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The influence of body composition on scoliosis in primary school children

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Summary. Background. This study aimed to determine the prevalence of scoliosis and to assess the contribution of body composition among children in the upper grades of primary school. **Methods**. The sample consisted of 484 school-aged children from fifth to eighth grade of both genders. Chi-square (χ^2) tests with supplementary Z-tests were used to examine differences in frequencies, while discriminant analysis was applied to evaluate the contribution of body composition parameters to scoliosis. **Results**. The results indicated that scoliosis was present in 39.5% of the participants (M=32.5%; F=47%). A gender related differences were observed in the prevalence of scoliosis and normal posture (M=0.000; F=0.393). Further analysis showed significant gender difference (overall=0.001; by grades: V=0.053; VI=0.155; VII=0.186; VIII=0.050). Discriminant analysis indicated limited and grade-specific associations between body composition parameters and scoliosis (BFMkg=-.638; PBF=-.692; RSMM=.734; PFFM=.615). **Conclusions**. It can be concluded that there is a high prevalence of scoliosis among older primary school children. Gender differences were also observed, indicating that strategies to address scoliosis and associated body composition parameters should be tailored according to both gender and age.

Key words. Assessment, body posture, deformities, childhood, gender differences.

L'influenza della composizione corporea sulla scoliosi nei bambini della scuola primaria

Riassunto. Background. Questo studio si è posto l'obiettivo di determinare la prevalenza della scoliosi e di valutare il contributo della composizione corporea tra i bambini di quinta della scuola primaria e della scuola superiore di I grado. **Metodi.** Il campione era composto da 484 bambini in età scolare, dalla quinta classe alla terza media (gradi V-VIII), di entrambi i sessi. Per esaminare le differenze nelle frequenze sono stati utilizzati i test del Chi-quadrato (χ^2) con test Z supplementari, mentre l'analisi discriminante è stata applicata per valutare il contributo dei parametri della composizione corporea alla scoliosi. **Risultati.** I risultati hanno indicato che la scoliosi era presente nel 39,5% dei partecipanti (M=32,5%; F=47%). Sono state osservate differenze legate al genere nella prevalenza della scoliosi e della postura normale (M=0.000; F=0.393). Ulteriori analisi hanno mostrato una differenza di genere significativa (totale=0.001; per classe: V=0.053; VI=0.155; VII=0.186; VIII=0.050). L'analisi discriminante ha indicato associazioni limitate e specifiche per grado scolastico tra i parametri della composizione corporea e la scoliosi (BFMkg=-.638; PBF=-.692; RSMM=.734; PFFM=.615). **Conclusioni.** Si può concludere che esiste un'elevata prevalenza di scoliosi tra i bambini più grandi della scuola primaria. Sono state osservate anche differenze di genere, indicando che le strategie per affrontare la scoliosi e i parametri della composizione corporea associati dovrebbero essere personalizzate in base sia al sesso che all'età.

Parole chiave. Valutazione, postura del corpo, deformità, infanzia, differenze di genere.

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Introduction

Health is a crucial factor during periods of rapid growth and development. In this intricate stage of life, modern living conditions often lead to numerous adverse effects on human health[1,2]. Vulnerability is initially reflected in functional changes, which over time may develop into structural problems. One of the health parameters directly related to the increasingly prevalent modern issue of hypokinesia is body composition, a crucial factor during the phases of intensive growth and development[3]. Body composition parameters that are becoming more frequent and negatively affecting children's health and normal development include body fat and Body Mass Index (BMI), which indicate obesity in children or individuals[4]. Additionally, a decrease in muscle mass parameters is a significant indicator of insufficient muscle strength necessary for normal posture and correct postural alignment[5]. Postural status in early adolescent children is a particularly vulnerable aspect of health, showing a concerning negative trend in recent years, especially in spinal regions affected by scoliosis. Scoliosis can be defined as a three-dimensional postural disorder or deformity located in the spinal column, with a lateral deviation of more than 10 degrees according to the Cobb method. This deviation often involves adjacent bones, tendons, and muscles, disrupting alignment and potentially affecting the positioning and function of trunk organs. The results of previous studies on the prevalence of scoliosis indicate not only a high percentage of occurrence, exceeding 30% among adolescents[6-9], but also significant variability due to the use of different diagnostic methods. These methods include Napoleon Wolanski's method[8], the "Spinal Mouse" device[7], somatometric and somatoscopic methods[6,9], and the spherometric method[10,11]. These diagnostic approaches are often characterized by a high degree of subjectivity. Furthermore, based on the results of scientific research, it is difficult to clearly identify a distinct period of increased scoliosis deformity in primary school children of different genders and grade levels.

Scientific research examining the relationship between the postural status of the spine and body composition in school-aged children has indicated a high statistical correlation[12-15]. The results also showed that parameters of body fat and fat-free mass, expressed in kilograms and percentages, have a high degree of statistically significant correlation with the angles of convexity in the sagittal and frontal planes of the spine in all analyzed studies[12-15]. A lower level of statistical significance was observed between parameters of muscle mass and total body water with the angles of convexity in the frontal and sagittal planes of the spine. However, no statistically significant correlation was observed between the parameters of bone tissue and the angles of convexity in the frontal and sagittal planes of the spine. A review of previous research[12-15] addressing the state and correlation between postural status and body composition in primary school-aged children reveals an insufficient number of monitored parameters used to determine the condition, as well as a lack of standardization in instruments and methods for monitoring both groups of parameters. Furthermore, no research has investigated the relationship between postural status and body composition in relation to age (fifth to eighth grade) or gender.

Materials and methods

Participants

The sample consisted of school-aged children from fifth to eighth grade. The participants were students from primary schools in Republic of Serbia. A detailed description of the sample is presented in table 1. Participation was voluntary, and the study adhered to the principles of the Declaration of Helsinki, with written informed consent obtained from parents. All participants were informed that they could withdraw from the study at any time without any penalties. The study was approved by the Ethics Committee of the University of Niš under the reference number 04-542/2.

Table 1. Description of the sample participants.

		Body height (cm) (mean±SD)	Body weight (kg) (mean±SD)
SUM (484)		154.96±10.11	50.36±14.50
M (252)		155.90±11.14	51.43±15.96
F (232)		153.95±8.75	49.19±12.65
R	Sex (#)		
V	M (78)	147.26±6.88	43.33±13.08
	F (74)	147.29±8.12	43.69±12.25
	Sum (152)	147.28±7.49	43.51±12.64
VI	M (55)	153.52±9.05	49.17±13.05
	F (59)	153.81±6.75	48.54±13.31
	Sum (114)	153.67±7.91	48.84±13.13
VII	M (61)	159.98±10.13	56.76±17.11
	F (56)	153.67±6.73	53.65±11.84
	Sum (117)	158.88±8.71	55.27±14.84
VIII	M (58)	165.48±8.87	58.86±15.48
	F (43)	160.74±6.37	53.77±9.47
	SUM (101)	163.46±8.21	56.69±13.44

Mean - mean value; SD - standard deviation

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Assessment

The instrument used for assessing the anthropometric parameters of the participants was an anthropometric device (SECA model 284; SECA, Hamburg, Germany). Measurements were conducted with the participant wearing minimal clothing and no footwear, standing barefoot on the platform of the instrument in clearly marked foot placement areas, maintaining an upright posture. The results of the measurements were displayed digitally on the device's screen with an accuracy of one-hundredth of a unit, measured in millimeters (mm).

The instrument used to assess the prevalence of scoliosis among the participants was the Formetric 4D System (Diers, Germany). This device belongs to the group of non-invasive diagnostic methods for evaluating the postural status of children and adults (16, 17). The diagnostic process is performed using photometry, based on the principle of triangulation. The validity and reliability of the instrument (ICC > 0.95) have been determined in previous studies[18,19]. The aforementioned studies show a high correlation between rasterography and radiography (0.582). Software analysis provided values in degrees of Cobb's angle for each analyzed segment. Each segment in the frontal plane with a Cobb's angle whose convexity is greater than 10 degrees was defined as scoliosis[19].

The measurement procedure requires the participant to have markers placed at specific locations, namely the fossae lumbales laterales and the C7-processus spinosus, before the diagnostic process begins. The participant must be dressed only in underwear. After preparation, the participant, typically a child, steps onto a designated platform, maintaining an upright posture with feet positioned parallel and theirs back facing the camera. The environment, or the room where the diagnostics take place, must be completely darkened to ensure clearer and more accurate results. The diagnostic results are displayed on a computer, which is connected to the instrument via specially designed software.

To evaluate the postural status of the spine in participants (from fifth to eighth grade) of both genders, the variables presented in table 2 were used.

The instrument used to assess the body composition parameters of the participants was the InBody 770 (InBody Co, Seoul, Korea). The reliability and validity of this instrument have been confirmed by studies conducted by various authors[20,21].

The measurement procedure required the participant to be dressed only in underwear before the diagnostic process began. After preparation, the participant stepped onto a designated platform, standing in an upright position with feet positioned parallel in the designated areas for toes and heels. The hands were held slightly apart from the body, with handles in the palms. The diagnostic results were displayed on the instrument's integrated computer screen and were directly printed using a printer connected to the device.

For the assessment of body composition parameters, the following variables were used: skeletal muscle mass (SMM kg); relative muscle mass (RMM%); body fat mass (BFM kg); percentage of body fat (PBF%); fat-free mass (FFM kg); relative fat-free mass (RFFM%).

Statistical data analysis

Descriptive statistical parameters were calculated for all variables, including: mean (AS), standard deviation (SD), frequency and percentage (%). To determine differences in the prevalence of scoliosis between genders and across grades, the Chi-square test for independence, supplemented with the Z-test, was applied. Discriminant analysis was used to assess the contribution of body composition to scoliosis. Differ-

Table 2. Variables for evaluating the postural status of the spine.

No.	Variable Name	Abbreviation
1.	No scoliosis	NS
2.	Scoliosis with thoracic left convexity	STL
3.	Scoliosis with thoracic right convexity	STR
4.	Scoliosis with lumbar left convexity	SLL
5.	Scoliosis with lumbar right convexity	SLR
6.	Scoliosis with thoracic left convexity and lumbar left convexity	STotL
7.	Scoliosis with thoracic right convexity and lumbar right convexity	STotR
8.	Scoliosis with thoracic left convexity and lumbar right convexity	STLCLR
9.	Scoliosis with thoracic right convexity and lumbar left convexity	STRVLL
10.	Scoliosis	S

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ence was considered as significant if p<.05.The data obtained from the measurements in this study were processed using statistical packages within the "SPSS 20" software.

Results

Table 3 shows that scoliosis was present in 191 students (39.5%), including 82 boys (32.5%) and 109 girls (47%). Prevalence increased progressively by grade: Grade V (35.5%), VI (39.5%), VII (40.2%), VIII (44.6%).

Table 4 indicates no significant difference between students with and without scoliosis (sig=0.551). However, there were significant differences between those with normal posture and scoliosis in all grades except Grade VIII (V=0.000; VI=0.031; VII=0.042; VIII=0.320; total=0.000), in favor of those with normal posture. Among boys, no significant difference was found between those with and without scoliosis (sig=0.772), but significant differences between normal posture and scoliosis were present in all grades (V=0.000; VI=0.014; VII=0.020; VIII=0.048; total=0.000). Among girls, no significant differences were observed in any grade or in the total sample (all sig > 0.29).

Table 5 shows a significant difference between scoliosis and normal posture in the overall sample (sig=0.001). By grade, a significant difference was found only in Grade VIII (V=0.053; VI=0.155; VII=0.186; VIII=0.050). Boys were more likely to have normal posture (170 vs. 123), while girls more often had scoliosis (109 vs. 82), with a significant gender difference in the total sample. By grade, a significant difference favoring boys was found only in Grade VIII.

Overall gender-based analysis showed a significant difference (sig=0.006), but not across individual grades, except for a borderline result in Grade V (sig=0.050), again favoring boys.

Table 6 reveals that body composition did not significantly contribute to scoliosis in the total sample (sig=0.106), nor among boys (sig=0.110) or girls (sig=0.421). An exception was found in Grade V, where the contribution was significant (sig=0.024), with PBF (-.543), RSMM (.629), and PFFM (.754) showing notable influence. However, in Grade V, the contribution was not significant within boys (sig=0.219) or girls (sig=0.113) individually. In Grades VI and VII, results were not significant (VI=0.626; VII=0.458). In

Table 3. Frequency and percentage values of spinal postural status variables in older primary school children.

			NS	STL	STD	SLL	SDD	STotL	STotD	DSTLLD	PSSKDRL	S
R	**G**	**N**	**(F/%)**	**(F/%)**	**(F/%)**	**(F/%)**	**(F/%)**	**(F/%)**	**(F/%)**	**(F/%)**	**(F/%)**	**(F/%)**
V	M	78	56/71.8%	6/7.7%	9/11.5%	/	/	4/5.1%	1/1.3%	/	2/2.6%	22/28.2%
	F	74	42/56.8%	1/1.4%	10/13.5%	1/1.4%	2/2.7%	5/6.8%	6/8.1%	2/2.7%	5/6.8%	32/43.2%
	U	152	98/64.5%	7/4.6%	19/12.5%	1/0.7%	2/1.3	9/5.9%	7/4.6%	2/1.3%	7/4.6%	54/35.5%
VI	M	55	37/67.3%	3/5.5%	6/10.9%	/	/	3/5.5%	3/5.5%	2/3.6%	1/1.8%	18/32.7%
	F	59	32/54.2%	3/5.1%	7/11.9%	2/3.4%	1/1.7%	1/4.7%	3/5.1%	3/5.1%	7/11.9%	27/45.8%
	U	114	69/60.5%	6/5.3%	13/11.4	2/1.8%	1/0.9%	4/3.5%	6/5.3%	5/4.4%	8/7.0%	45/39.5%
VII	M	61	40/65.6%	7/11.5%	7/11.5%	/	2/3.3%	1/1.6%	1/1.6%	2/3.3%	1/1.6%	21/34.4%
	F	56	30/53.6%	3/5.4%	10/17.9%	1/1.8%	2/3.6%	2/3.6%	1/1.8%	1/1.8%	6/10.7%	26/46.4%
	U	117	70/59.8%	10/8.5%	17/14.5%	1/0.9%	4/3.4%	3/2.6%	2/1.7%	3/2.6%	7/6.0%	47/40.2%
VIII	M	58	37/63.8%	2/3.4%	4/6.9%	2/3.4%	2/3.4%	3/5.2%	1/1.7%	2/3.4%	5/8.6%	21/36.2%
	F	43	19/44.2%	3/7.0%	6/14.0%	1/2.3%	2/4.7%	1/2.3%	6/14.0%	3/7.0%	2/4.7%	24/55.8%
	U	101	56/55.4%	5/5.0%	10/9.9%	3/3.0%	4/4.0%	4/4.0%	7/6.9%	5/5.0%	7/6.9%	45/44.6%
	M	252	170/67.5%	18/7.1%	26/10.3%	2/0.8%	4/1.6%	11/4.4%	6/2.4%	6/2.4%	9/3.6%	82/32.5%
	F	232	123/53%	10/4.3%	33/14.2%	5/2.2%	7/3%	9/3.9%	16/6.9%	9/3.9%	20/8.6%	109/47%
	UK	484	293/60.5%	28/5.8%	59/12.2%	7/1.4%	11/2.3%	20/4.1%	22/4.5%	15/3.1%	29/6%	191/39.5%

R - grade; P - gender; M - male subjects; F - female subjects; U - total number of subjects in each grade; UK - total; B - number; F - frequency; NS - No scoliosis; STL - Scoliosis with thoracic left convexity; STD - Scoliosis with thoracic right convexity; SLL - Scoliosis with lumbar left convexity; SLD - Scoliosis with lumbar right convexity; STotL - Scoliosis with thoracic left convexity and lumbar left convexity; STotT - Scoliosis with thoracic right convexity and lumbar right convexity; DSTLLD - Scoliosis with thoracic left convexity and lumbar right convexity; DSTDDL - Scoliosis with thoracic right convexity and lumbar left convexity; S – Scoliosis.

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Table 4. Difference in the postural status of the spinal column in older primary school children by grade.

	R	NS	STL	STD	SLL	SLD	STotL	STotD	DSTLLD	DSTDLL	Hi^n sig	NS	S	Z test sig	
UK (484)	V	98_a	7_a	19_a	1_a	2_a	9_a	7_a	2_a	7_a	.709	98_a	54_a	.000	**.000**
	VI	69_a	6_a	13_a	2_a	1_a	4_a	6_a	5_a	8_a		69_a	45_a	.031	
	VII	70_a	10_a	17_a	1_a	4_a	3_a	2_a	3_a	7_a		70_a	47_a	.042	
	VIII	56_a	5_a	10_a	3_a	4_a	4_a	7_a	5_a	7_a		56_a	45_a	.320	
													Hi^n + Z test		.551
M (252)	V	56_a	6_a	9_a	0_a	0_a	4_a	1_a	0_a	2_a	.271	56_a	22_a	.000	**.000**
	VI	37_a	3_a	6_a	0_a	0_a	3_a	3_a	2_a	1_a		37_a	18_a	.014	
	VII	40_a	7_a	7_a	0_a	2_a	1_a	1_a	2_a	1_a		40_a	21_a	.020	
	VIII	37_a	2_a	4_a	2_a	2_a	3_a	1_a	2_a	5_a		37_a	21_a	.048	
													Hi^n + Z test		.772
F (232)	V	42_a	1_a	10_a	1_a	2_a	5_a	$6_{a,b}$	2_a	5_a	.800	42_a	32_a	.295	.393
	VI	32_a	3_a	7_a	2_a	1_a	1_a	$3_{a,b}$	3_a	7_a		32_a	27_a	.603	
	VII	30_a	3_a	10_a	1_a	2_a	2_a	1_b	1_a	6_a		30_a	26_a	.689	
	VIII	19_a	3_a	6_a	1_a	2_a	1_a	6_a	3_a	2_a		19_a	24_a	.542	
													Hi^n + Z test		.614

R - grade; P - gender; M - male subjects; F - female subjects; U - total number of subjects in each grade; UK - total; B - number; F - frequency; NS - No scoliosis; STL - Scoliosis with thoracic left convexity; STD - Scoliosis with thoracic right convexity; SLL - Scoliosis with lumbar left convexity; SLD - Scoliosis with lumbar right convexity; STotL - Scoliosis with thoracic left convexity and lumbar left convexity; STotT - Scoliosis with thoracic right convexity and lumbar right convexity; DSTLLD - Scoliosis with thoracic left convexity and lumbar right convexity; DSTDDL - Scoliosis with thoracic right convexity and lumbar left convexity; S – Scoliosis.; Hin sig - significance of the Hi-square test for independence; Z test sig - significance of differences; Hin + Z test - significance of the matching of differences in the sagittal plane postural status.

Table 5. Difference in the postural status of scoliosis in older primary school children by grade.

R	G	NS	STL	STD	SLL	SLD	STotL	STotD	DSTLLD	DSTDDL	Hin sig	NS	S	Hin + Z test
V	M	56_a	6_a	9_a	0_a	0_a	4_a	1_a	0_a	2_a	.050	56_a	22_a	.053
	F	42_a	1_a	10_a	1_a	2_a	5_a	6_b	2_a	5_a		42_a	32_a	
VI	M	37_a	3_a	6_a	0_a	0_a	3_a	3_a	2_a	1_a	.341	37_a	18_a	.155
	F	32_a	3_a	7_a	2_a	1_a	1_a	3_a	3_a	7_b		32_a	27_a	
VII	M	40_a	7_a	7_a	0_a	2_a	1_a	1_a	2_a	1_a	.377	40_a	21_a	.186
	F	30_a	3_a	10_a	1_a	2_a	2_a	1_a	1_a	6_b		30_a	26_a	
VIII	M	37_a	2_a	4_a	2_a	2_a	3_a	1_a	2_a	5_a	.214	37_a	21_a	.050
	F	19_b	3_a	6_a	1_a	2_a	1_a	6_b	3_a	2_a		19_b	24_b	
UK	M	170_a	18_a	26_a	2_a	4_a	11_a	6_a	6_a	9_a	.006	170_a	82_a	.001
	F	123_b	10_a	33_a	5_a	7_a	9_a	16_b	9_a	20_b		123_b	109_b	

R - grade; P - gender; M - male subjects; F - female subjects; U - total number of subjects in each grade; UK - total; B - number; F - frequency; NS - No scoliosis; STL - Scoliosis with thoracic left convexity; STD - Scoliosis with thoracic right convexity; SLL - Scoliosis with lumbar left convexity; SLD - Scoliosis with lumbar right convexity; STotL - Scoliosis with thoracic left convexity and lumbar left convexity; STotT - Scoliosis with thoracic right convexity and lumbar right convexity; DSTLLD - Scoliosis with thoracic left convexity and lumbar right convexity; DSTDDL - Scoliosis with thoracic right convexity and lumbar left convexity; S – Scoliosis.; Hin sig - significance of the χ^2 test for independence; Z test sig - significance of differences; Hin + Z test - significance of the matching of differences in the sagittal plane postural status.

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Table 6. Contribution of body composition to the postural status of the spinal column in older primary school children by gender and grade.

R	G	SMMkg	RSMM	BFMkg	PBF	FFMkg	PFFM	p	WL	χ^2	CC	Ei	%CC
V	M	.554	.070	.040	.049	.536	.224	.219	.893	8.270	.327	.120	64.1
	F	.215	-.860	.855	.863	.277	-.868	.113	.880	8.891	.347	.136	67.6
	U	.203	**.629**	**-.491**	**-.543**	.164	**.754**	**.024**	.916	12.930	.290	.092	63.2
VI	M	-.498	-.498	-.130	.073	-.518	-.201	.809	.956	2.281	.210	.046	63.6
	F	.110	.110	-.629	-.749	.052	.901	.488	.922	4.443	.280	.085	62.7
	U	-.145	-.145	-.621	-.599	-.200	.671	.626	.969	3.480	.177	.032	57.9
VII	M	.252	.252	-.145	-.167	.378	.440	.791	.958	2.402	.204	.043	55.7
	F	.072	.072	-.553	-.624	.039	.886	.154	.855	8.048	.380	.169	67.9
	U	.038	.038	-.511	-.496	.097	.717	.458	.959	4.667	.202	.042	55.6
VIII	M	.195	.319	-.396	-.366	.129	.338	**.031**	.770	13.852	.480	.299	70.7
	F	.426	.426	-.520	-.731	.288	.749	.905	.960	1.570	.200	.042	53.5
	U	**.442**	.365	**-.487**	**-.591**	.371	**.586**	**.012**	.844	16.326	.395	.185	64.4
SUM	M	-.081	.149	-.263	-.093	-.141	-.057	.110	.959	10.378	.203	.043	65.1
	F	.236	-.098	.734	.835	.312	-.644	.421	.974	6.019	.162	.027	54.7
	UK	.073	.734	-.638	-.692	-.017	.615	.106	.978	10.473	.147	.022	58.1

R - grade; P - gender; M - male respondents; F - female respondents; U - total respondents, children within one grade; SMMkg - skeletal muscle mass in kilograms; RSMM% - relative muscle mass of the body; BFMkg - body fat mass in kilograms; PBF% - percentage of body fat mass; FFMkg - lean body mass in kilograms; PFFM% - relative lean body mass in percentage; WL - Wilks' Lambda, p - statistical significance; χ^2- Chi-square value; CC - Canonical Correlation; λ - Eigenvalue; %CC - percentage of correct reclassification.

Grade VIII, body composition had a significant contribution (sig=0.012), mainly through PBF (-.591) and PFFM (.586). Among boys, the result was significant (sig=0.031), but individual variable effects were not strong. Among girls, no significant contribution was found (sig=0.905).

Discussion

This study investigated the prevalence of scoliosis, gender- and age-related differences, and the role of body composition in primary school children. Scoliosis was observed in 39.5% of participants (males: 32.5%; females: 47%), with significant gender differences in scoliosis and normal posture (males: p=0.000; females: p=0.393) and overall (p=0.001), particularly in Grade VIII (p=0.050). Body composition parameters showed a notable contribution to scoliosis. Body composition showed a significant contribution to scoliosis (BFMkg=-.638; PBF=-.692; RSMM=.734; PFFM=.615). Analysis of scoliosis prevalence (Table 3) revealed a hierarchy of scoliosis types among participants. In the thoracic region, STD was most prevalent (12.2%), followed by STRVLL (6%) and STotR (4.5%). Other detected types included STL (5.8%), STotL (4.1%), and STLCLR (3.1%), with remaining types collectively accounting for only 3%. Additionally, among the other detected types of scoliosis, STL was present at 5.8%, followed by STotL at 4.1%, and STLCLR at 3.1%. Other types of scoliosis were collectively present at a very low percentage (3% in total).

These results, reflecting the hierarchy of segment prevalence, are generally consistent with previous research but differ in the prevalence of specific deformity localizations of idiopathic adolescent scoliosis, showing notably lower percentages[22]. Furthermore, a gender-based percentage difference in these types of scoliosis was observed, with scoliosis being less prevalent among male participants, consistent with previous studies[9,23,24]. When considering the results for the most prevalent types of scoliosis mentioned above, it is evident that their percentage prevalence increases with age. However, there is a notable percentage growth between seventh and eighth grade among female participants, as previously indicated in studies[25-27]. Among male participants, this percentage growth in the more prevalent types of scoliosis decreases between seventh and eighth grade. Based on the results of this study, as well as comparisons with previous research, periods of heightened risk for the development of scoliosis in older primary school-aged children, specifically idiopathic adolescent scoliosis, can be clearly identified, along with its most common localizations. The analysis of possible factors for the occurrence of idiopathic scoliosis is extensive. Prevalence factors for the onset of idiopathic

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adolescent scoliosis may include the region's distance from the equator[28], reduced vitamin D intake, calcium deficiency, and deficiencies in other minerals[29-31], polymorphism[32] social environment[33], nutritional status or body composition[12-15], and physical activity. A detailed analysis of previous research by authors from the Balkan region, who assessed the postural status of the spinal column in school children, revealed that the methods used by the authors varied[34], with a significant limitation being the high level of subjectivity of the measurer. In line with these findings, the results of this study provide a comprehensive overview of the postural status of the spinal column in adolescent-aged children using the most modern non-invasive diagnostic methods, based on the reference values prescribed by SOSORT.

Analyzing the results for the total sample of participants shows a statistically significant difference (sig=.000) between children without deformities (60.5%) and children with some form of scoliosis (39.5%). These results are not consistent with previous studies[9,25] which found a statistically significantly higher number of children with scoliosis. When analyzing the results of various studies[7,9,33] for the age group of 10 to 15 years, it is evident that this is a period of significant changes in the postural status of the spinal column in the frontal plane. Studies on children engaged in organized physical activity during this age period have shown a significantly lower prevalence of scoliosis[35,36]. Furthermore, organized physical exercise aimed at correction during this age has been shown to yield positive results[37,38], particularly through the application of exercise methods approved by the SOSORT organization[39].

Analyzing the results by gender in the total sample of participants reveals differences among male participants. Results shows statistically significant difference between participants with normal postural alignment (67.5%) and those with scoliosis (32.5%) (sig=.000). This was not the case for female participants (sig=.393). Previous studies on samples that included participants of both genders indicate a high prevalence of adolescent idiopathic scoliosis[9,25,42,43]. Furthermore, analysis of past research regarding gender highlights a significantly higher prevalence of idiopathic scoliosis among female participants[9,25]. Among younger primary school-aged participants, idiopathic scoliosis is significantly less prevalent[7,33]. The high percentage of scoliosis in the analyzed sample indicates that early adolescence is particularly sensitive to the development of idiopathic scoliosis in children. It is well established in the existing literature that the causes of idiopathic scoliosis are numerous and, accordingly, are defined as unknown.

Scoliosis prevalence by grade: total – V: 35.4%, VI: 39.5%, VII: 40.2%, VIII: 44.6%; boys – V: 28.2%, VI: 32.7%, VII: 34.4%, VIII: 36.2%; girls – V: 43.2%, VI: 45.8%, VII: 46.4%, VIII: 55.8%. Previous studies examining the prevalence of scoliosis have noted a percentage increase between grades, or ages 10 to 15, for both genders, though not with identical prevalence or growth rates[27,40,43,44]. The results of this study indicate that the trend of increasing prevalence between grades is significantly greater between fifth and sixth grades and between seventh and eighth grades. Similar percentage trends have been noted in earlier research[27,40,43,44]. These results of percentage fluctuations can be explained by sensitive phases of accelerated growth and varying periods of biological maturation relative to gender. In the study by Mišigoj-Duraković[45], a strong correlation was observed between height growth and the occurrence of idiopathic scoliosis, as well as a decrease in idiopathic scoliosis prevalence during periods of reduced bone growth and natural increases in muscle mass and lean body mass. Additionally, scoliosis is generally a more prevalent spinal deformity among female participants during adolescence, which has been confirmed through analysis of previous research[26,40].

The analysis of results by grade and gender within each grade indicates a general contribution of body composition to the postural status of the spinal column among students in the fifth (sig=0.024) and eighth grades (sig=0.012) in the total sample. A more detailed analysis of body composition variables reveals varying levels of contribution and direction in the fifth and particularly in the eighth grades (V - RSMM=.629; BFMkg=-.491; PBF=-.543; RFFM=.754; VIII -SMMkg=.442; BFMkg=-.487; PBF=-.591; RFFM=.586). These results suggest that, in both fifth and eighth grades and in the total sample, relative body composition values have a statistically significant contribution, with the exception of the BFMkg variable, which also showed a significant contribution. Additionally, the analysis of the percentage values of body composition parameters indicates the direction of contribution. PMM% and PFFM% are significantly higher in individuals diagnosed with scoliosis, while PBF% and BFMkg are lower. However, in the eighth grade, not all body composition parameters contributed equally to the increased percentage of scoliosis. For instance, PMM% did not show a contribution, but SMMkg did. Based on the results of descriptive statistics for body composition parameters and the percentage values of scoliosis, it can be observed that in the eighth grade, children show increases in height and body mass. Within body composition, significant increases in BFMkg, PBF%, and PFFM% are noted, while PMM% remains at the same level, but SMMkg increases. Accordingly, it becomes evident that children with higher average BFMkg and PBF% values had statistically significantly lower levels of scoliosis prevalence. These results can also be explained by analyzing PMM% and PFFM%, which in-

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crease progressively from grade to grade, alongside a concurrent increase in the percentage of scoliosis. Furthermore, this can be attributed to biological maturation factors and transformations in body composition parameters, which are just one aspect that may contribute to understanding the occurrence of postural disorders, such as scoliosis deformities, among older primary school children.

A key strength of this study is the analysis of scoliosis prevalence using a state-of-the-art non-invasive diagnostic method in a large sample of early adolescent participants. Additionally, this study's strength compared to previous ones is its examination of differences in each analyzed segment of the spinal column where scoliosis is located, as well as its analysis of trends based on grade and gender. Furthermore, the study investigated the influence and contribution of body composition parameters in individuals with scoliosis using highly precise methods and instruments, employing a wide range of parameters to assess body composition.

The limitations of this research include the absence of analysis of the cervical and sacral regions of the spine, as well as parameters for determining bone tissue and levels of minerals and vitamins. Additionally, the study does not present the number of participants diagnosed with scoliosis who also have hyperkyphosis and hyperlordosis in the lumbar region. A recommendation for future research is to analyze the cervical and sacral regions of the spinal column concerning the localization of scoliosis and to examine the prevalence, differences, and contributions of body composition to scoliosis among younger school-age children and high school students.

Conclusion

Postural disorders and suboptimal body composition are rapidly increasing health concerns in early adolescence. Previous research indicates that spinal postural disorders remain highly prevalent and continue to rise in the 21st century. Likewise, body composition parameters – particularly body fat and BMI – are increasing, trends commonly attributed to biological maturation, inadequate physical activity, and sedentary behavior. This study confirms the high and increasing prevalence of scoliosis among older primary school children, along with evident gender differences. All body composition parameters also show a consistent upward trend during this age, with noticeable gender differences in some values. Results indicate a statistically significant correlation between most body composition parameters and spinal posture, with several parameters making a notable contribution to scoliosis. These findings highlight the presence of both gender and age differences in postural status and body composition. Therefore, interventions aimed at improving spinal posture and body composition must be tailored according to gender and age.

Conflicts of interest. The authors declare that there is no conflict of interest.

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