516
10	1752	1542	3294
11	1047	901	1948
12	670	549	1219
13	569	462	1031
14	582	436	1018
15	424	355	779
total	8834	7774	16608

Source: own research

The legend
K – girls
M – boys

The measurement site for the value of selected body posture features consists of a computer, card, program, monitor, printer, projection and receiving device with a camera for measuring selected parameters of the spine-pelvis complex. The place of the examined person and the camera were spatially oriented according to the contour lines on the camera and in relation to the line of the child's toes. Obtaining a spatial image was possible by displaying lines with strictly defined parameters on the child's back, pic. 1. Lines falling on a body are distorted depending on the configuration of its surface. The image of the subject was received by a special optical system with a camera using a lens, and then transferred to a computer monitor. Distortions of the line image recorded in the computer's memory are processed by a numerical algorithm into a contour map of the examined surface [3, 6]. The research was carried out by a physiotherapist with 20 years of experience in diagnosing body posture using the photogrammetric method.

Pic. 1. Position 1: Habitual posture.

3. Subject of the study

Sixteen features describing the sagittal curvatures of the axial organ were selected to study the relationships of selected spinal traits, tab. 2.

Table. 2. List of registered spine features in the sagittal plane

No	Symbol	Parametres		
		Label	Name	Descrioption
1	Alfa	degrees	Sacfrolumbar tilt, fig. 1.	
2	Beta	degrees	Thoracolumbar tilt, fig. 1.	
3	Gamma	degrees	Upper thoracic tilt, fig. 1.	
4	Delta	degrees	The sum of the angular values	Delta = Alfa+Beta+Gamma.
5	DKP	mm	Length of thoracic kyphosis	The distance between LL a C_7 points, fig. 2.
6	DKP	%		DKP value as a percentage of total spine length C_7-S_1.
7	KKP	degrees	Angle of thoracic kyphosis	KKP = 180 – (Beta+Gamma), fig. 1.
8	RKP	mm	The height of thoracic kyphosis	The distance between C_7 a PL points, fig. 2.
9	RKP	%		RKP value as a percentage of total spine length C_7-S_1.
10	GKP	mm	The depth of thoracic kyphosis	Distance measured horizontally between vertical lines passing through the PL a KP points, fig. 2.
11	DLL	mm	The length of lumbar lordosis	The distance between S_1 a KP points, fig. 2.
12	DLL	%		DLL value as a percentage of total spine length C_7-S_1.
13	KLL	degrees	Angle of lumbar lordosis	KLL = 180 – (Alfa + Beta), fig. 1.
14	RLL	mm	The heigth of lumbar lordosis	The distance between S_1 a PL points, fig. 2.
15	RLL	%		RLL as a percentage of total spine length C_7-S_1.
16	GLL -	mm	The depth of lumbar lordosis	Distance measured horizontally between vertical lines passing through the PL i LL points, fig. 2.

Source: own research

Fig. 1. Selected angular features of the spine in the sagittal plane

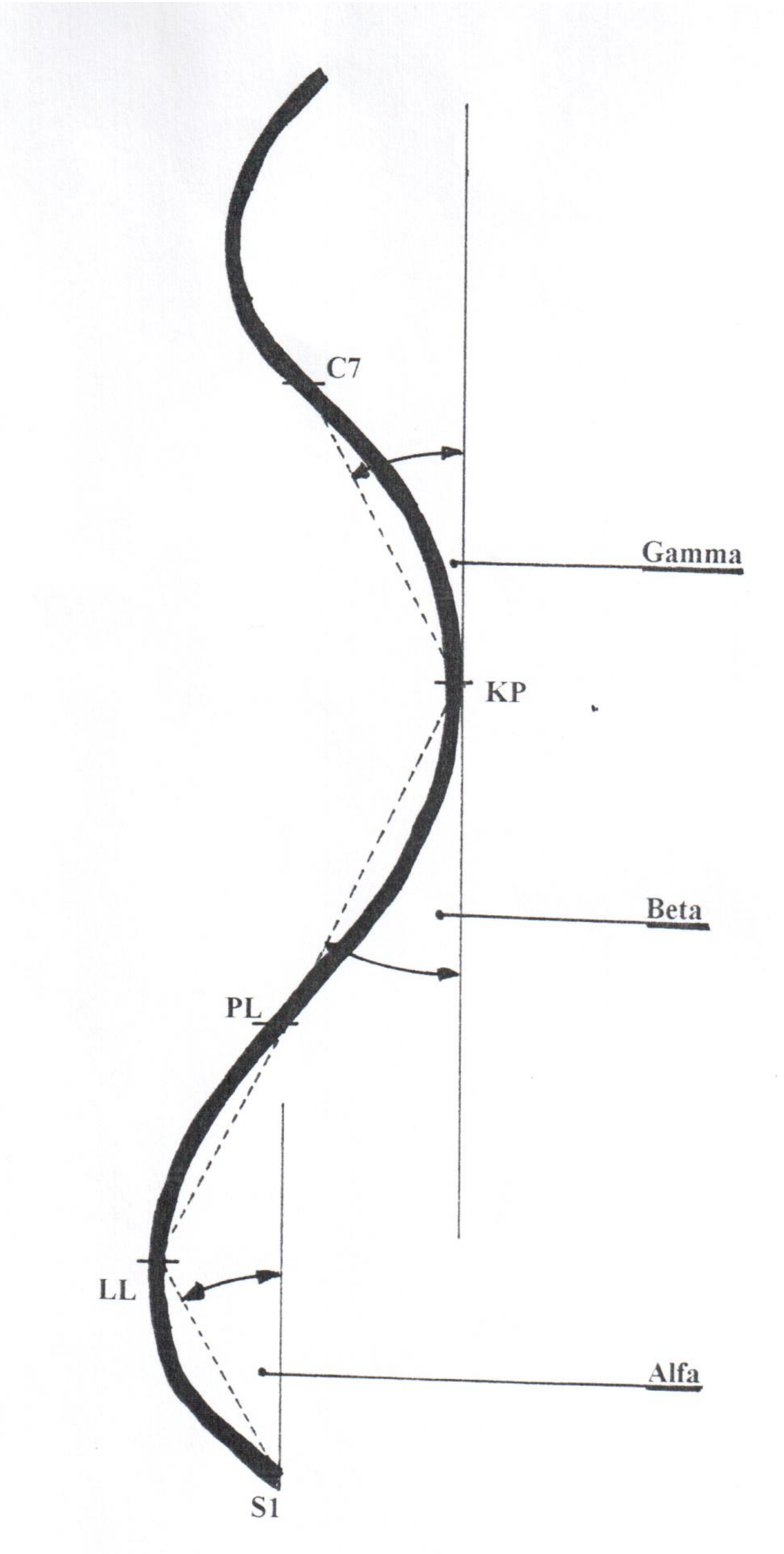
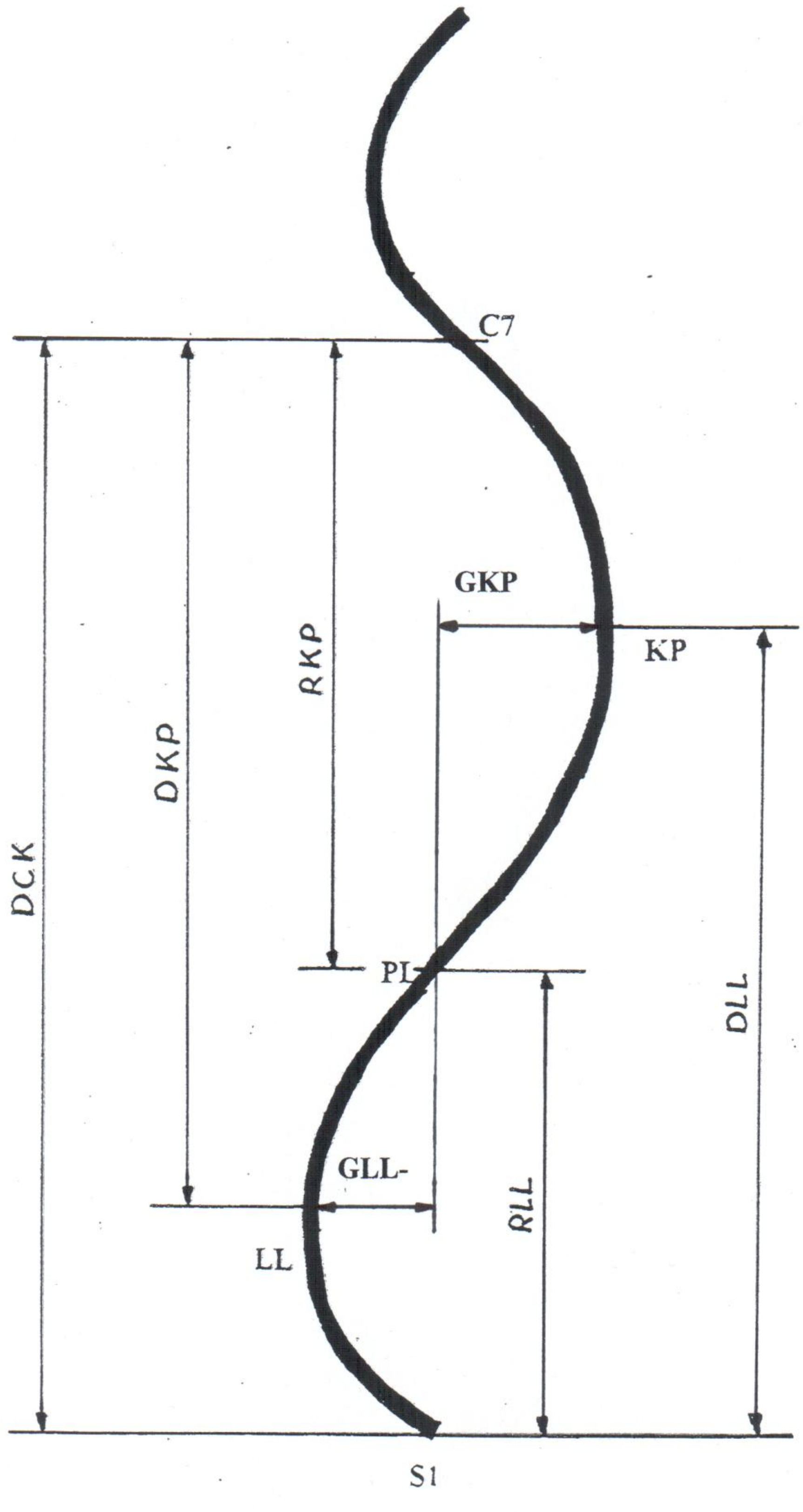


Fig. 2. Selected linear features in the sagittal plane



4 Statistical methods used

Statistical analysis was carried out on the results of measurements of individuals from 4 to 18 years of age in 6 semiannual editions. Empirical data were quantitative and qualitative characteristics (gender, place of residence, etc.). There were values of positional statistics (arithmetic mean, quartiles), dispersion parameter (standard deviation) and symmetry indices (asymmetry coefficient, clustering coefficient) calculated, which gave a complete view of the distribution of the studied traits considering age groups and gender. There was the significance of changes in the values of the averages in subsequent years within one sex analyzed for selected traits (Student's t-test was used). The obtained results allow to draw conclusions about the quality and dynamics of changes in the studied features. In addition, within age groups, there were comparative analyses of average values between gender groups (Student's t-test).

5 Results obtained

For multiple regression analysis with selection of a subset of the optimal set of variables one influential feature was selected like the length of lumbar lordosis (DLL). The set of variable features included the studied spine features: 1 - 16, table 2, 3. From the regression of the registered traits, it is noticeable that (DKP) length of thoracic kyphosis is significantly and positively influenced by length of lumbar lordosis (DLL), (KKP) thoracic kyphosis angle is significantly and negatively influenced by length of lumbar lordosis (DLL), (RKP) thoracic kyphosis height is significantly and positively influenced by length of lumbar lordosis (DLL), (GKP) depth of thoracic kyphosis is significantly and positively influenced by length of lumbar lordosis (DLL), (KLL) angle of lumbar lordosis is significantly and negatively influenced by length of lumbar lordosis (DLL), (RLL) height of lumbar lordosis is significantly and positively affected by length of lumbar lordosis (DLL), and (GLL) depth of lumbar lordosis is significantly and positively affected by length of lumbar lordosis (DLL), Tab. 7.

Tab. 3. Multiple regression analysis with selection of a subset of optimal explanatory variables like city, age, gender, weight and body height, length of lumbar lordosis, and characteristics of the 1 - 16 N = 16608

Name of parametres of variables in the model									R2%	I. r.
Variables		Influences								
No	Name	Xo	City	Age	Sex	W.C.	M.C.	DLL		
5	DKP	59,85	-3,49		3,58	0,47	0,1	0,7	46,29	***
6	DKP%	88,56	-0,79	0,01	0,93	-0,03	-0,03	0,0	2,29	***
7	KKP	165,98		0,02	-0,58	-0,03	0,03	-0,03	7,96	***
8	RKP	65,96	-3,73		1,97	0,46	0,34	0,29	27,93	***
9	RKP%	65,98	-0,98	0,0	0,48	0,02	0,05	-0,04	10,64	***
10	GKP	-3,26	-0,6		0,66	-0,11	-0,06	0,16	37,19	***
12	DLL%	63,14	0,17	0,01		-0,16	-0,05	0,11	40,88	***
13	KLL	170,03	-0,61	0,02	0,88			-0,04	5,75	***
14	RLL	-8,09	2,69	-0,05	-1,43	0,24	-0,07	0,5	58,81	***
11	RLL%	33,3	1,07	-0,0	-0,47	-0,02	-0,05	0,04	11,11	***
16	GLL -	-4,91	0,33	-0,01	0,47	-0,03	-0,09	0,12	25,64	***

Source: own research

For multiple regression analysis with selection of a subset of the optimal set of variables one influential trait was selected like the angle of lumbar lordosis (KLL). The variable feature set included spine features 1-16, table 2, 4. The regression shows that (DKP) the length of thoracic kyphosis is significantly and negatively affected by angle of lumbar lordosis (KLL), (KKP) angle of thoracic kyphosis is significantly and positively affected by the angle of lumbar lordosis (KLL), (RKP) height of thoracic kyphosis is significantly and positively affected by the angle of lumbar lordosis (KLL), (GKP) depth of thoracic kyphosis is significantly and negatively affected by the angle of lumbar lordosis (KLL), (RLL) height of lumbar lordosis is significantly and negatively affected by the angle of lumbar lordosis (KLL), and (GLL-) depth of lumbar lordosis is significantly and negatively affected by the angle lumbar lordosis (KLL), Tab. 7.

Tab. 4. Multiple regression analysis with selection of a subset of optimal explanatory variables like city, age, gender, weight and body height, angle of lumbar lordosis, and characteristics 1 – 16 N = 16608

Name of parametres of variables in the model									R2%	I. r.
Variables		Influences								
No	Name	Xo	City	Age	Sex	W.C.	M.C.	KLL		
5	DKP	233,08	-6,16		3,28	0,79		-0,15	16,42	***
6	DKP%	72,48	-0,77	0,01	0,82	0,03	-0,03	0,1	4,11	***
7	KKP	112,22	0,2	0,01	-0,84	-0,04	0,04	0,29	18,05	***
8	RKP	70,67	-4,63		1,47	0,59	0,29	0,35	19,92	***
9	RKP%	23,49	-0,71		0,32		0,06	0,2	11,16	***
10	GKP	105,11	-1,37	0,02	0,99	-0,06	-0,08	-0,46	20,05	***
12	DLL%	355,59	-3,97	0,05		0,39	-0,15	-0,88	14,28	***
14	RLL	110,16	-0,3	0,02		-0,11	-0,07	-0,13	10,02	***
15	RLL%	76,41	0,8		-0,31		-0,06	-0,2	11,45	***
16	GLL -	106,35	-0,34		0,88		-0,11	-0,52	23,96	***

Source: own research

For multiple regression analysis with selection of a subset of the optimal set of variables one influential trait was selected like height of lumbar lordosis (RLL). The set of variable features included spine features: 1 - 16, Table 2, 5. The regression shows that (DKP length of thoracic kyphosis is significantly and positively influenced by height of lumbar lordosis (RLL), (KKP) angle of thoracic kyphosis is significantly and negatively influenced by height of lumbar lordosis (RLL), (RKP) height of thoracic kyphosis is significantly and negatively influenced by height of lumbar lordosis (RLL), (GKP) depth of thoracic kyphosis is significantly and positively influenced by height of lumbar lordosis (RLL), (DLL) length of lumbar lordosis is significantly and positively influenced by height of lumbar lordosis (RLL), (KLL) angle of lumbar lordosis is significantly and negatively affected by height of lumbar lordosis (RLL), and (GLL-) depth of lumbar lordosis is significantly and positively affected by height of lumbar lordosis (RLL), Tab. 7.

Tab. 5. Multiple regression analysis with selection of a subset of optimal explanatory variables like city, age, gender, weight and body height, height of lumbar lordosis, and characteristics 1 - 16 N = 16680

Name of parametres of variables in the model									R2%	I. r.
Variables		Influences								
No	Name	Xo	City	Age	Sex	W.C.	M.C.	RLL		
5	DKP	166,52	-6,53		3,77	0,68		0,37	20,33	***
6	DKP%	101,67	-0,7	0,01	0,74		-0,04	-0,1	18,35	***
7	KKP	162,22		0,01	-0,61	-0,03	0,03	-0,03	6,37	***
8	RKP	138,09	-4,72		1,61	0,63	0,28	-0,1	19,66	***
9	RKP%	73,92	-,65		0,2	0,08	0,03	-0,18	51,91	***
10	GKP	22,57	-1,25	0,01	0,71	-0,08	-0,07	0,08	9,69	***
11	DLL	*102,26*	-4,59	0,07	1,3	-0,07		1,09	60,2	***
12	DLL%	*74,4*	-0,35	0,02		-0,17	-0,05	0,13	28,89	***
13	KLL	-171,39	-0,32	0,02	0,72	0,01		-0,11	11,47	***
15	RLL%	25,27	0,73		-0,19	-0,08	-0,03	0,18	54,61	***
16	GLL -	9,97			0,63		-0,1	0,13	14,05	***

Source: own research

For multiple regression analysis with selection of a subset of the optimal set of variables one influential trait was selected like the depth of lumbar lordosis (GLL-). The set of variable features included the studied spine traits: 1 - 16, table 2, 6. The regression shows that (DKP) length of thoracic kyphosis is significantly and positively influenced by depth of lumbar lordosis (GLL-), (KKP) angle of thoracic kyphosis is significantly and negatively influenced by depth of lumbar lordosis (GLL-), (RKP) height of thoracic kyphosis is significantly and positively affected by depth of lumbar lordosis (GLL-), (GKP) depth of thoracic kyphosis is significantly and positively affected by depth of lumbar lordosis (GLL-), and (DLL) length of lumbar lordosis is significantly and positively affected by depth of lumbar lordosis (GLL-), Tab. 7.

Tab. 6. Multiple regression analysis with selection of a subset of optimal explanatory variables like city, age, gender, weight and body height, and depth of lumbar lordosis, and characteristics 1 – 15 N = 16608

Name of parametres of variables in the model									R2%	I. r.
Variables		Influences								
No	Name	Xo	City	Age	Sex	W.C.	M.C.	GLL-		
5	DKP	162,33	-5,7	0,05	2,34	0,72	0,24	2,14	36,54	***
6	DKP%	85,09	-0,77	0,01	0,83	-0,04		0,23	13,92	***
7	KKP	169,73		0,01	-0,38	-0,04		-0,44	43,93	***
8	RKP	110,27	-4,78		1,46	0,6	0,39	0,74	23,21	***
9	RKP%	57,8	-0,8	0,0	0,53		0,05	-0,05	4,02	***
10	GKP	12,79	-1,07	0,02	0,25	-0,05		0,79	61,13	***
11	DLL	170,64	-3,41	0,06	-1,29	0,42		1,78	30,92	***
12	DLL%	83,78	-0,21	0,02	-0,26	-0,11	-0,05	0,18	13,55	***
13	KLL	169,41	-0,47	0,01	1,08	-0,02	-0,03	-0,4	2,34	***
14	RLL	84,74	1,02	-0,02	-2,06	0,4		0,84	17,39	***
15	RLL%	41,86	0,92		-0,52		-0,06	0,05	4,22	***

Source: own research

Tab. 7. Multiple regression of variable parameters with selection of the optimal subset N = 16608

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
11																
13																
14																
16																

Source: own research

The Legend:

Explanation of features numbers, tab. 2.

Features listed vertically affect those ranked horizontally

Red – significant positive influence

Yellow – significant negative influence

White – irrelevant influence

6 Discussion

Due to editorial limitations and the very large number of obtained test results, the author deliberately limited himself to describe lumbar lordosis and thoracic kyphosis features.

From Lewandowski's electro goniometric measurements [4], the angular values of the physiological curvatures of the spine present that their development shows a convergent course in both sexes, but the total increase in the angular values of individual curvatures is greater in male individuals. A study by Drzał-Grabiec et al [5] conducted using the photogrammetric method in a group of 480 students of the first third graders of elementary school showed that the parameters characterizing posture are mutually influencing parameters. They also showed that the angle of torso tilt is the most dependent parameter on the others and the least dependent parameter is the length of thoracic kyphosis. The author's research also proved the mutual influence of the various parameters describing posture on each other. They did not show a parameter that was independent on the others, which indicates that posture as a whole changes even if one of the describing characteristics is changed.

7. Summary

The presented statistical analysis shows the mutual influence of the values of the selected features. The study showed no independent trait, however, the degree of influence varied. This demonstrates the interrelatedness of the different spinal segments. Corrective actions that change the value of one postural trait force the change of others in a positive or negative way.

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