

THE INCIDENCE OF SPINAL POSTURAL DISORDERS IN FIRST-GRADE ELEMENTARY-SCHOOL STUDENTS

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**Stefan Đorđević, Bojan Jorgić,
Saša Milenković, Ratko Stanković, Mima Stanković**

Faculty of Sport and Physical Education, University of Niš, Niš, Serbia

Abstract. *The aim of this study is to determine the state of postural disorders in the sagittal and frontal planes of the spinal column, as well as any gender differences in first-year elementary school students. The participant sample comprised 138 school children, 73 male and 56 female participants, all from the territory of the municipality of Knjaževac, Serbia. The measuring instrument, the Formetric 4D System, Diers, Germany was used for the assessment of postural disorders of the spinal column. The testing results were presented in terms of frequencies and percentages, while the chi-square independence test was used to determine differences in spinal deformity incidence between male and female participants. The results obtained indicate that, in the sagittal plane, deformity was present in a total of 73.9% of the sample (72.6% among the male and 75.4% among the female participants), whereas in the frontal plane this percentage amounted to 84.1% (84.9% among the male, and 83.1% among the female ones). Moreover, the results indicate that no statistically significant differences were found in terms of the incidence of postural disorders between male and female participants in the sagittal plane ($\text{sig}=0.859$) and in the frontal plane of the spinal column ($\text{sig}=0.949$). In view of the results obtained, it can be concluded that a high incidence of spinal postural disorders in both the frontal and sagittal planes was equally present in participants of both genders.*

Key words: *Kyphosis, Lordosis, Scoliosis, Kypho-Lordosis, Flat Back, Gender Differences*

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Corresponding author: Stefan Đorđević

Faculty of Sport and Physical Education, University of Niš, Čarojevića 10a, Niš, Serbia

Phone: + 381 18 510900 • E-mail: stefan.robi.djordjevic@gmail.com

INTRODUCTION

Postural status refers to the specific alignment of various segments of the human body which, under normal conditions, enables the most economical and rational movement, from the viewpoint of biomechanics and energy expenditure. In terms of deviations from normal postural status, there are irregularities located in parts of the locomotor apparatus (muscles, tendons, joints and bones) (Beganović & Bošković, 2012), and, depending on their location in different regions of the locomotor apparatus, these can be functional or structural in character (Milenković, 2007). Irregularities, that is, deviations from normal postural status, present a growing problem in children (Jorgić & Đorđević, 2016; Đorđević et al., 2016; Novaković, Đorđević, Aleksandrović, Pivač, & Bjelica, 2016). Most frequently, postural disorders in children can be discerned on the frontal and sagittal planes of the spine (Živković, 2009).

Research results into the incidence of postural disorders on the sagittal plane indicate that, in children of a pre-school age, this percentage can go up to 40%, while there are no statistically significant gender differences during this developmental stage (Romanov, Stupar, Mededović, & Brkin, 2014). Furthermore, the incidence of spinal deformities on the sagittal plane in elementary-school children tends to be up to 40%, with a significant difference between the thoracic and lumbar portions in terms of deformity incidence (Đorđević et al., 2016; Novaković et al., 2016), between 15 and 20% for the thoracic segment, and up to 20% for the lumbar segment. Studies to date have also demonstrated the existence of gender differences in terms of the incidence of postural disorders on the sagittal plane (Đokić, Mededović, & Smiljanić, 2011). In elementary-school children, deviations in the thoracic part of the sagittal plane are more frequently found among male subjects compared to female subjects, while the latter tend to exhibit a higher percentage of deviations in the lumbar portion of the spinal sagittal plane (Nikšić, Mahmutović, & Rašidagić, 2015; Vukićević, Čokorilo, Lukić, Miličković, & Bjelica, 2018).

The presence of postural disorders on the frontal plane of the spinal column has been found to be greater than 50% (Protić-Gava, Šćepanović, & Rakić, 2011; Stanojković, Vukmanović, Draganac, & Petronić-Marković, 2012; Stančev, 2012). The results of studies conducted using elementary-school age participants indicate a significantly higher percentage of postural disorders on the frontal plane compared to the sagittal plane of the spine (Vukićević et al., 2018). Moreover, further analyses have discovered gender differences, in favor of female subjects, in the incidence of deviation from normal posture on the frontal plane of the spine (Đokić et al., 2011).

The diagnostic methods used in studies to date include: the Napoleon Wolanski method (Protić-Gava et al., 2011; Protić-Gava, Šćepović, & Batez, 2013), the clinical method (Stanojković et al., 2012), inspection method (Petrović et al., 2012), somatometric and somatoscopic method (Đokić & Stojanović, 2010; Đokić et al., 2011), the bending test and Cobb method (Đonović, Milić, Kocić, & Radovanović, 2009), Spinal mouse (Jorgić et al., 2015a; Jorgić, Milenković, Milenković, Stanković, & Bujanj, 2015b). The diagnostic methods employed to date were all non-invasive and allowed a high degree of subjectivity during assessment.

Based on the studies conducted so far into the incidence of spinal postural disorders on the frontal and sagittal planes in pre-school and elementary-school children, it is not possible to discern with clarity the incidence of deviation from normal posture on the frontal and sagittal planes of the spine, nor any attendant gender differences, particularly

for first-year students. The seventh year of life, which coincides with elementary-school enrolment, is a crucial point during the juvenile period when development of postural disorders is concerned (Korovljev, Marinković, Roška, & Madić, 2015).

In accordance with the above mentioned, the aim of this study is to determine the state of postural disorders in the sagittal and frontal planes of the spinal column, as well as any gender differences in first-year elementary school students.

METHODS

The sample of participants

The sample of participants comprised first-year students of the elementary schools “Dimitrije Todorović Kaplar,” “Vuk Karadžić” and “Mladost,” all in the municipality of Knjaževac, Serbia. The total number of participants included in the study was 138 (height 127.93 ± 6.06 ; mass 27.09 ± 6.42 and Body Mass Index-BMI 16.64 ± 3.21), where 73 participants were male (height 127.96 ± 5.83 ; mass 27.49 ± 6.48 and BMI 16.49 ± 2.95) and 65 participants were female (height 127.91 ± 6.34 ; mass 27.94 ± 6.56 and BMI 16.80 ± 3.49).

The participants were tested during the months of April and May during the 2018/2019 academic school year. Consent for participation in the study was obtained from school principals and first-grade teachers at the above mentioned elementary schools, in the form of a confirmation of participation in the Interreg IPA project: “Development of diagnostic centers for postural and muscular-skeletal disorders in schoolchildren in Serbia and Bulgaria”.

Measures

The standardized anthropometric instrument (SECA model 284; SECA, Hamburg, Germany) was used in order to determine the descriptive parameters of the tested sample: body height, mass, BMI. This instrument is a cutting-edge anthropometric station, compliant with the most stringent criteria as determined by the International Society for the Advancement of Kinanthropometry-ISAK (Stewart, Marfell-Jones, & Olds, 2011). The measuring device (Formetric 4D System, Diers, Germany) was used for determining the postural status of the sagittal and frontal planes of the spine. Methodology in the diagnostics of postural status in children and adults is non-invasive (Betsch et al., 2011; Mangone, Raimondi & Paoloni, 2013; Đorđević, Vidojević, Đokić, Milenković, & Stanković, 2018). Diagnostics is performed using photometry, which in turn is based on the principle of triangulation. The reliability and validity of the instrument was established in earlier studies (Somoskeöy, Tunyogi-Csapó, Bogyó, & Illés, 2012; Lason, Peeters, Vandenbergh, Byttebier, & Comhaire, 2015). The device relies on the Cobb method to calculate the angle of the physiological curves of the spinal column in the frontal and sagittal planes.

In accordance with the reference values for normal posture, as well as for deviation from normal posture for the sagittal plane (Schröder, Stiller, & Mattes, 2011), the following variables were used: normal posture on the sagittal plane, kyphotic bad posture, flat back in the thoracic portion of the sagittal plane of the spine, lordotic bad posture, flat back in the lumbar portion of the sagittal plane of the spine, kypho-lordotic bad posture, flat back in the thoracic and lumbar segments of the sagittal plane, flat back in the

thoracic portion and lordotic bad posture in the lumbar portion of the spine, kyphotic bad posture and flat back in the lumbar portion.

The variables used for assessing the status of the spinal column on the frontal plane included: Normal spinal posture on the frontal plane, left thoracic scoliotic bad posture I degree, left thoracic scoliotic bad posture II degree, right thoracic scoliotic bad posture I degree, right thoracic scoliotic bad posture II degree, left lumbar scoliotic bad posture I degree, left lumbar scoliotic bad posture II degree, right lumbar scoliotic bad posture I degree, right lumbar scoliotic bad posture II degree, total left scoliotic bad posture I degree, total left scoliotic bad posture II degree, total right scoliotic bad posture I degree, total right scoliotic bad posture II degree, duplex scoliotic left thoracic and right lumbar posture I degree, duplex scoliotic left thoracic and right lumbar posture II degree, scoliosis duplex right thoracic and left lumbar posture I degree, scoliosis duplex right thoracic and left lumbar posture II degree. The rankings for determining variables were adopted from the study by Devedžić and associates (2016).

Statistical data analysis

Testing results were presented as means and standard deviation, as well as in the form of frequencies and percentages. The Chi-Squared Independence Test was used to determine any differences in the incidence of spinal deformity on the sagittal and frontal planes between male and female participants. Statistical analysis of the obtained results was conducted using the software SPSS version 20.

RESULTS

Table 1 Postural status in the sagittal plane

	Participants		
	Male and female (№/%)	Male (№/%)	Female (№/%)
Normal posture	36 / 26.1	20 / 27.4	16 / 24.6
Kyphotic bad posture	8 / 5.8	4 / 5.5	4 / 6.2
Flat back in the thoracic segment of the sagittal plane	31 / 22.5	18 / 24.7	13 / 20.0
Lordotic bad posture	16 / 11.6	4 / 5.5	12 / 18.5
Flat back in the lumbar segment of the sagittal plane	13 / 9.4	8 / 11.0	5 / 7.7
Kypho-lordotic bad posture	6 / 4.3	2 / 2.7	4 / 6.2
Flat back in thoracic and lumbar segments of the sagittal plane	25 / 18.1	16 / 21.9	9 / 13.8
Thoracic flat back and lordotic bad posture	3 / 2.2	1 / 1.4	2 / 3.1
Number of participants	138	73	65

Table 1 provides the basic descriptive statistics parameters on the incidence, presented in the form of numbers and percentages, of the spinal deformity on the sagittal plane in first-year elementary-school children from the municipality of Knjaževac. The data obtained regarding normal posture on the sagittal plane, for the total sample, are given as follows: normal posture was found in 36 participants, i.e., 26.1%, whereas deviations were found in 102 participants (73.9%). The data indicate a rather small deviation in terms of the percentages of normal posture for boys (27.4%) and girls (24.6%). In addition, a much greater incidence of abnormality of the physiological curve in the lumbar segment was found compared to the

thoracic segment: kyphotic bad posture accounted for 5.8% of the total sample, with 5.5% among the boys and 6.2% among the girls, whereas lordotic bad posture was present in 11.6% of the total sample, namely 5.5% among the male participants and 18.5% among the female participants. The disorder with the greatest incidence was an insufficiently developed physiological curve, found in 52.2% of the total sample, 59% among the male and 44.6% among the female participants.

Table 2 Postural status in the sagittal plane

	Participants		
	Male and female (No/%)	Male and female (No/%)	Male and female (No/%)
Normal spinal posture	22 / 15.9	11 / 15.1	11 / 16.9
Left thoracic scoliotic bad posture of the I degree	24 / 17.4	15 / 20.5	9 / 13.8
Left thoracic scoliotic bad posture of the II degree	2 / 1.4	2 / 2.7	
Right thoracic scoliotic bad posture I degree	24 / 17.4	15 / 20.5	9 / 13.8
Right thoracic scoliotic bad posture of the II degree	2 / 1.4	1 / 1.4	1 / 1.5
Left lumbar scoliotic bad posture I degree	5 / 3.6	3 / 4.1	2 / 3.1
Right lumbar scoliotic bad posture I degree	4 / 2.9	1 / 1.4	3 / 4.6
Total left scoliotic bad posture I degree	15 / 10.9	8 / 11.0	7 / 10.8
Total left scoliotic bad posture II degree	3 / 2.2	2 / 2.7	1 / 1.5
Total right scoliotic bad posture I degree	7 / 5.1	1 / 1.4	6 / 9.2
Total right scoliotic bad posture II degree	4 / 2.9	1 / 1.4	3 / 4.6
Duplex scoliotic left thoracic and right lumbar posture I degree	8 / 5.8	4 / 5.5	4 / 6.2
Duplex scoliotic left thoracic and right lumbar posture II degree	2 / 1.4	1 / 1.4	1 / 1.5
Duplex scoliotic right thoracic and left lumbar posture of the I degree	14 / 10.1	8 / 11.0	6 / 9.2
Duplex scoliotic right thoracic and left lumbar posture of the II degree	2 / 1.4		2 / 3.1
Number of participants	138	73	65

Table 2 presents results which refer to the frontal plane, with results presented in the form of numbers and percentages, as well. The data obtained regarding normal posture in the frontal plane, for the total sample, are given as follows: normal posture was found in 22 participants, or 15.9% of the total sample, while some form of deviation was found in 116 participants, or 84.1% of the total sample. The data indicate very small deviations between boys and girls regarding the percentage for normal posture, 15.1% and 16.9%, respectively. In addition, there is significantly greater incidence of abnormality of the physiological curve in the left and right thoracic portion, compared to: the right and left sides of the lumbar portion: scoliotic left thoracic bad posture (18.8%) and right thoracic bad posture (18.8%); left lumbar deviation (3.6%) and right lumbar deviation (2.9%), in the thoracic portion of the spinal column in male participants: left (23.2%), right (21.9%), and in the lumbar portion: left (4.1%) and right (1.4%); among the female participants: thoracic left (13.8%) and right (15.3%), and lumbar left (3.1%) and right (4.6%). The results also indicate a significantly greater number of deviations on the frontal plane which are of a functional first degree (73.2%), compared to the second degree (10.7%); in the boys, this percentage for the first degree of deformity was (75.4%), and (9.6%) for the second degree of deformity, whereas for the girls the percentage for the first degree of deformity was (70.7%) and (12.2%) for the second degree of deformity.

Table 3 Difference between the male and female participants in terms of the postural status

Difference between male and female participants in terms of postural status on the sagittal plane				
	Value	df	P	phi coefficient / degree of effect
Continuity Correction ^b	.031	1	.859	.032 (medium)
N of Valid Cases	138			
Difference between male and female participants in terms of postural status on the frontal plane				
Continuity Correction ^b	.004	1	.949	-.025 (low)
N of Valid Cases	138			

Table 3 presents the results obtained based on Yates' Correction for Continuity, which compensates for the overestimation of the value of the chi-squared test which is a consequence of the low number of dimensions. The tables indicate that there is no statistically significant difference ($\text{sig}=0.859$) between male and female participants in the study in terms of the incidence of postural disorders on the sagittal plane, expressed as a percentage. Additionally, no statistically significant difference ($\text{sig}=0.949$) was found between the genders regarding disorders on the frontal plane of the spine.

DISCUSSION

The results of this study indicate a deviation from normal posture on the sagittal and frontal planes in a high percentage. Deviation from normal posture on the sagittal plane, that is, postural disorders, were found in the thoracic and lumbar portion in a total of 73.9%, namely in 72.6% of the male participants and in 75.4% of the female participants. Earlier studies looking into a similarly aged, also juvenile, sample of participants, have reported high percentages of postural disorders of a functional type (Milenković, 2007; Dragić, Midić, & Midić, 2012; Protić-Gava et al., 2013; Jorgić et al., 2015b; Vukićević et al., 2018). More detailed analysis yields that, from the total percentage of postural disorders on the sagittal plane, the greatest percentage is accounted for by a lack of a physiological curve (50%) in the thoracic (22.5%), lumbar segments (9.4%) and thoracolumbar segments of the spine (18.1%), with very little difference between the genders (among the male participants in the thoracic (24.7%), lumbar (11%) and thoracolumbar segments (21.9%); among the female participants, it is in the thoracic (20%), lumbar (7.7%) and thoracolumbar portion of the spine (13.8%)). Furthermore, Table 1 indicates the percentage of postural disorders on the sagittal plane which accounts for an over-pronounced physiological curve in the thoracic portion and lumbar portion of the spine (23.9%). While the percentage of an over-pronounced physiological curve on the sagittal plane in relation to the gender of the participants is the following: for the male participants it is (5.5%) in the thoracic segment, (6.9%) in the lumbar and thoracolumbar segments (2.7%); and for the females it is (6.2%) in the thoracic segment and (21.6%) in the lumbar segment and thoracolumbar segments of the spine (6.2%). The results obtained in the present study are very similar to those obtained in earlier studies (Dragić et al., 2012; Protić-Gava et al., 2013; Vukićević et al., 2018).

Postural disorders located on the frontal plane indicate a high incidence percentage, with 84.9% among the male participants and 83.1% among the female participants, which is in accordance with the findings of earlier studies looking into the same age group (Vukićević et al., 2018). A more detailed analysis of the results obtained clearly indicates that a functional first degree constitutes the highest percentage, among the male participants

75.4% and among the female participants 70.7%, where changes have occurred strictly due to muscular imbalance (Živković, 2009; Jovović & Čanjak, 2011), whereas a functional second degree is found at a percentage of (10.9%), with (9.5%) among the male participants and (12.4%) among the female participants. Furthermore, an analysis of the results clearly indicates a higher concentration of partial disorders on the frontal plane (44.1%), primarily in the thoracic region (37.6%), compared to the lumbar region (6.5%), while total and duplex scoliotic bad posture is found in the percentage (39.8%). Earlier studies also indicate an approximately equal incidence, in terms of percentages, of postural disorders on the frontal plane in the same age group (Vukićević et al., 2018). Some of the causes of the emergence of such functional disorders on the frontal plane of the spine might lie in muscle imbalance due to long periods spent in an incorrect seated posture, carrying heavy schoolbags, a sedentary lifestyle, and ever-increasing hypokinesia encountered in this age group (Stanojčić et al., 2019).

An analysis of results regarding the incidence of postural disorders of the spinal column did not yield statistically significant differences between the male and female participants on the sagittal plane ($\text{sig}=0.859$), or on the frontal plane ($\text{sig}=0.949$); similarly, earlier studies (Protić-Gava, Krsmanović, Jevtić, Kadović, & Romanov, 2009; Protić-Gava, Krneta, Bošković, & Romanov, 2010; Protić-Gava et al., 2013; Vukićević et al., 2018) also found no differences in this developmental period, whereas at the start of adolescence there is a statistically significant difference. Results thus obtained may indicate that there are no gender differences in this respect, for this particular developmental period, as a result of similar habits and behaviors, as well as due to effects of the omnipresence of a contemporary sedentary lifestyle (Stanojčić et al., 2019). Also, this developmental period tends to be characterized by biological maturity following chronological age, which is not the case during the onset of adolescence, where we find statistically significant gender differences in terms of the incidence of postural disorders of the spine.

CONCLUSION

Based on the results obtained in the present study, there is an exceptionally high incidence of postural disorders of the spinal column. Also, in terms of the presence of deformities at this particular age of development, no difference between the genders was found, on the sagittal or on the frontal plane of the spine. It can be concluded that the first grade of elementary school is an important period for preventive action to be taken by professionals in the field of kinesitherapy and corrective gymnastics, both in the form of educating the parents, teachers and children, and in the form of specific measures, i.e., specific exercises aimed at prevention and correction, within the framework of physical education classes that are a part of the first-grade elementary school curriculum. Finally, preventive and corrective gymnastics programs can also form part of activities which can be provided by physical education teachers and physical therapists within the framework of fitness centers.

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UČESTALOST POSTURALNIH POREMEĆAJA KIČMENOG STUBA UČENIKA PRVOG RAZREDA OSNOVNE ŠKOLE

Cilj istraživanja bio je da se utvrdi zastupljenost i razlika prema polu u posturalnim poremećajima kičmenog stuba u sagitalnoj i frontalnoj ravni učenika prvog razreda osnovne škole. Uzorak ispitanika sačinjavalo je 138 učenika, tj., 73 ispitanika muškog pola i 65 ispitanika ženskog pola sa teritorije gradske opštine Knjaževac, Srbija. U proceni posturalnih poremećaja kičmenog stuba korišćen je merni instrument Formetric 4D System, Diers, Germany. Rezultati merenja predstavljeni frekvenciono i procentualno, dok je za utvrđivanje razlika u zastupljenosti deformiteta kičmenog stuba između ispitanika muškog i ženskog pola korišćen je Hi kvadrat test za testiranje nezavisnosti. Rezultati su ukazali da je u sagitalnoj ravni prisutnost deformiteta na ukupnom uzorku 73.9% (kod ispitanika muškog pola 72.6% i kod ispitanika ženskog pola 75.4%), dok je u frontalnoj ravni taj procenat generalno iznosio 84.1% (kod ispitanika muškog pola 84.9% i kod ispitanika ženskog pola 83.1%). Takođe, rezultati su ukazali da nisu uočene statistički značajne razlike u zastupljenosti posturalnih poremećaja između ispitanika muškog i ženskog pola u sagitalnoj ($\text{sig}=0.859$) i frontalnoj ravni kičmenog stuba ($\text{sig}=0.949$). U skladu sa dobijenim rezultatima može se zaključiti da je visok nivo zastupljenosti posturalnih poremećaja kičmenog stuba u frontalnoj i sagitalnoj ravni podjednako prisutan kod ispitanika oba pola.

Ključne reči: kifozna, lordozna, skoliozna, kifolordozna, ravna leđa, polne razlike