Lucele G. L. Araújo, Vandilson P. Rodrigues*, Ivan A. Figueiredo and Maria N. L. Medeiros

Association between sitting posture on school furniture and spinal changes in adolescents

<https://doi.org/10.1515/ijamh-2020-0179>

Received May 4, 2020; accepted July 19, 2020;

published online August 24, 2020

Abstract

Objectives: To investigate the association between sitting posture during the use of school furniture and changes in the spine in adolescents.

Methods: A cross-sectional study was conducted with 240 students. The sitting position on school furniture was collected five times (3, 6, 9, 12, and 15 min). Postural alteration of the spine was identified by direct observation in front of a symmetograph. Screening for scoliosis was obtained by Adams test.

Results: The presence of the factor away from the table presented higher percentages at times 3, 6, 9, and 15 min (24.2, 25, 29.2, and 26.7%, respectively). At 12 min, the highest frequency was the presence of poorly positioned lower limbs (25.8%). Associations were observed between poor sitting posture with changes in head anteriorization and retroversion of the pelvis among women and with thoracic hyperkyphosis in men.

Conclusions: The findings suggest that there are sex-dependent associations between poor sitting posture during use of school furniture and spinal alterations in adolescents.

Keywords: posture; school furniture; spinal column; students.

Introduction

Postural changes among children and adolescents are considered common findings, a fact that can be explained by the adoption of an inappropriate postural habit during the period of stay in school and in the use of equipment

such as computers, smartphones, and video games [1–3]. In addition to these habits, curvatures of the spine show physiological changes, during the phase of body growth, for the definition of the determinant curvature that can contribute to inadequate postural development [4].

The acquisition of incorrect and vicious static postures assumed early in a sitting posture to write on school furniture can damage the curvature of the spine in children and adolescents, because in this period, the locomotor system is in the process of adjusting and maturing [5, 6]. In addition, staying in a prolonged seated posture a day can trigger postural imbalance as well as increase the pressure between the intervertebral discs, bringing future risks and damage to the spine [7].

Characterized as a public health problem, postural changes in children and adolescents have a high prevalence, emphasizing the need for prevention, diagnosis and treatment even during the phase of growth and body development because in this period individuals are considered more vulnerable to changes in habits [5, 8, 9]. In a study conducted in Brazil, the prevalence of postural changes in children and adolescents was 79.7%, with an association between thoracic kyphosis and the female gender, inadequate postures for sitting on the bench, and sitting down to write [8].

The ergonomics of chair–table furniture represents an important factor for maintaining postural balance among students [10]. However, there is no consensus on the variables associated with changes in the spine in a sitting posture in children and adolescents [11]. Given the above, the objective of this study was to investigate the association between sitting posture while using school furniture and changes in the spine in adolescents.

Methods

This observational study was conducted at an elementary and high school Education Center at the city of São Luís, MA, Brazil, from May to June 2015. The research project was approved by the Research Ethics Committee of Universidade Ceuma (Opinion No. 44770615.8.0000.5084/2014). All participants were informed of the objectives and procedures of the study. The legal guardians and students signed the Free and Informed Consent Term (ICF).

The municipality of São Luís, capital of the State of Maranhão, in the northeast region of Brazil, is located on a maritime island in the north of the state. In 2015, the year of the study, it had a territorial area

*Corresponding author: Vandilson Pinheiro Rodrigues, Department of Morphology, Federal University of Maranhão, Avenida dos Portugueses, 1966, 65080-805, São Luís, Maranhão, Brazil, E-mail: vandilson.rodrigues@ufma.br.
<https://orcid.org/0000-0002-6785-7864>.

Lucele G. L. Araújo, Department of Morphology, Federal University of Maranhão, São Luís, Maranhão, Brazil

Ivan A. Figueiredo, School of Medicine, Federal University of Maranhão, Pinheiro, Maranhão, Brazil

Maria N. L. Medeiros, School of Medicine, Ceuma University, São Luís, Maranhão, Brazil

of 834.78 km² and an estimated population of 1,073,893 inhabitants, 109,986 adolescents aged 10–15 years. In 2010, it had a municipal human development index of 0.768, above the national average and a schooling rate of 96.8% in the 6–14 years age group [12].

Students of both sexes, regularly enrolled in the Teaching Unit, aged between 10 and 16 years were included. Exclusion criteria included the presence of congenital and/or traumatic postural changes, the presence of physical disabilities that made the study procedures impossible, patients with motor disorders and known pregnancy.

For the sample calculation, the formula for simple random sample was used, adopting the parameters of the total population of students between 10 and 16 years old of both sexes, enrolled in Education Center in 2015 (643 students), assuming a sampling error of 5%, confidence level of 95%, and the prevalence of postural change of 50%, a measure used to maximize the sample size. Thus, the minimum number required was 240 students. The sample was stratified according to sex and age group. The sample was representative of the school unit evaluated in this study. Research participants were selected by lot, using a table of random numbers to reduce sampling bias.

Information on demographic characteristics was obtained from a semi-structured questionnaire designed and completed by the researchers. Direct observation was used to observe the presence of changes in spine curvatures. The students were kept in an orthostatic position in a right lateral view at a distance of 15 cm in front of a symmetrograph like Banner (Fisiobras), barefoot, with their feet slightly joined and parallel to each other, elbows in flexion and forearms supported on the upper abdomen, hair fastened when necessary to allow visualization of the cervical curvature, top and shorts for women, and shorts for men. The students were instructed to keep their eyes open while looking at the horizon and in silence during the clinical examination. With the students in position, photographs were taken at a distance of 3 m with the aid of a camera (Canon Power Shot SX30IS) supported on a tripod 1 m high at an angle of 90° on a flat surface to ensure horizontality.

The angles of the spinal curvatures were measured using an instrument adapted [13]. To measure the angles of the spine (cervical lordosis, thoracic kyphosis, and lumbar lordosis), small balls of styrofoam were prepared with double-sided adhesive tape and used as markers. The curvature of the cervical lordosis was measured through an angle formed by the ear tragus, the seventh cervical vertebra (C7) and the scapular acromion, the acromion being the vertex of the angle. The curvature of the thoracic kyphosis was measured using the angle formed by the scapular acromion, the seventh thoracic vertebra (T7), and the first lumbar vertebra (L1), with L1 being the vertex of the angle. While the curvature of the lumbar lordosis was quantified through the angle formed by the L1, antero-superior iliac spine (ASIS), and greater trochanter of the femur with ASIS being the vertex of the angle. Thoracic hyperkyphosis was considered the angle of kyphosis greater than 40°, the anterior head had an angle of cervical lordosis greater than 60°, and retroversion of the pelvis was the angle of lumbar lordosis greater than 40°.

The error of the method was calculated using the Dahlberg formula to guarantee the reproducibility and agreement of the intra-examiner to measure the angles of the curvatures of the spine. For this purpose, 25 photographs were selected randomly from the sample of the present study and analyzed in two moments with an interval of 10 days, obtaining an error level of 0.5°.

Scoliosis was screened using Adams test. The students were in an orthostatic position, barefoot, with symmetrical feet and heels slightly apart, knees extended, in anterior flexion of the trunk until their backs were in a horizontal position (functional position), keeping their arms hanging down, palms together, with fingers in opposition. A tangential view of the dorsum was made to identify changes in the rib cage, costal gibbosity and changes in the protrusion of the lumbar muscle silhouette. To this end, students were positioned after school to identify costal, right or left gibbosity suggestive of scoliosis, as well as to identify changes in the right or left lumbar silhouette.

To assess the dynamic posture while seated on the school chair, we considered writing posture obtained through filming, with the aid of a digital video camera (Canon Vixia HF G20 Full HD). The camera was positioned on an aluminum tripod (Canon Tripod 300), positioned 3 m away from the student at a height of 1 m and a 90° angle on a flat surface to ensure horizontality. The filming was carried out in a large school room while students were filling the demographic data form along with a drawing and painting activity, the latter with the intention of completing the 15 min filming time.

For each shot obtained in side view, students were arranged, one behind the other (in single file), with four chair-table sets for individual students, lasting 15 min for each group. The frequency of four factors was analyzed: (A) maintenance of the curvatures of the spine (dorsal), (B) position close to the table, (C) neutral positioning of the pelvis (support in the hamstrings), and (D) distant lower limbs (equal or less) beyond the hip line. The times evaluated in the study were: 3, 6, 9, 12, and 15 min. These different moments were used to minimize the potential loss of spontaneity of the studied population when being filmed [14, 15].

The data were analyzed using SPSS software (version 17.0). Descriptive statistics of the variables were performed using measures of frequency, mean, and standard deviation. Categorical variables were analyzed using Chi-square and Fisher's exact tests. The prevalence ratio (PR) measure and 95% confidence interval (95% CI) were used to estimate the association between changes in sitting posture and dependent variables. The level of significance adopted was 5%.

Results

A total of 240 students, aged 10–16 years, were evaluated in the present study. Table 1 shows the sample distribution by sex and age. Most of the sample consisted of female students (67.1%). The most frequent ages were 15 years (19.2%) and 10 years (17.1%).

Changes in sitting position ranging between 17 and 30% were detected in the five evaluated times (Table 2). The factor away from the table presented higher percentages at times 3, 6, 9, and 15 min (24.2, 25, 29.2, and 26.7%, respectively). In 12 min, the factor with the highest percentage was that of poorly positioned lower limbs (25.8%). Male students showed higher frequencies of alteration of the curvature of the spine in 3 min than female students ($p=0.021$). Female students showed statistically higher

Table 1: Descriptive analysis of the study sample.

Variables	n	(%)
Sex		
Male	79	(32.9)
Female	161	(67.1)
Age, years		
10	41	(17.1)
11	39	(16.3)
12	34	(14.2)
13	23	(9.6)
14	33	(13.8)
15	46	(19.2)
16	24	(10.0)

frequencies of position far from the table in 3 min ($p < 0.001$) and 6 min ($p = 0.008$).

In the sample studied, a risk association was detected between factor D in 15 min and the anterior head ($PR = 3.2$, 95% $CI = 1.2-8.3$) for females. For the variable thoracic kyphosis, a significant association was observed only in males for factors A and C in 6 min ($PR = 5.0$, 95% $CI = 1.0-24.2$) and factor B in 9 min ($PR = 3.9$, 95% $CI = 1.0-15.1$) (Table 3).

The results showed an association of pelvis retroversion for the females in factor D in 3 min ($PR = 5.8$, 95% $CI = 1.3-25.9$) and in 15 min ($PR = 4.2$, 95% $CI = 1.2-14.8$). However, there was no statistically significant association between changes in sitting position and the scoliosis variable for both sexes (Table 4).

Discussion

The main findings of the present study suggest sex-dependent associations between the position adopted by adolescents between 10 and 16 years old when using school furniture and the presence of postural changes such as anterior head, thoracic kyphosis, and retroversion of the pelvis.

In the present study, the prevalence of changes in sitting position among students ranged between 17 and 30% in the five periods evaluated. This finding is due, in part, to the time spent in this posture to write, see, hear, and absorb disciplinary explanations, favoring postural changes [16–19].

The distant position of the table was the most frequent change in sitting posture in the evaluated sample. However, the prevalence of factors related to sitting posture was different between genders. The male gender presented higher frequencies for the alterations in the curvatures of the spine

Table 2: Comparative analysis of sitting posture between sexes.

Sitting posture	Sex						p-Value
	Total		Male		Female		
	n	(%)	n	(%)	n	(%)	
Time 3 min							
Factor A: Change in spinal curvatures	48	(20.0)	23	(29.1)	25	(15.5)	0.021*
Factor B: Far from the table	58	(24.2)	8	(10.1)	50	(31.1)	<0.001*
Factor C: Alteration of the pelvis	43	(17.9)	20	(25.3)	23	(14.3)	0.055
Factor D: Lower limbs in altered position	50	(20.8)	13	(16.5)	37	(23.0)	0.317
Time 6 min							
Factor A: Change in spinal curvatures	41	(17.1)	15	(19.0)	26	(16.1)	0.713
Factor B: Far from the table	60	(25.0)	11	(13.9)	49	(30.4)	0.008*
Factor C: Alteration of the pelvis	43	(17.9)	15	(19.0)	28	(17.4)	0.901
Factor D: Lower limbs in altered position	39	(16.3)	14	(17.7)	25	(15.6)	0.405
Time 9 min							
Factor A: Change in spinal curvatures	53	(22.1)	17	(21.5)	36	(22.4)	0.985
Factor B: Far from the table	70	(29.2)	18	(22.8)	52	(32.3)	0.169
Factor C: Alteration of the pelvis	55	(22.9)	17	(21.5)	38	(23.6)	0.843
Factor D: Lower limbs in altered position	53	(22.1)	13	(16.5)	40	(24.8)	0.191
Time 12 min							
Factor A: Change in spinal curvatures	47	(19.6)	16	(20.3)	31	(19.3)	0.991
Factor B: Far from the table	57	(23.8)	20	(25.3)	37	(23.0)	0.811
Factor C: Alteration of the pelvis	46	(19.2)	16	(20.3)	30	(18.6)	0.900
Factor D: Lower limbs in altered position	62	(25.8)	16	(20.3)	46	(28.6)	0.220
Time 15 min							
Factor A: Change in spinal curvatures	45	(18.8)	18	(22.8)	27	(16.8)	0.344
Factor B: Far from the table	64	(26.7)	23	(29.1)	41	(25.5)	0.656
Factor C: Alteration of the pelvis	47	(19.6)	19	(24.1)	28	(17.4)	0.294
Factor D: Lower limbs in altered position	57	(23.8)	16	(20.3)	41	(25.5)	0.465

Chi-square or Fisher's exact test. *Statistically significant differences ($p < 0.05$).

and pelvis, sitting without support on the sciatic bones, while female students presented higher frequencies of distant position of the table and poor position of lower limbs.

Table 3: Association between anterior head, thoracic hyperkyphosis, and sitting posture.

Sitting posture	Anterior head		Thoracic hyperkyphosis	
	Male	Female	Male	Female
	PR (95% CI)	PR (95% CI)	PR (95% CI)	PR (95% CI)
Time 3 min				
Factor A	0.8 (0.3–2.3)	0.7 (0.3–1.8)	2.9 (0.9–8.9)	1.3 (0.5–3.3)
Factor B	0.1 (0.1–0.8)	0.6 (0.2–1.2)	*	1.2 (0.6–2.5)
Factor C	1.1 (0.3–3.1)	0.6 (0.2–1.5)	3.1 (0.9–10.5)	1.2 (0.4–3.2)
Factor D	0.4 (0.1–1.4)	0.3 (0.1–0.7)	4.0 (0.8–19.7)	0.5 (0.2–1.3)
Time 6 min				
Factor A	0.5 (0.1–1.8)	0.9 (0.3–2.4)	5.0 (1.0–24.2)	0.8 (0.3–2.0)
Factor B	0.4 (0.1–1.5)	0.5 (0.2–1.1)	1.7 (0.4–7.2)	0.7 (0.3–1.6)
Factor C	0.5 (0.1–1.8)	1.1 (0.4–2.7)	5.0 (1.0–24.2)	0.8 (0.3–2.2)
Factor D	0.5 (0.1–1.6)	1.9 (0.6–5.4)	4.5 (0.9–21.9)	1.3 (0.5–3.2)
Time 9 min				
Factor A	0.7 (0.2–2.3)	1.4 (0.6–3.2)	1.6 (0.5–5.1)	0.7 (0.3–1.6)
Factor B	0.4 (0.1–1.4)	1.7 (0.8–3.6)	3.9 (1.0–15.1)	0.6 (0.3–1.4)
Factor C	0.7 (0.2–2.3)	1.5 (0.6–3.5)	1.6 (0.5–5.1)	0.7 (0.3–1.7)
Factor D	0.9 (0.2–3.1)	0.6 (0.3–1.3)	1.4 (0.4–5.2)	1.1 (0.5–2.4)
Time 12 min				
Factor A	0.6 (0.2–2.1)	1.6 (0.6–4.1)	3.2 (0.8–12.5)	1.5 (0.7–3.5)
Factor B	0.6 (0.2–1.7)	1.4 (0.6–3.4)	1.6 (0.5–4.7)	0.9 (0.4–2.1)
Factor C	0.6 (0.2–2.1)	1.5 (0.6–3.8)	3.2 (0.8–12.5)	1.6 (0.7–3.8)
Factor D	1.3 (0.4–4.3)	1.0 (0.4–2.1)	0.7 (0.2–2.2)	1.5 (0.7–3.1)
Time 15 min				
Factor A	0.3 (0.1–1.0)	1.6 (0.6–4.3)	0.7 (0.2–2.0)	1.7 (0.7–4.0)
Factor B	0.5 (0.1–1.3)	0.5 (0.2–1.2)	1.5 (0.5–4.4)	0.5 (0.2–1.2)
Factor C	0.5 (0.1–1.5)	1.1 (0.4–2.7)	0.4 (0.1–1.2)	1.9 (0.8–4.5)
Factor D	1.9 (0.5–6.8)	3.2 (1.2–8.3)	1.0 (0.3–3.1)	1.6 (0.8–3.5)

PR, prevalence ratio; 95% CI, 95% confidence interval. Statistically significant association measures are marked in italics ($p < 0.05$). *The frequencies of some categories were 0, and thus, it was impossible to calculate the PR.

Studies in adolescents have reported gender differences in sitting posture [20–22]. Females show more erect with a more lordotic lumbar posture than males in the habitual sitting posture [20]. The more erect sitting posture in females when looking straight ahead and looking down may be associated with anatomical and/or behavioral factors [21]. The degree of slump in usual sitting posture in adolescent seems to be higher in males as well as is associated with physical, lifestyle, and psychosocial factors [22].

These results suggest that there are different characteristics between the sexes for adopting a sitting posture in the performance of daily activities, specifically in the school period [19, 23, 24]. Divergences on the prevalence of postural changes among students in a sitting position may be associated with the maturity level of growth patterns and body development [25].

In this study, an association was observed between altered lower limbs in the sitting position and anterior head detection for females in 15 min. This finding reinforces the

hypothesis that longer periods of time may increase the chance of adopting an inappropriate sitting posture [26]. A study identified changes in the curvature of the spine, anterior head, in 76.92% of the investigated students, which may be indicative of inadequate posture when sitting [8].

Among male students, an association was observed between thoracic hyperkyphosis and failure to maintain spinal curvatures in sitting posture and pelvis changes in 6 and 9 min, in addition to the factor of the distant position of the table in 9 min. Thus, the posture assumed by the students seems to be the result of several factors, among them the ergonomics of the school chair–table object [27, 28] and may not satisfy the objective for which it is intended, and such fact, sometimes, may not meet the recommendations of the Brazilian Regulatory Standard–NBR, which standardized school furniture in Brazil (ABNT NBR 14006) [29].

The association between pelvis retroversion and presence of altered lower limbs in 3 and 15 min was found

Table 4: Association between pelvis retroversion, scoliosis, and sitting posture.

Sitting posture	Pelvis retroversion		Scoliosis	
	Male	Female	Male	Female
	PR (95% CI)	PR (95% CI)	PR (95% CI)	PR (95% CI)
Time 3 min				
Factor A	2.2 (0.5–8.6)	0.7 (0.2–2.1)	0.6 (0.2–1.8)	1.0 (0.4–2.3)
Factor B	2.0 (0.2–17.7)	0.8 (0.3–2.0)	0.2 (0.0–1.2)	0.6 (0.3–1.2)
Factor C	3.0 (0.6–14.8)	0.5 (0.1–1.4)	1.0 (0.3–2.8)	0.8 (0.3–2.0)
Factor D	3.8 (0.4–31.8)	<i>5.8 (1.3–25.9)</i>	0.9 (0.2–3.2)	1.6 (0.7–3.4)
Time 6 min				
Factor A	1.1 (0.2–4.5)	1.5 (0.4–4.7)	0.4 (0.1–1.5)	0.7 (0.3–1.7)
Factor B	3.0 (0.3–25.9)	0.7 (0.3–1.6)	0.6 (0.1–2.3)	0.6 (0.3–1.3)
Factor C	1.1 (0.2–4.5)	1.6 (0.5–5.2)	0.4 (0.1–1.5)	0.7 (0.3–1.6)
Factor D	4.2 (0.5–35.1)	3.4 (0.7–15.5)	0.5 (0.1–1.8)	0.6 (0.2–1.6)
Time 9 min				
Factor A	0.3 (0.1–1.2)	1.8 (0.6–5.0)	0.9 (0.3–2.7)	0.7 (0.3–1.5)
Factor B	1.4 (0.3–5.8)	2.0 (0.8–5.0)	1.0 (0.3–3.0)	0.7 (0.4–1.5)
Factor C	0.3 (0.1–1.2)	1.5 (0.5–4.0)	0.9 (0.3–2.7)	0.6 (0.3–1.3)
Factor D	0.5 (0.1–2.0)	1.3 (0.5–3.2)	0.9 (0.2–3.2)	0.7 (0.3–1.4)
Time 12 min				
Factor A	0.1 (0.0–0.5)	2.8 (0.8–9.9)	0.4 (0.1–1.3)	0.6 (0.3–1.5)
Factor B	1.1 (0.3–3.9)	1.8 (0.6–5.2)	0.6 (0.2–1.6)	1.0 (0.4–2.1)
Factor C	0.1 (0.0–0.5)	2.7 (0.7–9.5)	0.4 (0.1–1.3)	0.7 (0.3–1.6)
Factor D	0.5 (0.1–1.7)	2.0 (0.7–5.4)	0.8 (0.2–2.4)	0.9 (0.4–1.8)
Time 15 min				
Factor A	0.6 (0.1–2.1)	1.1 (0.4–3.3)	0.7 (0.2–2.2)	1.7 (0.7–4.1)
Factor B	0.9 (0.3–3.1)	1.3 (0.5–3.4)	0.6 (0.2–1.8)	0.8 (0.4–1.8)
Factor C	0.7 (0.2–2.3)	1.2 (0.4–3.5)	1.2 (0.4–3.4)	1.8 (0.7–4.3)
Factor D	0.2 (0.1–0.8)	<i>4.2 (1.2–14.8)</i>	0.8 (0.2–2.4)	1.5 (0.7–3.1)

PR, prevalence ratio; 95% CI, 95% confidence interval. Statistically significant association measures are marked in italics ($p < 0.05$).

in females, with pelvis retroversion being more prevalent in females. These data suggest that the school furniture, chair–table, may have favored the acquisition of this alteration of the spine, because, in addition to the time spent in sitting position, the chair–table object was blue for individual student set, for all age groups of the present study, seeming not considering the height of the students [29].

The ergonomic conditions of the school furniture can add up in favor of the ideal posture of the students in a seated posture; however, it is assumed that there is no ideal posture, but, positions that are functionally and for a determined time, as staying for too long in this position, can cause recurrent muscle fatigue [19]. Thus, changes in the chair–table object for the individual student group are favorable, since they can positively influence the students' sitting position pattern [23, 26, 27]. The use of this object inappropriately can corroborate for the development and/or worsening of postural disorders in the spine such as, for example, rectifying lumbar lordosis can contribute to maintaining the thoracic region close to the back of the

chair, causing pelvic retroversion. However, other factors should also be assessed, such as the type of activities performed in the classroom and the time spent on them, in order to investigate the impact of these factors on sitting posture.

An investigation of the body posture of schoolchildren in Brazilian studies showed that lumbar hyperlordosis was prevalent in 15.3–78.0% of those evaluated up to 10 years of age [5]. Therefore, seated postural misconduct is capable of causing changes in the curvatures of the spine and appears to develop from the beginning of schooling [8, 16, 17].

Some procedures for quality assurance and control in this study can be highlighted. For example, calculating measurement error showed a low error level of 0.5° with good intraexaminer reproducibility. The random sample was representative for the group of students in the school unit evaluated, with a statistically similar distribution of age between genders. A limitation of the study was the failure to use radiographic exams to determine the angles of the curvatures of the spine, which would result in a more accurate diagnosis of changes in the spine. However, the

methodology adopted in the present study used techniques with no exposure to ionizing agents, in addition to being an easily reproducible and low cost method. Another limitation was that the follow-up time was relatively short in the current study. Therefore, new studies must be carried out to evaluate the sitting posture while using school furniture for more than 15 min.

In this context, it is recommended to carry out research to develop investigative methods with greater precision for the lateral asymmetries of the spine and the sitting posture. The findings of this study can contribute as a source of information for health and public education agencies, when planning preventive strategies and adapted to the reality of each school, with a view to students acquiring healthy postural habits.

Conclusions

The findings of this study suggest that poor sitting posture can be associated with presence of spinal alterations in adolescents. The results indicate the need to adopt measures for early diagnosis and correction of incoherent spinal postural habits, stimulating and changing life habits, especially in sitting posture, to avoid aggravating these behaviors.

Research funding: None declared.

Author contributions: All authors have accepted responsibility for the entire content of this manuscript and approved its submission.

Competing interests: Authors declare that there is no conflict of interest.

Informed consent: Informed consent was obtained from all individuals included in this study

Ethical approval: The research project was approved by the Research Ethics Committee of Universidade Ceuma (Opinion No. 44770615.8.0000.5084/2014).

References

1. Sampaio MH, Oliveira LC, Pinto FJ, Muniz MZ, Gomes RC, Coelho GR. Postural changes and pain in the academic performance of elementary school students. *Fisioter Mov* 2016;29:295–303.
2. Castellucci HI, Arezes PM, Molenbroek JF, Bruin R, Viviani C. The influence of school furniture on students' performance and physical responses: results of a systematic review. *Ergonomics* 2017;60:93–110.
3. Syazwan AI, Mohamad AMN, Anita AR, Azizan HS, Shaharuddin MS, Hanafiah MJ, et al. Poor sitting posture and a heavy schoolbag as contributors to musculoskeletal pain in children: an ergonomics school education intervention program. *J Pain Res* 2011;4:287–96.
4. Janakiraman B, Ravichandran H, Demeke S, Fasika S. Reported influences of backpack loads on postural deviation among school children: a systematic review. *J Educ Health Promot* 2017;6:41.
5. Badaró AF, Nichele LF, Turra P. Student body posture in Brazilian studies. *Fisioter Pesqui* 2015;22:197–204.
6. Brink Y, Louw Q, Grimmer K, Jordaan E. The relationship between sitting posture and seated-related upper quadrant musculoskeletal pain in computing South African adolescents: a prospective study. *Man Ther* 2015;20:820–6.
7. Samoladas E, Barmpagianni C, Papadopoulos DV, Gelalis ID. Lower back and neck pain among dentistry students: a cross-sectional study in dentistry students in Northern Greece. *Eur J Orthop Surg Traumatol* 2018;28:1261–7. 2018.
8. Sedrez JA, Rosa MIZ, Noll M, Medeiros FS, Candotti CT. Risk factors associated with structural postural alterations on the spine of children and adolescents. *Rev Paul Pediatr* 2015;33:72–81.
9. Prins Y, Crous L, Louw QA. A systematic review of posture and psychosocial factors as contributors to upper quadrant musculoskeletal pain in children and adolescents. *Physiother Theor Pract* 2008;24:221–42.
10. Carneiro V, Gomes Â, Rangel B. Proposal for a universal measurement system for school chairs and desks for children from 6 to 10 years old. *Appl Ergon* 2017;58:372–85.
11. Kasten AP, Rosa BN, Schmit EF, Noll M, Candotti CT. Prevalence of postural deviations in the spine in schoolchildren: a systematic review with meta-analysis. *J Hum Growth Dev* 2017;27:99–108.
12. Brazilian National Institute of Geography and Statistics. Cities and states. Brazil; 2015. Available from: <https://www.ibge.gov.br/cidades-e-estados>.
13. Yi LC, Jardim JR, Inoue DP, Pignataril SS. The relationship between excursion of the diaphragm and curvatures of the spinal column in mouth breathing children. *J Pediatr* 2008;84:171–7.
14. Bartz PT, Vieira A, Noll M, Candotti CT. Effectiveness of the back school program for the performance of activities of daily living in users of a basic health unit in Porto Alegre, Brazil. *J Phys Ther Sci* 2016;28:2581–6.
15. Noll M, Candotti CT, Vieira A. Tools for evaluation the dynamic posture: applicability to the school environment. *Fisioter Mov* 2013;26:203–17.
16. Naddeo A, Califano R, Vink P. The effect of posture, pressure and load distribution on (dis) comfort perceived by students seated on school chairs. *Int J Interact Des Manuf* 2018;12:1179–88.
17. Fonseca CD, Santos AC, Candotti CT, Noll M, Luz AM, Corso CO. Postural education and behavior among students in a city in southern Brazil: student postural education and behavior. *J Phys Ther Sci* 2015;27:2907–11.
18. Caromano FA, Amorim CA, Rebelo CF, Contesini AM, Fávoro FM, Frutuoso JR, et al. Permanência prolongada na postura sentada e desconforto físico em estudantes universitários. *Acta Fisiátr* 2015;22:176–80.
19. Sedrez JA, Furlanetto TS, Noll M, Gontijo KN, Rosa BN, Candotti CT. Relação entre alterações posturais e fatores associados em escolares do ensino fundamental. *Rev Baiana Saude Publica* 2014;38:279–96.
20. Noll M, Candotti CT, Rosa BN, Sedrez J, Vieira A, Loss JF. Layout for assessing dynamic posture (LADy): development, validation, and reproducibility. *Pediatr Phys Ther* 2016;28:435–44.
21. Kumar G, Chhabra A, Dewan V, Yadav TP. Prevalência e impacto nas atividades diárias da dor musculoesquelética idiopática em crianças da Índia. *Rev Bras Reumatol* 2017;57:8–14.

22. Azabagic S, Spahic R, Pranjić N, Mulic M. Epidemiology of musculoskeletal disorders in primary school children in Bosnia and Herzegovina. *Mater Sociomed* 2016;28:164–7.
23. Clemes SA, Barber SE, Bingham DD, Ridgers ND, Fletcher E, Pearson N, et al. Dunstan. Reducing children's classroom sitting time using sit-to-stand desks: findings from pilot studies in UK and Australian primary schools. *J Public Health* 2016;38:526–33.
24. Dornhecker M, Blake J, Benden M, Zhao H, Wendel M. The effect of stand-biased desks on academic engagement: an exploratory study. *Int J Health Promot Educ* 2015;53:271–80.
25. Shan Z, Deng G, Li J, Li Y, Zhang Y, Zhao Q. How schooling and lifestyle factors effect neck and shoulder pain? A cross-sectional survey of adolescents in China. *Spine* 2014;39:E276–83.
26. Associação Brasileira de Normas e Técnicas (ABNT). Norma Brasileira Regulamentadora – NBR 14006 /2008. Móveis estudantes: cadeiras e mesas para conjunto individual aluno individual. Rio de Janeiro: ABNT; 2008.
27. Desouzart G, Gagulić S. Analysis of postural changes in 2nd cycle students of elementary school. *J Spine* 2017;6:357.
28. Furlanetto TS, Sedrez JA, Candotti CT, Loss JF. Photogrammetry as a tool for the postural evaluation of the spine: a systematic review. *World J Orthoped* 2016;7:136–48.
29. Barczyk-Pawełec K, Piechura JR, Dziubek W, Rożek K. Evaluation of isokinetic trunk muscle strength in adolescents with normal and abnormal postures. *J Manip Physiol Ther* 2015; 38:484–92.