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THE IMPORTANCE OF MODERN NON-INVASIVE METHODS FOR ASSESSING STUDENTS' POSTURAL DEFICIENCIES

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Abstract: *Due to the daily habits young people's posture is a challenge. The aim of this observational study is to present Spinal Mouse device posture assessment in 20 students (average age 18,05 yrs, 20 boys) who exhibit variations in habits due to the use of electronic devices. A structured questionnaire highlights screen time as a key factor in technology-related spinal risk for spine diseases. The results show us that the main value in the region is around 0° and indicate that both vertebral bodies of a sector have practically not moved from one posture to the next. These methods used in prevention help to design correction programs, contributing to the improvement of young people's spinal health.*

Key words: *non-invasive assessment, postural deficiencies, spine, screen time.*

1. Introduction

Postural alignment in childhood and adolescence can be considered one of the most significant concerns for parents, with particular attention given to the spine. Altered postural alignments can be classified as structural and non-structural misalignments, even though the postural appearance of these disturbances may be

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similar [6]. Structural misalignment indicates the presence of morphological abnormalities in the bones and soft tissues. In contrast, non-structural misalignment does not reveal any bone pathology but is characterized by a non-anatomical alignment of the spine, with a moderate to good degree of self-correction [4]. Both types of misalignments, structural and non-structural, can affect the sagittal balance of the spine [1], [11], [13]. Posture investigation procedures can be widely used, for example, through posturography, to analyze the effect of certain interferences on postural control [7], [15], [16]; or they can be analytical and descriptive, such as photogrammetric analysis of the spine, focusing on evaluating sagittal balance using non-radiographic methods as an example [3].

Given the impact of this condition on the future development of young individuals, early identification of kyphoscoliosis, periodic evaluation, and the implementation of age-appropriate preventive programs become imperative in reducing incidence and preventing associated complications. Clinically, this condition leads to significant structural changes, potentially affecting posture, respiratory function, and the patient's quality of life. Clinical symptoms vary depending on the degree and location of spinal curvatures and may include pain, restricted mobility, and pulmonary functional disorders. The clinical evaluation of kyphoscoliosis involves specific and multidimensional methods, including detailed physical examination, standard radiography to measure the Cobb angle, postural assessment, and pulmonary function tests. Using EOS imaging technology [5], Le Huec and Hasegawa [10] define the value of T1–T4 kyphosis in an asymptomatic population, this segment accounts for between 8° and 10° of the total thoracic kyphosis.

Regular monitoring is very important, in addition to early diagnosis and treatment [2], [8], [12] in all spine deformities, especially for young subjects.

2. Materials and Methods

The purpose of this observational study consists in a postural analysis by evaluating the static alignment of the spine functionality. The main objective is the clinical and functional assessment of young individuals aged 16–20, with the aim of identifying postural deficiencies of the kyphoscoliotic type.

The study was conducted between October 2024 and February 2025, involving 20 male healthy adolescents aged between 16 and 20 years (mean age: 18.05 years), with an average height of 174.40 cm, average weight of 67.25 kg, and an average body mass index (BMI) of 21.91. All participants were high school students from urban area. The study was initiated after obtaining approval from the Ethics Committee of FEFS Craiova, as well as informed consent from the participants or their legal guardians. The research was carried out in compliance with data protection regulations in accordance with GDPR and the provisions of the Declaration of Helsinki (2013 version). Participant selection was based on inclusion and exclusion criteria, as follows:

2.1. Inclusion criteria:

- Male gender.
- Postural deficiencies classified as grade I, considered poor postural habits.
- Engaged in daily physical activity.

2.2. Exclusion criteria:

- Structural postural deficiencies.
- Participants with a history of rehabilitation programs.
- Neurological disorders or locomotor system conditions.

The assessment was carried out in a suitable, relaxing environment with thermal comfort and included: clinical evaluation, assessment of the subjects' physical behavior, and evaluation of spinal alignment using the Spinal Mouse device. The device determines precise measurements of spinal curvatures in both the sagittal and frontal planes. This included quantification of the total thoracic and lumbar angles to identify and classify significant postural changes. Subsequently, the obtained results were statistically analysed — both descriptively and inferentially — aiming to highlight the particularities of the condition that led to the proposed therapeutic intervention directions specific to this age group.

a) Clinical evaluation was performed through somatoscopy to assess body alignment, focusing on shoulder alignment, scapular positioning in relation to the spine and rib cage, pelvic line alignment, paravertebral muscle balance, and lower limb positioning.
b) Behavioral evaluation was carried out using a 13-question questionnaire that allowed the subjects to provide various details about their perception of body posture and daily habits that may influence postural and musculoskeletal health. Each question was scored individually.
c) Evaluation of spinal alignment using the Spinal Mouse device.

The spinal alignment assessment with the Spinal Mouse was carried out after each subject received a full explanation of the examination and the tasks it involved, as this type of evaluation requires a high level of attention from both the evaluator and the subject.

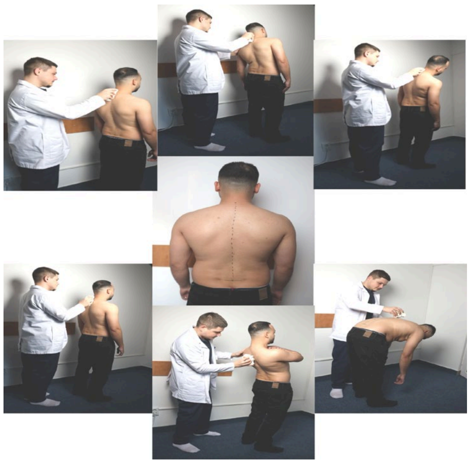

Fig. 1. *The spine evaluation*

The evaluation was performed in a standing (orthostatic) position, following the standard procedure recommended for this device, but adapted to a custom protocol developed by our team. (figure 1) The assessment was conducted in both the frontal plane and the sagittal plane.

3. Results

a. **Clinical evaluation** showed that all subjects presented with grade I kyphoscoliosis, which is corrected through movement. Seven subjects exhibited a lowered right shoulder, while the remaining thirteen subjects showed forward projection of the left shoulder. Clinically, all subjects presented with kyphoscoliosis accompanied by an S-shaped thoraco-lumbar scoliosis.

b. **Behavioral evaluation** was carried out using a 13-question questionnaire (Table 1).

Behavioral evaluation Table 1

No.	Question	Observations and results
1.	How much time do you spend sitting each day? (except classes)	45% spend between 4 and 6 hours sitting each day. 25% spend either more than 6 hours or between 2 and 4 hours a day in this position. 5% spend less than 2 hours sitting daily.
2.	How much time do you spend standing each day?	40% spend between 3 and 6 hours standing each day. 25% report spending more than 6 hours a day on their feet. 25% spend between 1 and 3 hours standing daily. 10% spend less than one hour a day in this position.
3.	How do you feel when standing for long periods of time?	55% report frequently experiencing pain or muscle fatigue when standing for extended periods. 30% say they sometimes feel tension in their back or neck area. 15% state that they feel comfortable and experience no discomfort under these conditions.
4.	How is your body weight distributed when you are standing?	50% of respondents say they distribute their body weight evenly. 40% place more weight on one leg. 10% lean back or stand on their toes.
5.	Do you notice your shoulders slouching forward or your back being curved?	55% say they sometimes notice adopting a hunched posture. 35% claim their posture is upright, without frequently noticing issues with their shoulders or back. 10% admit to often having slouched shoulders and a curved back.
6.	What is your usual sitting posture?	50% say they tend to lean forward with a slightly curved back, a posture recognized as ergonomically poor. 35% of respondents choose a relaxed or exaggerated position, leaning back against the chair. 15% report adopting a correct posture, with a straight back properly supported by the backrest.
7.	How often do you sit with your legs crossed?	65% say they occasionally sit with their legs crossed. 30% report frequently adopting this position. 5% state that they never sit with their legs crossed.
8.	Do you experience back or neck pain after sitting for long periods?	50% report occasional back or neck pain, which disappears quickly. 30% say they experience this pain very often. 20% state that they never have back or neck pain after sitting for extended periods.
9.	How do you maintain your posture while walking?	65% say they walk with slightly hunched shoulders, indicating poor posture. 20% adopt a correct posture, with a straight back and relaxed shoulders. 15% mention having clearly incorrect posture, often walking hunched over with a curved back.
10.	Do you tend to look down when walking?	70% say they occasionally tend to look down while walking. 15% report frequently looking down while walking. 15% state that they look straight ahead and do not adopt this posture.

No.	Question	Observations and results
11.	How do you usually lift a heavy object?	50% state that they use an incorrect technique, bending their back without bending their knees when lifting heavy objects. 35% apply the correct technique (bending the knees and keeping the back straight). 15% say they are not aware of the posture they adopt in such situations.
12.	Do you use an ergonomic desk or a supportive chair?	65% say they do not use ergonomic furniture at all. 25% occasionally use an ergonomic desk or chair. 10% regularly use an ergonomic desk or special support chair.
13.	How often do you correct your posture during the day?	70% say they occasionally realize they need to correct their posture and take action accordingly. Equal percentages (15% each) say either "I'm always mindful of my posture" or "I almost never think about my posture.

The Spinal Mouse assessment included the measurement of the following parameters: *total angle of the thoracic spine (ThSp)* and *total angle of the lumbar spine (LSp)*. Evaluating these angles allowed for the quantification of segmental posture in the thoracic and lumbar regions. It is shown that two-thirds of lumbar lordosis is located at the last two lumbar levels, as reported by Jackson [9] and confirmed by Roussouly and Pinheiro-Franco [14].

To assess mobility, the thoracolumbar and lumbosacral regions were analyzed. It is important to note that thoracic vertebra T1 was used as a reference point for evaluating mobility in all the previously mentioned situations.

The data recorded using the Spinal Mouse device was statistically processed as presented in tables 2 and 3a and 3b.

c) Spinal evaluation using the Spinal Mouse device descriptive statistical analysis

Segmental mobility of the thoracic and lumbar regions, relative to the thoracic vertebra T12, is presented in Table 2 for all evaluated subjects.

Intervertebral and lumbosacral mobility in the sagittal plane (flexion – SF, extension – SE) and in the frontal plane (right inclination - FRI, left inclination - FLI) are presented in Tables 3a and 3b as average values.

In the statistical analysis, we focused on two regions considered important for mobility and, more specifically, for evaluating potential spinal stiffness caused by postural imbalances: the Th12–L1 area and the L5–S1 area.

Table 2

Regional mobility - thoracic and lumbar values

Patient ID	S. Flexie-ThSp fixed at Th12	S. Extensie-ThSp fixed at Th12	F.Left-ThSp fixed at Th12	F. Right-ThSp fixed at Th12	S.Flexie-LSp fixed at Th12	S.Extensie-LSp fixed at Th12	F.Left-LSp fixed at Th12	F.Right-LSp fixed at Th12
Patient 1	59	39	-4	32	28	-51	-18	9
Patient 2	49	34	8	21	29	-50	-27	16
Patient 3	66	44	3	33	20	-50	-12	20
Patient 4	61	35	0	46	49	-2	-12	1
Patient 5	57	19	-8	21	41	-55	-34	15
Patient 6	67	40	8	13	36	-32	-17	30
Patient 7	64	32	-9	19	25	-40	-14	11
Patient 8	36	17	-16	9	41	-32	-10	17
Patient 9	74	31	0	27	30	-37	-9	12
Patient 10	56	31	-3	29	40	-36	-17	7
Patient 11	54	23	-15	44	37	-20	-16	13
Patient 12	64	48	4	21	17	-6	-9	8
Patient 13	51	43	-6	31	53	-45	-15	15
Patient 14	46	36	-4	20	22	-23	-14	17
Patient 15	51	56	8	20	35	-30	-12	21
Patient 16	77	42	-3	21	19	-35	-9	19
Patient 17	63	24	-14	12	47	-40	-26	21
Patient 18	43	27	-8	29	41	-31	-13	10
Patient 19	42	12	-4	20	29	-36	-18	20
Patient 20	56	27	-4	25	47	-45	-19	13
Minimum	36	12	-16	9	17	-55	-34	1
Maximum	77	56	8	46	53	-2	-9	30
Mean	57	33	-3.35	24.65	34	-35	-16.05	14.75
Standard deviation	10.65	11.03	7.24	9.54	10.65	13.99	6.54	6.38

Intervertebral and lumbosacral mobility in the sagittal plane (flexion – SF, extension – SE) and in the frontal plane (right inclination - FRI, left inclination - FLI) are presented in Tables 3a and 3b as average values.

In the statistical analysis, we focused on two regions considered important for mobility and, more specifically, for evaluating potential spinal stiffness caused by postural imbalances: the Th12–L1 area and the L5–S1 area.

Table 3a

Average values of thoracolumbosacral intervertebral mobility in the sagittal and frontal planes (Th1–Th10)

	Spine Segment								
Mobility	**Th1/2**	**Th2/3**	**Th3/4**	**Th4/5**	**Th5/6**	**Th6/7**	**Th7/8**	**Th8/9**	**Th9/10**
Mean values SF	3.65	3.8	3.15	2.6	2.85	3.3	2.85	2.25	1.65
Mean values SE	4.1	3.3	3.3	2.75	4.3	3.8	3.9	3.25	4.45
Mean values FS	5.35	4.7	4.9	5.25	4.95	5.35	5.55	5	4.2
Mean values FD	4.2	3.8	4.45	4.05	4.35	4.3	4.5	4.95	3.85

Table 3b

Average values of thoracolumbosacral intervertebral mobility in the sagittal and frontal planes (Th10–Lumbosacral region)

	Spine Segment								
Mobility	**Th10/ 11**	**Th11/ 12**	**Th12/ L1**	**L1/2**	**L2/3**	**L3/4**	**L4/5**	**L5/S1**	**Sac/ Hip**
Mean values SF	2.75	2.35	3.7	3.1	3.3	2.55	2.55	2.25	46.4
Mean values SE	3.85	3.65	3.6	2.75	2.75	2.9	3.45	2.5	5.1
Mean values FS	5.15	5.05	4	5	4.1	3.55	3.4	4.2	4.85
Mean values FD	4.25	3.75	4.25	3.75	3.25	3.5	4.4	5.45	3.85

The results after inferential statistical processing (t Test) of Spinal Mouse mobility values, compared to the neutral position of the spine values, indicate the following for the analysis subjects:

For the segment T12 - L1:

In the sagittal plane (flexion and extension): there is no marked mobility (statistically significant, p=0.89, tobs=0.141, df19),

In the frontal plane (left-right tilt): there is no marked mobilit. (statistically significant, p=0.69, tobs=-0.401, df19).

For the segment L5 -S1:

In the sagittal plane (flexion and extension): there is no marked mobility (statistically significant, p=0.714, tobs=-0.372, df19).

In the frontal plane (left-right tilt): there is significant mobility. (statistically significant, p=0.004, tobs=-3.32, df19).

In conclusion, the mobility of the spine is limited in the sagittal plane at both the T12-L1 and L5-S1 vertebrae. However, there is significant mobility in the frontal plane only at the L5-S1 vertebrae.

4. Discussions

These statistical analyses reveal a marked musculoskeletal rigidity in the thoracolumbar region across both planes, as well as in the lumbosacral region in the sagittal plane. This suggests the development of a possible kyphoscoliotic pattern with a tendency toward structurization if no therapeutic intervention is applied. But the Spinal mouse values should be always analyzed in the posture behavior context.

The data clearly indicates a predominance of sedentary behavior, by a significant percentage (~~45% + 25% =~~ 70%) of respondents spend more than 4 hours a day in a seated position. In contrast, the very small percentage (5%) of those who sit for less than two hours daily suggests a physically active minority or individuals with a lifestyle that involves frequent physical activity, which is encouraging from a general health perspective.

These results suggest that most respondents spend a significant portion of the day in standing (orthostatic) posture, possibly due to professional activities requiring prolonged standing. On the other hand, the low percentage (10%) of those who spend less than one hour per day standing indicates that this position plays an important role in the daily routine of most respondents.

Findings indicate that a vast majority of respondents (85%) experience discomfort or health issues when standing for extended periods, pointing toward a trend of posture-related problems, especially muscle fatigue or pain. This may reflect either a lack of adequate physical conditioning or poor ergonomic conditions at work or at home.

The fact that half of the respondents predominantly put on weight on one leg suggests an imbalanced posture, which could have long-term negative consequences for musculoskeletal health. In contrast, only a quarter of respondents distribute their body weight evenly—a sign of either low awareness or insufficient ergonomic training regarding the benefits of maintaining a correct stance.

Results show that a significant majority (55%) are periodically aware of adopting an incorrect posture, particularly slouched shoulders and curved back. The 35% who believe their posture is correct may either have a good awareness of their body alignment or may underestimate existing issues—highlighting the potential need for further objective evaluation.

The data show that a considerable majority (85%) adopt poor sitting postures during sedentary activities. Half of the respondents prefer sitting leaned forward with a curved back, a position that poses significant risks for spinal conditions such as kyphosis, chronic lower back pain, or constant muscle tension. Meanwhile, the 35% who choose an overly relaxed posture, though seemingly comfortable—may be indirectly contributing to postural problems by reducing muscle tone and overstressing spinal structures.

The fact that only 15% of respondents maintain a recommended (straight, ergonomic) sitting posture highlights a widespread lack of awareness or discipline regarding the importance of healthy posture during sedentary tasks.

Results also show that a very high percentage (95%) of respondents sit with their legs crossed either occasionally or frequently, indicating a common habit that, while perceived as comfortable in the short term, may have negative long-term implications for posture and musculoskeletal health.

Most respondents (80%) experience at least occasional back or neck pain after long periods of sitting, suggesting that prolonged sitting has a clearly negative impact on their musculoskeletal health. A notably high percentage (30%) report frequent pain, indicating a significant prevalence of postural problems that could negatively affect quality of life and long-term health.

5. Conclusions

The present study allows for the development of discussions regarding the existence of certain behavioral patterns in the way the evaluated subjects approach posture. These discussions are supported by the numerical data collected through the questionnaire and validated by the objective findings obtained using the Spinal Mouse assessment tool.

These statistical analyses reveal a marked musculoskeletal rigidity in the thoracolumbar region across both planes, as well as in the lumbosacral region in the sagittal plane. This suggests the development of a possible kyphoscoliotic pattern with a tendency toward structurization if no therapeutic intervention and awareness programs of risk factors to be avoided are applied.

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