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Physiotherapy diagnosis of scoliosis in the population of school-age children

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Original article

Abstract

Objective: The aim of the study was to assess the prevalence of trunk asymmetry in school-aged children using the Bunnell scoliometer in the screening diagnosis of idiopathic scoliosis and to analyze the relationship between the occurrence of menstruation and the values of the angle of trunk rotation (ATR).

Material and methods: The study included 44 students (24 girls and 20 boys) from two primary schools. The ATR was measured according to the recommendations of the Committee of Rehabilitation during the Adams Test in three spinal sections (Th1–Th4, Th5–Th12, L1–L5) using the Bunnell scoliometer. The results were statistically analyzed with PQStat software version 1.8.6, with a significance level set at $p < 0.05$.

Results: Trunk asymmetry requiring further diagnostics was found in 18.18% of the children. Girls required additional assessment more frequently than boys (29.17% vs 5%; $p = 0.048$). No significant differences in ATR values were found between sexes, whereas non-menstruating girls had significantly higher ATR values in the thoracic region (5° vs 0.5°; $p = 0.02$).

Conclusions: Trunk asymmetry suggesting a risk of idiopathic scoliosis occurs in a considerable proportion of school-aged children, especially during the peripubertal period. Sexual maturation influences ATR values, indicating the need for regular screening. The Bunnell scoliometer is an effective tool for early detection of idiopathic scoliosis in school settings.

Approval of ethics committee

This study received ethical approval from the University of Applied Sciences in Tarnow (Poland) Bioethics Committee: Resolution No. 18/2024, June 12, 2024.

Keywords

- idiopathic scoliosis
- screening examination
- Bunnell scoliometer
- body posture
- scoliosis

Contribution

A – Preparation of the research project
B – Assembly of data
C – Conducting of statistical analysis
D – Interpretation of results
E – Manuscript preparation
F – Literature review
G – Revising the manuscript

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Conflict of interest

None declared.

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Introduction

Idiopathic scoliosis is one of the most common postural disorders observed among children and adolescents, particularly during periods of intensive growth and development. The prevalence of AIS in the general pediatric population is estimated at 2–4%, with a markedly higher risk of curve progression observed in girls, particularly during periods of rapid skeletal growth.[1,2]

Idiopathic scoliosis accounts for approximately 80% of all spinal deformities. It is defined as a three-dimensional spinal deformity characterized by flattening of the thoracic kyphosis and lumbar lordosis in the sagittal plane, lateral curvature of the spine in the frontal plane, and simultaneous vertebral rotation in the transverse plane.[3-5]

The etiology of idiopathic scoliosis remains complex and multifactorial. Among the potential risk factors, hormonal and neurogenic influences are frequently reported, as well as abnormal or pathological fetal positioning. Additionally, asymmetric loading of the body during the child's growth and development, as well as during the course of systemic diseases, may contribute to the development of the condition. Other important etiological factors include developmental abnormalities of the osseous, muscular, and ligamentous structures, as well as disturbances in the static and dynamic balance of the spine.[4,6]

Curves detected before or during the peak height velocity are considerably more likely to progress than those identified after skeletal maturation. Therefore, early recognition of spinal asymmetry remains one of the key objectives of school health programmes and preventive musculoskeletal care.[2]

Early detection of scoliosis enables timely observation or implementation of conservative treatment, reducing the likelihood of severe deformity requiring surgical intervention. Current SOSORT recommendations emphasize that conservative management is most effective when initiated before rapid curve progression occurs, highlighting the importance of standardized screening protocols during the pubertal growth spurt.[7]

Treatment of scoliosis begins at the time of diagnosis and is individually tailored depending on the type, severity, and location of the spinal curvature, as well as the patient's age. Two main approaches are distinguished: conservative and surgical treatment. In 8–9% of patients, bracing is necessary, while 0.1% require surgery involving spinal instrumentation and fusion.[1]

The primary aim of conservative management is to prevent the progression of the spinal curvature. Conservative treatment includes kinesiotherapy, physical therapy modalities, and the use of orthopaedic braces and corrective insoles. In curvatures <20°, postural correction and therapeutic exercises constitute the primary treatment method. For curvatures between 25° and 45° in patients who have not yet reached skeletal maturity, brace treatment is recommended.[8,9]

Physiotherapeutic assessment constitutes the foundation for treatment planning, enabling evaluation of the patient's functional status, identification of the underlying problem, and individualization of therapy. It is based on both subjective and objective (functional) examination.[10]

The objective examination is used to assess the deformity, including the localization and direction of spinal curvatures, evaluation of the magnitude of primary and secondary curves, as well as assessment of musculoskeletal function. The evaluation is performed under both static and dynamic conditions, including posture analysis during gait and the Adams forward bending test with measurement of trunk asymmetry, for example using a scoliometer.[11,12]

Measurement using a scoliometer is applied for the quantitative assessment of the angle of trunk rotation. The device enables measurement of the angle formed between the horizontal plane and the transverse plane of the patient's back. Scoliometer assessment is recommended, among others, by SOSORT (Society on Scoliosis Orthopaedic and Rehabilitation Treatment) as well as by the Committee of Rehabilitation, Physical Culture and Social Integration of the Polish Academy of Sciences. [13]

Aim of the study

The main aim of this study was to assess the prevalence of trunk asymmetry in school-aged children using the Bunnell scoliometer in the screening diagnosis of idiopathic scoliosis. The study also aimed to identify cases requiring re-examination or further diagnostic evaluation, as well as to assess the impact of menstruation in girls on trunk rotation (ATR) values obtained through scoliometric measurements. The examination of students was conducted in accordance with the guidelines of SOSORT (Society on Scoliosis Orthopaedic and Rehabilitation Treatment), ensuring a high level of standardization and compliance with international recommendations regarding the diagnosis and assessment of body posture in children.

Material and methodology

Sample

The study included 44 students from two primary schools, including 24 girls aged 11 years (52%) and 20 boys aged 13 years (48%).

All students and their parents or legal guardians were informed about the course and purpose of the study and provided written informed consent for the children's participation. Additionally, approval was obtained from the school principals as well as from the appropriate Bioethics Committee (Resolution No. 18/2024 of the Bioethics Committee of the University of Applied Sciences in Tarnow, Poland, dated 12 June 2024). Participation in the study was voluntary.

Inclusion criteria:

1. Age corresponding to the period of the growth spurt:
   - girls – completed 10 years of age (11 years old);
   - boys – completed 12 years of age (13 years old);
2. Written informed consent from a parent or legal guardian.
3. No medical contraindications to participation in the examination.[13]

Exclusion criteria:

1. Previously diagnosed medical conditions (e.g. congenital defects or cerebral palsy);
2. History of spinal surgery;
3. Lack of consent from a parent or legal guardian.[13]

Table 1. General characteristics of boys

Student	Maximum values of trunk rotation angle		
	Thoracic spine Th1–Th4 (°)	Thoracic spine Th5–Th12 (°)	Thoracolumber junction or L1–L5 (°)
1	3	4	5
2	0	2	1
3	0	3	2
4	1	3	2
5	0	1	0
6	1	2	3
7	0	0	1
8	2	6	4
9	1	2	2
10	0	3	2
11	1	4	3
12	2	4	2
13	0	2	0
14	4	9	5
15	0	0	1
16	1	2	3
17	3	5	4
18	0	0	1
19	1	3	2
20	2	6	5

Source: Authors' own elaboration.

Table 1. General characteristics of girls

Student	Menstruation	Maximum values of trunk rotation angle		
		Thoracic spine Th1–Th4 (°)	Thoracic spine Th5–Th12 (°)	Thoracolumber junction or L1–L5 (°)
1	No	6	9	4
2	No	0	2	1
3	No	4	7	5
4	No	1	4	3
5	No	1	3	2
6	No	2	5	3
7	Yes	2	3	1
8	No	1	2	0
9	No	5	12	6
10	No	2	4	2
11	Yes	0	1	2
12	No	1	0	2
13	No	3	8	6
14	No	2	4	6
15	No	0	2	1
16	No	3	7	4
17	No	2	6	5
18	Yes	0	0	0
19	No	0	2	0
20	Yes	0	0	2
21	No	4	6	3
22	No	5	8	4
23	No	4	7	3
24	No	0	3	*1*

Source: Authors' own elaboration.

Table 3. Number of study participants in each school

School	Boys		Girls		Total	
	n	%	n	%	n	%
Łomnica Zdrój	11	25	10	23	21	48
Piwniczna Zdrój	9	20	14	32	23	52
Total	**20**	**45**	**24**	**55**	**44**	**100**

Source: Authors' own elaboration.

Research methodology

The examinations were conducted in school settings, in specially prepared rooms that ensured appropriate privacy and comfort for the students, as well as stable conditions for performing the measurements.

The study was carried out in accordance with the recommendations of the Committee of Rehabilitation, Physical Culture and Social Integration of the Polish Academy of Sciences. The main component of the assessment was the measurement of the angle of trunk rotation using a Bunnell scoliometer. The evaluation of the angle of trunk rotation was performed in accordance with the established guidelines during the Adams forward bending test, which serves as a tool for the early detection of back asymmetry.

The starting position of the study participants during the assessment was a standing posture, with the feet placed parallel, aligned in one line, and positioned hip-width apart, with the knee joints fully extended. The upper limbs were positioned with the palmar surfaces of the hands joined together at shoulder level.

The test consisted of the participant performing a forward trunk bend, directing the fingers of the hands toward the midpoint between the feet. The examiner stood behind the participant, with their gaze positioned at the level of the evaluated spinal segment. During the assessment of the angle of trunk rotation, the depth of the forward bend was adjusted by the examiner in such a way that the examined spinal segment remained parallel to the floor (Figures 1–3).

The measurement of the angle of trunk rotation (ATR) was performed at the level of all spinous processes (Figure 4). During the examination, the highest ATR values were recorded from three spinal segments:

- upper thoracic segment: Th1–Th4 (proximal thoracic);
- main thoracic segment: Th5–Th12 (main thoracic);
- thoracolumbar or lumbar segment: (thoracolumbar, lumbar).[14]

Recommendations for further management:

- for angle of trunk rotation (ATR) values of 0–3°, follow-up examination within 3–6 months is not required;
- for ATR values of 4–6°, repeat assessment using a scoliometer is recommended after 3–6 months;
- for ATR values ≥7°, referral for further diagnostic evaluation is indicated, including radiological examination of the spine.[14]

Statistical analyses were performed using PQStat software version 1.8.6 (PQStat Software, Poznań, Poland). Qualitative variables were presented as absolute values and percentages, while quantitative variables were described using ranges, means and standard deviations (SD), or medians with interquartile ranges (IQR). The Shapiro–Wilk test was used to assess the distribution of variables in the analysed group of participants. Comparisons between groups were performed using the chi-square test, Fisher's exact test, Student's *t*-test, the Mann–Whitney *U* test.



Figure 1. Forward trunk bending – lateral view (photo by Authors)



Figure 2. Forward trunk bending – posterior view (photo by Authors)



Figure 3. Upper limb position in the final phase of the movement (photo by Authors)



Figure 4. Trunk rotation angle measurement (photo by Authors)

Results

Measurement of the angle of trunk rotation

Among the participants, 7 individuals (15.91%) had previously been diagnosed with or evaluated for scoliosis ($p = 0.55$). The median ATR in the Th1–Th4 segment was 1° (0–6; IQR = 2.25; $p = 0.98$), in the Th5–Th12 segment – 3° (0–12; IQR = 4; $p = 0.84$), and in the L1–L5 segment – 2° (0–6; IQR = 3; $p = 0.75$).

Additional follow-up examination was recommended for 12 participants (27.27%), while further diagnostic evaluation was indicated in 8 participants (18.18%) (Table 4).

Table 4. Angle of trunk rotation (ATR) measurements

Variable	Total	*p*
Previous scoliosis diagnosis N (%)	7 (15.91%)	0.55
ATR measurement Th1–Th4 Med (Q1; Q3) IQR	1 (0–6) IQR 2.25	0.98
ATR measurement Th5–Th12 Med (Q1; Q3) IQR	3 (0–12) IQR 4	0.84
ATR measurement L1–L5 Med (Q1; Q3) IQR	2 (0–6) IQR 3	0.75
Additional examination after 6 months N (%)	12 (27.27%)	1.00
Further examination N (%)	8 (18.18%)	0.70

Abbreviations: IQR – interquartile range; ATR – angle of trunk rotation; *p* – statistical significance (ATR measurement).

Source: Authors' own elaboration.

Influence of sex on the results of angle of trunk rotation measurements

The values of the angle of trunk rotation in the Th1–Th4, Th5–Th12, and L1–L5 segments did not differ significantly between girls and boys ($p = 0.17$; p = 0.21; $p = 0.53$, respectively). The need for further diagnostic evaluation occurred more frequently in girls than in boys (7 vs. 1; $p = 0.048$) (Table 5).

Table 5. Angle of trunk rotation (ATR) measurements by sex

Variable	Girls (n = 24)	Boys (n = 20)	*p*
ATR measurement Th1–Th4 Med (Q1; Q3) IQR	2 (0–6) IQR 3.5	1 (0–4) IQR 2	0.17
ATR measurement Th5–Th12 Med (Q1; Q3) IQR	3 (0–12) IQR 5	3 (0–9) IQR 2	0.21
ATR measurement L1–L5 Med (Q1; Q3) IQR	3 (0–6) IQR 3	2 (0–5) IQR 2	0.53
Additional examination after 6 months N (%)	5 (20.83%)	7 (35%)	0.39
Further examination N (%)	7 (29.17%)	1 (5%)	0.048

Abbreviations: IQR – interquartile range; ATR – angle of trunk rotation; *p* – statistical significance (ATR measurement).

Source: Authors' own elaboration.

In the next step, the influence of menarche on the results of the angle of trunk rotation measurements was analysed. Girls who had not yet experienced menarche showed higher ATR values in the Th5–Th12 segment compared with menstruating girls (5 vs. 0.5; $p = 0.02$). No significant differences between the groups were observed in the angle of trunk rotation values measured at the Th1–Th4 and L1–L5 levels (Table 6).

Table 6. Results of trunk rotation angle measurement depending on the occurrence of menstruation in girls

Variable	Postmenarcheal (n = 4)	Premenarcheal (n = 20)	*p*
ATR measurement Th1–Th4 Med (Q1; Q3) IQR	0 (0–2) IQR 0.5	2 (0–6) IQR 3	0.07
ATR measurement Th5–Th12 Med (Q1; Q3) IQR	0,5 (0–3) IQR 1.5	5 (0–12) IQR 4.5	0.02
ATR measurement L1–L5 Med (Q1; Q3) IQR	1,5 (0–2) IQR 1.25	3 (0–6) IQR 3	0.09
Additional examination after 6 months N (%)	0 (0%)	5 (26.32%)	0.54
Further examination N (%)	0 (0%)	7 (36.84%)	0.27

Abbreviations: IQR – interquartile range; ATR – angle of trunk rotation; *p* – statistical significance (ATR measurement).

Source: Authors' own elaboration.

Discussion

The results of the screening examinations conducted in the analysed group of students indicated that trunk asymmetry suggesting a risk of idiopathic scoliosis was present in 18.18% of the children. The obtained data are comparable to the results of studies conducted among children aged 8–12 years in Warsaw, where an ATR ≥ 7° was reported in 19.4% of the examined participants.[15]

Furthermore, it was found that the need for further diagnostic evaluation occurred significantly more often in girls (29.17%) than in boys (5%; $p = 0.048$). These findings are consistent with reports in the literature indicating a higher prevalence of idiopathic scoliosis in the female population, particularly during the peripubertal period. According to data presented by Negrini et al., for a Cobb angle of 10–20°, the female–to–male ratio is approximately 3:1, increasing to 5:1 for angles of 20–30°, and reaching 7:1 for curvatures exceeding 30°.[14]

The higher prevalence of trunk asymmetry among girls observed in the present study is also consistent with the findings reported by Grivas et al., who examined more than 2,000 children aged 5–18 years. Their study demonstrated not only a higher frequency of trunk asymmetry in girls but also confirmed that right-sided trunk asymmetry predominated in the examined population. Furthermore, the authors suggested that the sitting forward bending position more accurately reflects structural trunk asymmetry because it minimizes the influence of lower-limb length discrepancy on trunk rotation measurements.[16]

Recent epidemiological evidence further confirms the growing importance of systematic scoliosis screening. In one of the largest population-based studies published to date, involving nearly 1.8 million schoolchildren, Mei et al. demonstrated that girls and adolescents older than 15 years presented the highest prevalence of suspected scoliosis, while trunk rotation measured with a scoliometer remained one of the strongest indicators for referral to further diagnostic evaluation.[17]

Although most children identified during screening do not require immediate treatment, recognition of individuals at increased risk enables timely specialist evaluation before substantial curve progression occurs. This approach is consistent with the position of SOSORT and the Scoliosis Research Society, which indicate that screening programmes improve early case identification and facilitate initiation of conservative treatment at the most appropriate stage of skeletal growth.[1,7]

The analysis of the influence of menstruation showed that pre-menarcheal girls presented significantly higher ATR values in the thoracic segment (median 5°, IQR 4.5°) compared with post-menarcheal girls (median 0.5°, IQR 1.5°; $p = 0.02$). These findings highlight the importance of the timing of sexual maturation in the dynamics of scoliosis development, which is consistent with studies by Goldberg et al. and Kikanloo et al., indicating that the period of accelerated growth preceding menarche constitutes a critical stage for scoliosis progression.[18,19]

Czaprowski et al. emphasize that idiopathic scoliosis most commonly manifests during periods of rapid growth, particularly at the onset of puberty. The occurrence of menarche (12–13 years of age) is associated with a reduced risk of curve progression due to the deceleration of skeletal growth. The authors also indicate that the female sex is associated with a higher risk of both the occurrence and progression of scoliosis, which justifies the need for more frequent screening examinations in this group.[20]

Similar correlations were also demonstrated by Schiller et al., who emphasized that, in addition to the degree of curvature, one of the most important factors determining scoliosis progression is the degree of skeletal maturity. The authors note that girls reach peak height velocity approximately 18–24 months earlier than boys, which partially explains the higher incidence of scoliosis progression in the female population.[2]

The most common deformities occur in the thoracic region, followed by thoracolumbar and lumbar curvatures. In girls, thoracic curves predominate (more frequently right-sided), typically located at the Th7–Th12

level, whereas in boys thoracolumbar curves are observed more often, usually within the Th12–L4 range and predominantly left-sided. These findings are consistent with population-based studies involving more than 1.7 million students in China conducted by Mei et al. and Li et al., which demonstrated similar relationships regarding the localization and direction of spinal curvatures.[17,21]

Assessment of trunk asymmetry is a fundamental element of screening, as dorsal surface deformity often appears before radiographic changes. Grivas et al. demonstrated that ATR measurement represents the degree of rotational trunk deformity and may occur in children requiring use. The authors note that trunk asymmetry does not always equate to structural scoliosis, as the results may also be influenced by two biomechanical factors, such as lower limb length inequality or compensatory pelvic positioning. Therefore, several limitations of the study should be considered. The assessment of the angle of trunk rotation (ATR) using the Bunnell scoliometer is a screening method and does not replace radiographic evaluation, which remains the gold standard for the diagnosis of scoliosis. The obtained measurements may depend on the examiner's experience, accurate identification of the spinal segment, correct positioning of the scoliometer, and the participant's trunk flexion during the Adam's forward bend test. Furthermore, the cross-sectional design of the study precludes the assessment of spinal deformity progression over time. The sample size and participant selection may also limit the generalizability of the findings to the broader population. In addition, intra- and inter-rater reliability were not assessed, and the results may have been influenced by uncontrolled individual and environmental factors. The side of trunk rotation was not taken into account in the screening. Only the value of the trunk rotation angle (TRA) was analyzed, regardless of the direction of rotation.[1,16]

Despite these limitations, the applied methodology was consistent with current recommendations for school-based scoliosis screening. The Scoliosis Research Society International Task Force concluded that ATR measurement provides sufficient technical and clinical effectiveness for identifying children requiring further diagnostic evaluation and recommended referral thresholds between 5° and 7°, depending on the screening strategy. Many authors also agree that scoliosis screening should aim to identify suspected cases of scoliosis, which are then referred for diagnostic assessment to be confirmed or ruled out.[1]

The obtained results indicate that measuring the trunk rotation angle can be a practical tool to aid in qualifying children for further orthopedic diagnostics. Particular attention should be paid to premenarchal girls, as this is the period of greatest growth dynamics and the highest risk of progression of idiopathic scoliosis in accordance with the recommendations of SOSORT[14] and the Committee of Rehabilitation of the Polish Academy of Sciences.[13] In this context, the Bunnell scoliometer remains a practical and effective tool for assessing the angle of trunk rotation (ATR) in school-based screening settings.[13,14,20]

Conclusions

1. The results indicate that cases of trunk asymmetry suggesting an elevated risk of idiopathic scoliosis were identified among school-aged children, justifying the need for screening in this population.
2. The higher prevalence of trunk asymmetry in girls than in boys suggests that sex may be an important factor associated with the risk of developing idiopathic scoliosis during periods of rapid growth.
3. Higher trunk rotation angle (ATR) values in premenarcheal girls suggest that an earlier stage of biological maturation may be associated with greater susceptibility to spinal deformities, highlighting the importance of considering biological age during postural assessment.
4. The use of the Bunnell scoliometer enabled the identification of children requiring further diagnostic evaluation, confirming its usefulness as a screening tool for idiopathic scoliosis.
5. The findings indicate the need for regular postural screening in children, particularly during puberty, when the risk of scoliosis progression is greatest.

References

[1] Labelle H, Richards SB, De Kleuver M, et al. Screening for adolescent idiopathic scoliosis: An information statement by the scoliosis research society international task force. *Scoliosis*. 2013;8:17. doi: 10.1186/1748-7161-8-17.

[2] Schiller JR, Thakur NA, Eberson CP. Brace management in adolescent idiopathic scoliosis. *Clin Orthop Relat Res*. 2010;468(3):670-678. doi: 10.1007/s11999-009-0884-9.

[3] Lehnert-Schroth C, Gröbl P. *Trójpłaszczyznowa terapia skolioz. Oddechowo-ortopedyczny system według Schroth*. Wrocław: Edra Urban & Partner; 2017.

[4] Rychter P, Paprocki M, Wilczyński I, Wilczyńska K, Wilczyński J. [Assessment of the progress of the therapy by the FED in patients with scoliosis idiopathic]. *J Educ Health Sport*. 2017;7(3):177-191.

[5] Trzcińska S, Myśliwiec A, Koszela K, Żurawski A. *Nowoczesna diagnostyka skolioz*. Warszawa: PZWL; 2022.
[6] Wilczyński J. *Korekcja wad postawy człowieka*. Starachowice: Anthropos; 2005.
[7] Grivas TB, Wade MH, Negrini S, et al. SOSORT consensus paper: School screening for scoliosis. Where are we today? *Scoliosis*. 2007;2:17. doi: 10.1186/1748-7161-2-17.
[8] Czaprowski D, Kotwicki T, Durmała J, Stoliński Ł. Physiotherapy in the treatment of idiopathic scoliosis – current recommendations based on SOSORT 2011. *Postępy Rehabil*. 2014;28(1):23-29. doi: 10.2478/rehab-2014-0030.
[9] Kasperczyk T. *Wady postawy ciała. Diagnostyka i leczenie*. Kraków: Kasper; 2001.
[10] Elias-Jones C, Perry M. *Ortopedia i reumatologia*. 3rd ed. Wrocław: Edra Urban & Partner; 2018.
[11] Buckup K, Buckup J. *Testy kliniczne w badaniu kości, stawów i mięśni*. Warszawa: PZWL; 2014.
[12] Jędra B, Kiwerski J, Sikorska A, Korabiewska I. Wpływ asymetrii miednicy na symetrię tułowia u dzieci. *Ortop Traumatol Rehabil*. 2022;24:181-191. doi: 10.5604/01.3001.0015.9056.
[13] Czaprowski D, Tyrakowski M, Dembińska A, et al. Zasady prowadzenia badań przesiewowych w kierunku wczesnego wykrywania skoliozy idiopatycznej – rekomendacje Komitetu Rehabilitacji, Kultury Fizycznej i Integracji Społecznej Polskiej Akademii Nauk. *Praktyczna Fizjoterapia & Rehabilitacja*. 2021;(128):18-26.
[14] Negrini S, Donzelli S, Aulisa AG, et al. 2016 SOSORT guidelines: Orthopaedic and rehabilitation treatment of idiopathic scoliosis during growth. *Scoliosis Spinal Disord*. 2018;13:3. doi: 10.1186/s13013-017-0145-8.
[15] Żuk B, Tołłoczko K, Lewandowska M, Sobol M. Wartości kątów rotacji tułowia w dwóch pozycjach ciała. *Med Og Nauk Zdr*. 2022;28(2):184-189. doi: 10.26444/monz/147618.
[16] Grivas TB, Vasiliadis ES, Koufopoulos G, Segos D, Triantafyllopoulos G, Mouzakis V. Study of trunk asymmetry in normal children and adolescents. *Scoliosis*. 2006;1:19. doi: 10.1186/1748-7161-1-19.
[17] Mei Y, Lin YF, Gong Z, Yan B, Liang Q. Prevalence of incorrect posture among school adolescents after the COVID-19 pandemic: A large population-based scoliosis screening in China. *J Orthop Surg Res*. 2025;20(1):156. doi: 10.1186/s13018-025-05479-8.
[18] Goldberg CJ, Moore DP, Fogarty EE, Dowling FE. Adolescent idiopathic scoliosis: Natural history and prognosis. *Stud Health Technol Inform*. 2002;91:59-63.
[19] Kikanloo SR, Tarpada SP, Cho W. Etiology of adolescent idiopathic scoliosis: a literature review. *Asian Spine J*. 2019;13(3):519-526. doi: 10.31616/asj.2018.0096.
[20] Czaprowski D, et al. Principles of screening for early detection of idiopathic scoliosis – recommendations of the Polish Academy of Sciences. *Chir Narzadow Ruchu Ortop Pol*. 2021;86(4):97-105. doi: 10.31139/chnriop.2021.86.4.1.
[21] Li M, Nie Q, Liu J, Jiang Z. Prevalence of scoliosis in children and adolescents: A systematic review and meta-analysis. *Front Pediatr*. 2024;12:1399049. doi: 10.3389/fped.2024.1399049.