

Evaluation of the prevalence of sagittal plane changes in the spine of elementary students in the city of Ceres, Brazil

Avaliação da prevalência de alterações no plano sagital na coluna de estudantes da cidade de Ceres, Brasil

Evaluación de la prevalencia de cambios de plano sagital en la columna de estudiantes de primaria de la ciudad de Ceres, Brasil

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Abstract

Background: Adolescence is the period when postural changes occur, as it is a phase when the body develops and grows. It is also the most appropriate time to evaluate and detect postural problems, and preventive measures may help to avoid these possible changes. However, studies evaluating the postural changes in this age group are lacking. **Objective:** The objective of this study was to evaluate thoracic kyphosis and lumbar lordosis changes in the spine of 9th grade students at a state military school in Goiás, Brazil. **Methods:** A total of 113 students (54 boys and 59 girls) participated in the study. A radiation-free three-dimensional scanning system was used to evaluate the students' spine. The equipment emits a light on the participants' back and uses its topography to automatically calculate asymmetries. **Results:** The prevalence of increased thoracic kyphosis was 14%, increased lumbar lordosis 2% and 72% straightening of the curvature of the lumbar lordosis. Thoracic kyphosis was reported by 9% of male students and 19% of female students. Students of both sexes had increased lumbar lordosis (2%). Females had a higher prevalence of rectified lumbar lordosis (59%) than males (11%). **Conclusion:** The prevalence of postural changes, especially lumbar lordosis, was very high in the elementary students.

Keywords: Evaluation; Posture; Spine; Elementary school; Students.

Resumo

Introdução: A adolescência é o período em que ocorrem as mudanças posturais, pois é uma fase em que o corpo se desenvolve e cresce. É também o momento mais adequado para avaliar e detectar problemas posturais, e medidas preventivas podem ajudar a evitar essas possíveis alterações. No entanto, faltam estudos que avaliem as mudanças posturais nessa faixa etária. **Objetivo:** O objetivo deste estudo foi avaliar as alterações da cifose torácica e da lordose lombar na coluna vertebral de alunos do 9º ano de uma escola militar estadual de Goiás, Brasil. **Métodos:** Participaram do estudo 113 alunos (54 meninos e 59 meninas). Um sistema de varredura tridimensional sem radiação foi usado para avaliar a coluna vertebral dos alunos. O equipamento emite uma luz nas costas dos participantes e usa sua topografia para calcular automaticamente as assimetrias. **Resultados:** A prevalência de aumento da cifose torácica foi de 14%, aumento da lordose lombar 2% e de endireitamento da curvatura da lordose lombar 72%. A alteração da cifose torácica foi relatada por 9% dos estudantes do sexo masculino e 19% do sexo feminino. Os estudantes de ambos os sexos apresentaram lordose lombar aumentada (2%). O sexo feminino apresentou maior prevalência para

lordose lombar retificada (59%) do que o sexo masculino (11%). Conclusão: A prevalência de alterações posturais, principalmente lordose lombar, foi muito elevada nos alunos do ensino fundamental.

Palavras-chave: Avaliação; Postura; Coluna; Escola primária; Alunos.

Resumen

Antecedentes: la adolescencia es el período en el que ocurren los cambios posturales, ya que es una fase en la que el cuerpo se desarrolla y crece. También es el momento más adecuado para evaluar y detectar problemas posturales, y las medidas preventivas pueden ayudar a evitar estos posibles cambios. Sin embargo, faltan estudios que evalúen los cambios posturales en este grupo de edad. Objetivo: El objetivo de este estudio fue evaluar los cambios en la cifosis torácica y la lordosis lumbar en la columna de estudiantes de noveno grado de una escuela militar estatal en Goiás, Brasil. Métodos: Participaron en el estudio un total de 113 estudiantes (54 niños y 59 niñas). Se utilizó un sistema de exploración tridimensional sin radiación para evaluar la columna vertebral de los estudiantes. El equipo emite una luz en la espalda de los participantes y utiliza su topografía para calcular automáticamente las asimetrías. Resultados: La prevalencia de aumento de la cifosis torácica fue del 14%, aumento de la lordosis lumbar del 2% y enderezamiento de la curvatura de la lordosis lumbar del 72%. La cifosis torácica fue informada por el 9% de los estudiantes varones y el 19% de las estudiantes mujeres. Los estudiantes de ambos sexos presentaron un aumento de la lordosis lumbar (2%). Las mujeres tuvieron una mayor prevalencia de lordosis lumbar rectificadas (59%) que los hombres (11%). Conclusión: La prevalencia de cambios posturales, especialmente lordosis lumbar, fue muy alta en los estudiantes de primaria.

Palabras clave: Evaluación; Postura; Columna vertebral; Escuela primaria; Estudiantes.

1. Introduction

Nowadays, a large number of adolescents suffer from early postural changes, generating great concern. These health problems are caused by several factors, including psychological, congenital, and traumatic factors or acquired habits (da Rosa et al., 2016). Students have inadequate posture in everyday life due to shyness, puberty, physical inactivity, and incorrect use of school bags. Thus, the school environment becomes conducive to such behavior (da Rosa et al., 2016; Maekawa et al., 2021; Noll, Candotti, et al., 2017).

Daily activities greatly affect the physical health of young people, causing changes and discomfort. In addition, postural problems can cause respiratory and circulatory dysfunction, and affect physical and psychological development (Maekawa et al., 2021). The asymmetrical use of heavy backpacks (Noll et al., 2019), long periods of sitting in an improper position, inadequate posture for sleeping (Noll, Candotti, et al., 2017), use of inappropriate furniture, watching television for a long time (Noll et al., 2019), and performance of different daily life activities (DLA) with improper posture are related to the onset of musculoskeletal symptoms (Junior et al., 2015). Proper posture is defined as spinal alignment that reduces stress on tendons, ligaments, and muscles. Inadequate posture, on the other hand, is defined as remaining incorrectly positioned for long periods of time, causing musculoskeletal injuries and changes (Guadagnin & Matheus, 2012). This inadequate habit acquired by most students can lead to an increased curvature of the thoracic kyphosis, causing hyperkyphosis (Barbieri et al., 2014). This change is one of the most frequent postural problems in adolescents.

There are few studies on this subject (Noll, Candotti, et al., 2017). The evaluation of postural changes in students is of paramount importance, as it provides the opportunity to diagnose and prevent possible permanent spinal injury (Iunes et al., 2005). Adolescence is the most common period for the onset of postural changes, because it is a phase when the body develops and grows. For this reason, it is the most appropriate time to evaluate and detect such problems, and preventive measures may be implemented to avoid possible changes (Lemos et al., 2012).

Radiological examinations are commonly used to evaluate the spine; however, they are not recommended due to high costs and patient exposure to radiation. Radiation exposure can cause serious health damages if the patient needs to undergo frequent examinations (Teixeira & Carvalho, 2007). Thus, the use of noninvasive equipment in research is relevant. Three-dimensional scanning provides a clinical examination without exposure to ionizing radiation (Sedrez et al., 2016). Therefore,

the aim of this study was to evaluate the sagittal curvature of 9th grade students in the city of Ceres to identify the prevalence of hyperkyphosis and hyperlordosis, understand the causes of these changes and implement preventive measures.

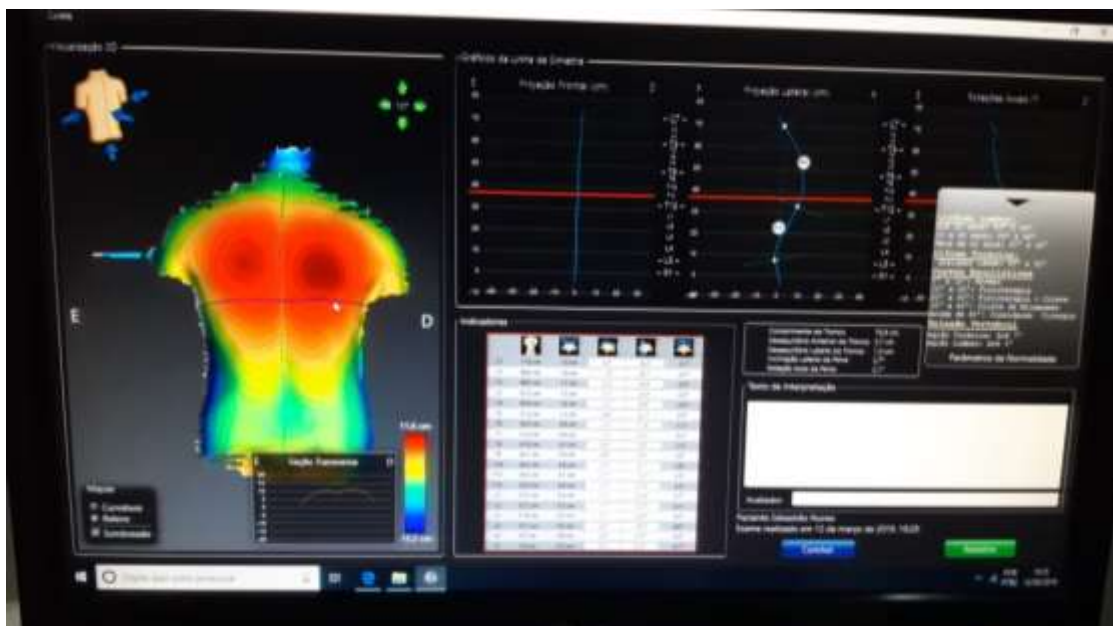
2. Methods

This study was based on the methodology of Sedrez et al. (2016, 2019), which has a cross-sectional design with a quantitative approach. The research was carried out at Instituto Federal Goiano - Campus Ceres in a room properly equipped with the Vert 3D evaluation system by Miotec Equipamentos Biomédicos Ltda., located in Rio Grande do Sul, Brazil. The project was approved by the Research Ethics Committee of the Instituto Federal Goiano and all safety precautions for research involving human beings were ensured. All students who voluntarily agreed to participate provided written informed consent. Students were informed that they could leave the study at any time if they chose not to participate in any of the procedures. Participants had a very low degree of risk, as data collection lasted a few minutes and the assessment was non-invasive.

Participants had the option of withdrawing from the study at the time of evaluation or during the data analysis period. In total, 113 9th grade students from that school were invited to participate in the research. After contacting the school to schedule exam dates, a bus from the Federal Institute was hired to transport students to the laboratory. The laboratory, furniture and equipment were prepared, cleaned and organized in advance. Researchers received specific training on how to use the Vert 3D system by analyzing their own posture and evaluating spinal normality patterns. A folder was created during the first semester to publicize the project and a “jacket” was provided to cover the women's breasts during the exam.

During examination and data collection, the patients were placed in orthostatic position, with arms placed in a relaxed position along the sides of the body, back naked, and feet bare and placed parallel to each other. Next, the student's C7 and S2 spinous processes and right and left posterosuperior iliac spines (PSIS) were identified through palpation, and small adhesive stickers were placed on each location (Sedrez et al., 2016). Subsequently, an image demonstrating the light deformations caused by the relief of the patient's back was captured and interpreted by a mathematical algorithm and digitized and converted into a three-dimensional surface through a geometric triangulation process (Figure 1). The whole process of palpation and image capturing lasted for <6 minutes per patient.

Figure 1: Evaluation results.



Source: Authors (2018).

After examination, a report containing information of the patient's clinical status was issued and readily compared to other examinations or transferred to other computers. The data were also stored in the system for further analysis at any time. Standards of normality were classified according to studies by Teixeira and Carvalho (2007), who used a range of 20° to 50° for thoracic kyphosis in adolescents (Teixeira & Carvalho, 2007). The range of 31° to 49.5° was used for lumbar lordosis (Sedrez et al., 2015).

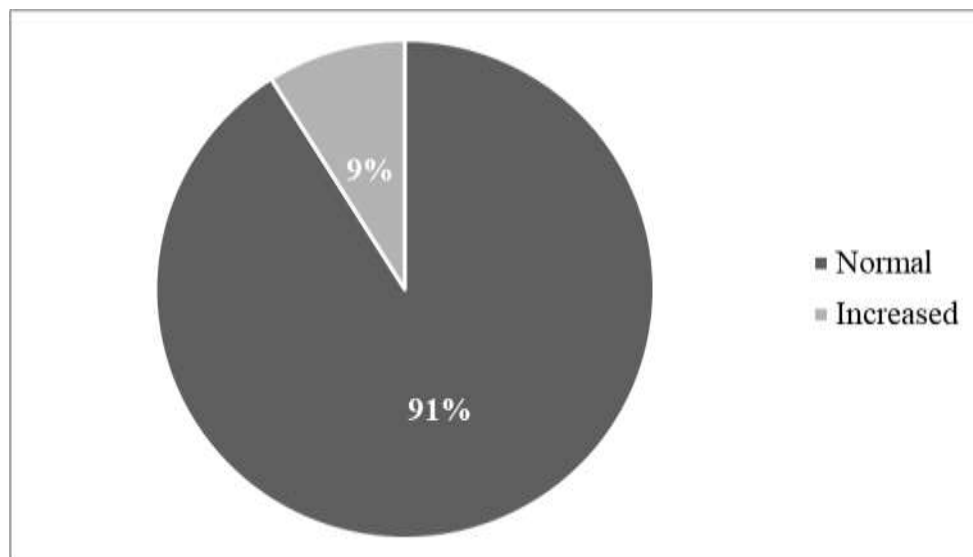
After examinations and data collection, the Back Pain and Body Posture Evaluation Instrument (BackPEI) questionnaire was used to obtain relevant information on the possible causes of postural changes in adolescents (Noll et al., 2013). The patients were evaluated using the following questions: how does the student sit when using the computer?; how does the student pick up objects?; how does the student wear his/her school bag?; and does the student feel pain or discomfort and, if so, does this pain prevent him/her from performing certain activities?

The students were also advised on how to prevent such problems and encouraged to seek treatment in case of severe spinal deformity. The data were analyzed using descriptive and inferential statistics in the SPSS20.0 statistical software. The responses to the Back Pain and Body Posture Evaluation Instrument (BackPEI) questions were analyzed using the Chi-square statistical test to verify their significant association with postural changes.

3. Results

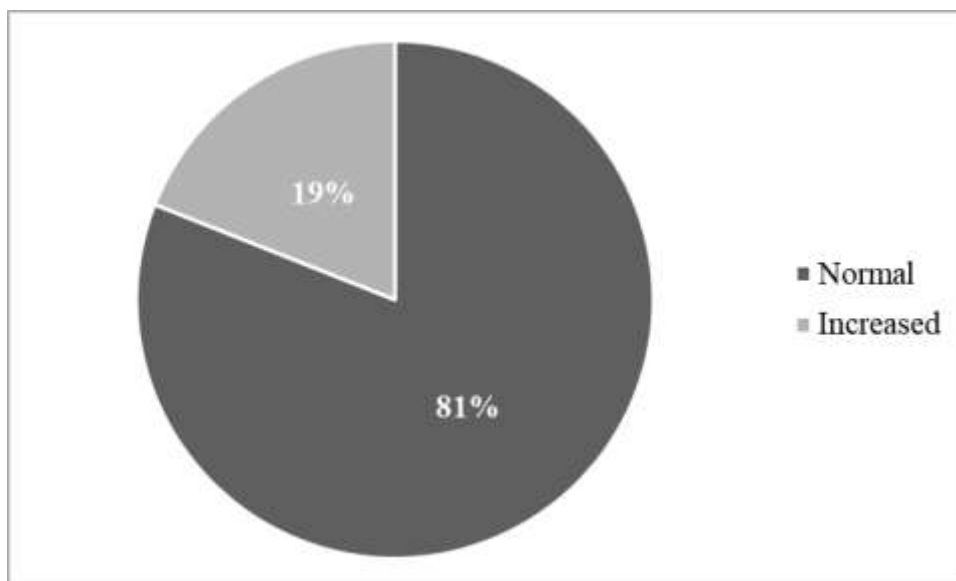
113 students enrolled in the 9th grade of elementary school participated in this research, who took the exam using the Vert 3D equipment and answered the questionnaire on the day of data collection. Among these, 47.8% are male (n=54) and 52.2% are female (n=59). The results showed that 14.2% of 113 participants had increased thoracic kyphosis, while 85.8% had normal thoracic kyphosis curvature. Of these individuals, 9% of the boys had an increased thoracic kyphosis angle, while 91% of the boys had a normal thoracic kyphosis angle (Figure 2). 19% of the girls had an increased thoracic kyphosis angle, while 81% of the girls had a normal thoracic kyphosis angle (Figure 3). Regarding lumbar lordosis, 2% of all students had an angle increase, 26% had an angle within the normal range, and 72% had angle rectification. Considering the percentage of changes in lumbar lordosis by sex, 2% of the boys had an increased lumbar lordosis angle, 11% had a normal angle, and 87% had a rectified lumbar lordosis angle (Figure 4). 2% of the girls had a rectified lumbar lordosis angle, 39% had an angle within the normal range, and 59% (Figure 5) had an increased lumbar lordosis angle.

Figure 2. Prevalence of changes in thoracic kyphosis in male 9th grade students.



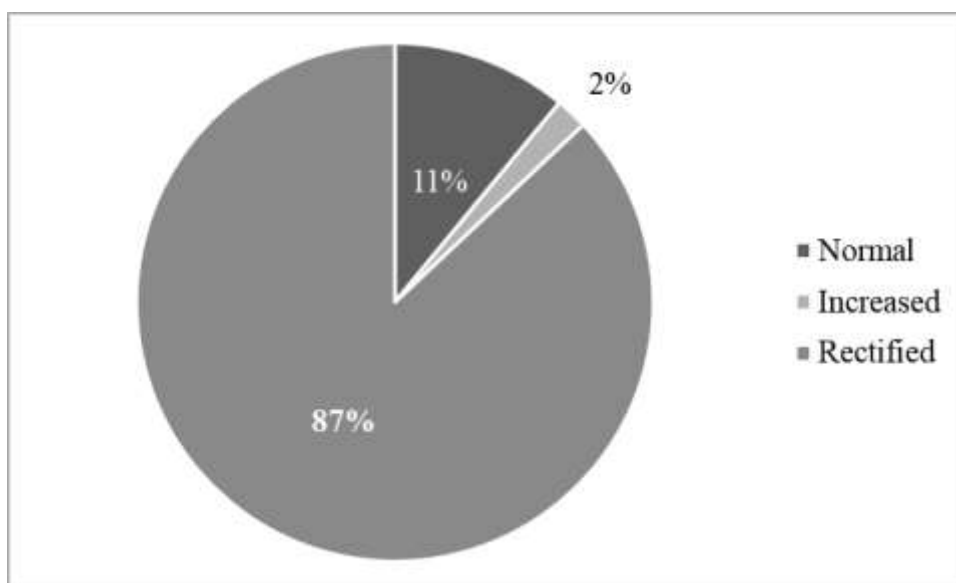
Source: Authors (2021).

Figure 3. Prevalence of changes in thoracic kyphosis in female 9th grade students.



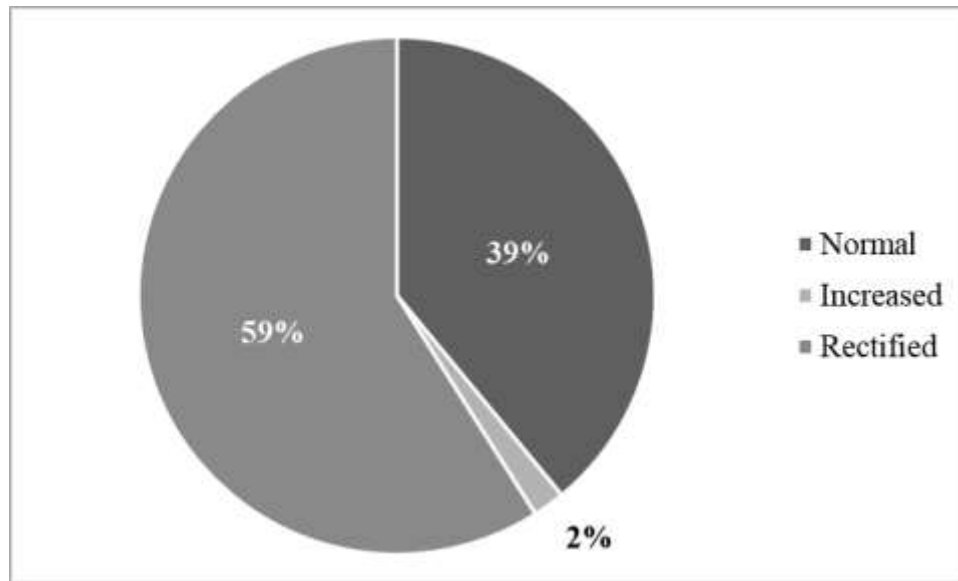
Source: Authors (2021).

Figure 4. Prevalence of alterations in lumbar lordosis in male 9th grade students.



Source: Authors (2021).

Figure 5. Prevalence of alterations in lumbar lordosis in female 9th grade students.



Source: Authors (2021).

In our analysis, no relationship was established between spinal alteration and bad behavioral habits as none of the results were significant. But 15.5% of the students that had an increase in thoracic kyphosis reported that they felt inadequate when using the computer. a percentage of 69.9% of students with rectification of lumbar lordosis sit inappropriately when using the computer. Regarding the position when picking up objects from the floor, 14.4% of the students with hyperkyphosis said they did it in an inappropriate position and 73.1% of the students with lumbar lordosis correction said they used an inappropriate position to pick up objects from the floor (Table 1). Regarding the use of backpacks, 15.4% of students with hyperkyphosis reported not using the backpack correctly, on the other hand, 65.4% of students with lumbar lordosis rectification reported incorrect use of the backpack (Table 1).

Regarding the presence of pain, 17.7% of hyperkyphotic students said they felt pain and 25% said that pain prevents them from performing daily activities. 67.1% of students with lumbar lordosis rectification reported the presence of pain and 68.8% stated that the pain prevents them from performing daily activities. There was no significant association between the studied variables (Table 1).

Table 1. Prevalence of alterations in kyphosis and lumbar lordosis in relation to study variables.

	Thoracic kyphosis				<i>P</i> *	Lumbar lordosis				<i>P</i> *
	Normal	Increase d	Rectified	Total		Normal	Increased	Rectified	Total	
How the students sit when using the computer (n = 113)										
Adequate	100%	0%	0%	100%	0.179	0%	0%	100%	100%	0.126
Inadequate	84.5%	15.5%	0%	100%		28.2%	1.9%	69.9%	100%	
How the students pick up objects (n = 113)										
Adequate	88.9%	11.1%	0%	100%	0.785	33.3%	0%	66.7%	100%	0.801
Inadequate	85.6%	14.4%	0%	100%		25.0%	1.9%	73.1%	100%	
Use of backpack (n = 113)										
Adequate	86.2%	13.8%	0%	100%	0.838	23.0%	2.3%	74.7%	100%	0.388
Inadequate	84.6%	15.4%	0%	100%		34.6%	0%	65.4%	100%	
Pain (n = 104)										
Yes	82.3%	17.7%	0%	100%	0.240	30.4%	2.5%	67.1%	100%	0.119
No	92.0%	8.0%	0%	100%		12.0%	0%	88.0%	100%	
Pain prevents them from performing activities (n = 95)										
Yes	75.0%	25.0%	0%	100%	0.268	31.3%	0%	68.8%	100%	0.894
No	86.1%	13.9%	0%	100%		29.1%	1.3%	69.6%	100%	

* Chi-Square p-value. Source: Authors (2021).

4. Discussion

Health and physical performance are closely related with the daily activities of young people. Their activities affect all physical aspects, especially relating to the spine, and can trigger a series of problems. In this context, the onset of most spine-related diseases occurs during childhood and adolescence, and these problems become more severe with age. Many factors can cause such problems, including physical inactivity in children and adolescents nowadays who focus their attention on electronic games, cell phones, computers, television, and other aspects of the Internet that cause individuals to remain seated for a long period of time, often in improper positions, which can cause long-term pain and injury.

Therefore, this study evaluated the prevalence of alterations in kyphosis and lordosis in 113 students enrolled in the 9th grade of elementary school. It also compared the variables kyphosis and lordosis with variables related to the student daily habits. There was no significant association between the variables studied, however, it is noteworthy that 72% of the students had rectification of their lumbar lordosis, while the prevalence of an increase in thoracic kyphosis was a lower percentage, being only 14.2%.

Some activities, especially in childhood, can cause changes in body posture, impairing health and quality of life. According to Vieira et al. (2015, p. 241) "Postural habits begin to be incorporated in the early years of school life. Activities that can stimulate an adequate performance of DLAs promote kinetic-functional health in school children". Consequently, they state that both children and adolescents spend most of their time sitting in improper positions that could lead to unhealthy poor posture habits, especially the students who stay in school for 4 to 6 hours a day. Behavior patterns are developed at this stage of life and favor the onset of postural changes (Noll, Noll, et al., 2017; Vieira et al., 2015).

High percentages were found for reports of inadequate posture. 15.5% of the students who said that they sit inappropriately when using the computer had an increase in thoracic kyphosis and 14.4% of the students who claimed to pick up objects from the floor inappropriately also had an increase in thoracic kyphosis. Higher percentages were found in relation to changes in lumbar lordosis. 69.9% of the students who claimed to sit inappropriately while using the computer showed rectification of their lumbar lordosis and 73.1% of the students who claimed to pick up objects from the floor inappropriately, also showed rectification of their lumbar lordosis. Iunes et al., (2005) recalls that posture maintains muscles, skeletal structure and joints in static balance, and that postural dysfunctions can generate overloads in the spine and impair the performance of ADLs. That is why postural assessments are essential, as they help to prevent postural problems and their complications (Iunes et al., 2005; Vieira et al., 2015). Changes in kyphosis have already been related to psychological aspects, including anxiety, depression, aggressive behavior (Ozrudi & Amiri, 2021) and loss of function, especially with aging (Almujel et al., 2021). Changes in lordosis can cause body imbalance, back pain and others (Abrisham et al., 2020).

Our results demonstrate that there was a higher percentage of thoracic kyphosis alterations in females, a result that was also found by other studies reported in Sedrez et al., (2015). The authors suggested that, upon entering puberty, girls sought to hide bodily changes, especially breast growth, generating behavior that favors postural change. However, for lumbar lordosis, the highest percentage was registered by males. The puberty causes physical and emotional changes in both sexes. Age-related activities also include habits that corroborate poor body posture. In this sense, the physical and biological development that occurs in young people during puberty may also be responsible for the behavior as they try to hide such physical changes with posture (da Rosa et al., 2016; do Valle et al., 2016).

Although there was no significance in the association of variables, it is worth mentioning that students who use the computer inappropriately had thoracic kyphosis increased (15.5%), lumbar lordosis increased (1.9%) and lumbar lordosis rectified (19.9%). Prolonged computer use can influence body posture, especially by inducing an unconscious posture that overloads the spine and other musculoskeletal structures. In the study of Brink, Low and Grimmer, (2018) posture changes were associated with the occurrence of pain in adolescents who used the computer for a long time (Brink et al., 2018). The proper sitting posture is to sit upright on a horizontal surface, looking ahead with relaxed shoulders, arms vertically down, forearms on a surface, and seat height adjusted so that the thighs are positioned horizontally and the lower legs vertically (Reis et al., 2003). Thus, a position showing body imbalance can lead to development of changes that may be irreversible.

Inappropriate way of picking up objects was not significantly associated with the variables, but had a percentage of 14.4% for thoracic kyphosis increased, 1.9% for lumbar lordosis increased and 73.1% for lumbar lordosis rectified. Even though we did not find an association in our study, this habit can be considered risky. Bertolini and Gomes (1997) reported that the improper posture of adolescents when performing daily activities, such as picking objects on the floor, can result in severe curvatures (Bertolini & Gomes, 1997). Kunzler et al. (2014) reported that sagittal spinal changes are significantly associated with improper sitting posture (Kunzler et al., 2014). Bueno and Rech (2013) report that factors such as backpack weight, improper postural habits, height, and age are closely related to spinal changes (Bueno & Rech, 2013). Two-strap backpacks carried using both straps are considered the most suitable manner of carrying bags in the literature (Benini et al., 2010; Bueno & Rech, 2013).

For students who reported inappropriate backpack the increased thoracic kyphosis was 15.4% and for rectified lumbar lordosis it was 65.4%. Pain and intense pain in the back of children and adolescents is considered common, but pain cannot be normalized in this public (Mosaad & Abdel-aziem, 2018). The incorrect use of the backpack with the load distributed asymmetrically causes the body to become unbalanced and requires load compensation. Thus, the adolescent who performs the behavior of using the backpack with only one of the straps or another way that is not with equal weight distribution on both shoulders may develop a postural change in the future (Kasović et al., 2018; Malik et al., 2017; Mosaad & Abdel-aziem, 2018).

Pain indicates a problem, and the prevalence of back pain in school-age youth has increased with the use of a backpack (Shah & Saller, 2016). In addition to the asymmetrical use, the backpack load was associated with postural impairment in a recent study (Hell et al., 2021). Regarding pain, the sensation was reported by students with thoracic kyphosis increased (17.7%), lumbar lordosis increased (2.5%) and lumbar lordosis rectified (67.1%).

The pain prevents students with increased thoracic kyphosis (25.0%) and rectified lumbar lordosis (68.8%) from performing activities. Araújo et al. (2010) stated that pain has a role of communicating that there is something wrong within the organism. Thus, the presence of pathologies such as hyperlordosis and hyperkyphosis is associated with pain. It should be considered that individuals can be severely affected by the presence of back pain and are unable to perform daily activities properly. The incapacity resulting from pain is multidetermined; thus, different pain locations and intensities, among other characteristics, seem to be associated with greater or lesser degree of disability (Araújo et al., 2010; Dellaroza et al., 2013).

Mantovani (2011) states that it is important to investigate these postural changes because asymmetries during this phase of body development in adolescents can lead to reduced spine length, pain, imbalance, and short stature. In this age group, knowledge about this subject is indispensable because it is a transition phase between childhood and adulthood, and the correct posture in performing daily activities results in the prevention of postural changes (Dellaroza et al., 2013; Mantovani et al., 2011).

Our study has some limitations. First, the main limitation of this study we cannot infer causality. Second, the Vert 3D system is a subjective method of assessment. The third point concerns the sample size. The small sample limits the information that could be reflected in the results. Therefore, we encourage future studies, with a larger sample, to verify the relationship between postural changes and other factors, as well as work using other analysis equipment.

5. Final Considerations

Considering that most spinal problems occur during childhood and adolescence and that they are mainly caused by poor body posture, it is necessary to identify which actions trigger such problems. Although some activities are common to all people, being recurrent collective practices, it is also necessary to analyze each patient individually and consider that habits vary from person to person, and several factors, such as behavior, environment, family education, awareness, physical activities, culture, and social relations, must be considered. Therefore, we need to consider the mechanisms that can raise awareness about the existing risks of poor posture. Prevention can decrease the development of posture-related pathological conditions that may appear during childhood and adolescence, affecting students and causing problems such as kyphosis and lordosis.

Acknowledgments

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