ORIGINAL ARTICLE

Postural assessment: quantitative evaluation of static posture in children from six to ten years old

Avaliação postural: avaliação quantitativa da postura estática de crianças de seis a dez anos de idade

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ABSTRACT

Static postural evaluation of children allows for identifying and preventing musculoskeletal disorders in the early stages. **Objective:** To evaluate the static posture of students at a public school, comparing age groups and sex. **Methods:** The sample consisted of 130 schoolchildren (62 males and 68 females) who were 6-10 years old. Each student was photographed at the anterior, posterior, and right lateral views, and the photographic records were analyzed with the Software Postural Assessment (SAPo). **Results:** The ankle angle was different between sexes, presenting interaction between sex and age group. Regarding age groups, the horizontal alignment of acromion processes and horizontal alignment of the head were different between 6-7 and 9 years. The horizontal alignment of the head, the horizontal alignment of the anterior superior iliac spines, and the sagittal alignment of the lower limb also showed a significant interaction between sex and age group. **Conclusion:** On average, most results show a vertical alignment and a horizontal symmetry in the analyzed angles. However, the sagittal alignment of the lower limb, ankle angle, and sagittal alignment of the body did not maintain satisfactory alignment. The participants of our study presented good musculoskeletal health.

Keywords: Posture, Musculoskeletal Diseases, Child Development, Software

RESUMO

A avaliação da postura corporal estática de crianças permite identificar e prevenir desordens musculoesqueléticas no estágio inicial. **Objetivo:** Avaliar a postura estática de alunos de uma escola pública, comparando a postura entre as faixas etárias e entre os sexos. **Métodos:** A amostra foi composta por 130 escolares (62 do sexo masculino e 68 do sexo feminino), os quais tinham entre 6 e 10 anos de idade. Cada escolar foi fotografado nas vistas anterior, posterior e lateral direita, e o registro fotográfico foi analisado por meio do Software de Avaliação Postural (SAPo). **Resultados:** Somente foi encontrada diferença entre os sexos no ângulo do tornozelo, além de interação entre sexo e faixa etária. Em relação à idade, o alinhamento horizontal dos acrômios e o alinhamento horizontal da cabeça foram diferentes entre 6-7 e 9 anos. O alinhamento horizontal da cabeça, o alinhamento horizontal das espinhas ilíacas ântero-superior (EIAS) e o alinhamento sagital do membro inferior também apresentaram interação significativa entre sexo e idade. **Conclusão:** Em média, a maioria dos resultados demonstra que há um alinhamento vertical e uma simetria horizontal nos ângulos analisados, com exceção do alinhamento sagital do membro inferior, do ângulo do tornozelo e do alinhamento sagital do corpo que não demostraram um alinhamento próximo do ideal. Logo, os escolares avaliados apresentam uma boa saúde musculoesquelética.

Palavras-chaves: Postura, Doenças Musculoesqueléticas, Desenvolvimento Infantil, Software

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INTRODUCTION

Several studies have reported a high prevalence of postural changes in children and adolescents.[1-5] This high prevalence is correlated with some risk factors such as obesity, excess load, and the type of backpack used by schoolchildren, considering the recurrence of postural alterations among students of the same age group.[6]

These postural changes are considered risk factors for degenerative spine conditions in adult life during childhood, whose common symptom is pain.[7] Poor posture can damage the respiratory system and, consequently, the central nervous system, possibly causing memory and learning disorders among the young.[8] In addition, it is known that 49% of students with low back pain carry their backpacks in the wrong way, causing the probability to develop low back pain to be 1.83 times as high as those who carried them properly.[8] Also, associations between incorrect postural habits and the presence of pain during activities such as watching television, playing video games, and standing have been found.9 Likewise, these inappropriate habits during childhood increase the chances of developing postural alterations.[2,3,10]

Childhood comprises the period in which postural changes are more effectively recovered.[11,12] Therefore, early preventive measures should be applied to assess postural changes and educate children about the appropriate postures to study, carry their school supplies, and practice guided physical exercises, avoiding the deterioration of the musculoskeletal system.[3] Hence, Dugan[13] demonstrates the importance of benefiting from this early stage of development to correct posture neglect, considering the overall flexibility of young individuals' bodies.

The literature brings little quantitative information about the postural alignment of children.[14] In the study by Lafond et al.[14] one of the few studies that conducted a quantitative assessment, the authors report a postural evolution from 4 to 12 years of age. This phase is characterized by an anterior displacement of the head, shoulders, hips, and knees in the sagittal plane. Also, these authors found differences between the sexes for all variables except for head displacement.

Camargo & Fujisawa[15] compared preschool and school stages and found that the position of the head, neck, and shoulders undergoes changes, especially concerning the forward posture of the shoulders and head. Furthermore, monitoring the children's postural evolution assures that weight-related changes begin during preschool, influencing the posture in subsequent phases along the children's growth and development.

Applying a qualitative posture assessment, Penha et al.[11] also found differences between the sexes in children aged 7 to 10 years. They showed that boys have a higher incidence of postural problems, such as winged scapula, unevenness and protraction of the shoulder, protraction of the head, and cervical hyperlordosis, whereas girls have a higher incidence of head tilt. Furthermore, other authors observed that, except for the scapular abduction, changes in the shoulder girdle were more significant in girls when compared to boys, whereas a greater number of abducted scapulae was found among boys.[16]

Regarding the difference between both sexes, Batistão et al.[17] reported a higher prevalence of winged scapulae among boys and an association of winged scapulae with age, BMI, and head protraction. Also, shoulder elevation was associated with increasing age.

By analyzing schoolchildren in the sagittal plane and upright posture, Araújo et al.[18] demonstrated that both genders presented a flat pattern, however, this trend was more prevalent among boys. Furthermore, they reported that oscillating and “neutral to hyperlordotic” patterns were identified among girls, whereas “oscillating to neutral” and hyperlordotic patterns were observed among boys. Therefore, due to the high incidence of postural deviations and the lack of quantitative studies on postural changes in children, the principal objective of this study was to evaluate the static posture of children.

OBJECTIVE

Other objectives include comparing the static posture between both sexes and ages 6 to 10 years.

METHODS

The study sample consisted of 130 children (62 males and 68 females) aged 6 to 10 years, measuring 1.23m to 1.43m in height, weighing 23.19 kg to 34.19kg (Table 1). All children came from a city school in Petrolina, State of Pernambuco, Brazil.

This study was approved by the Institutional Research Ethics Committee approved under protocol number 0013/270812 and authorized by the City Education Department. The Informed Consent Form was obtained from a responsible party, either parents or tutors of the participants.

Table 1. Sample characteristics (n= 130) with the body mass and height mean (standard deviation)

	6 a 7 years		8 years		9 years		10 years	
	♂	♀	♂	♀	♂	♀	♂	♀
	(n= 17)	(n= 16)	(n= 12)	(n= 10)	(n= 18)	(n= 19)	(n= 15)	(n= 23)
Height (m)	1,23 (0,07)	1,22 (0,06)	1,31 (0,05)	1,30 (0,04)	1,37 (0,07)	1,34 (0,06)	1,41 (0,06)	1,43 (0,07)
Weight (kg)	24,84 (5,59)	23,19 (3,22)	27,17 (5,48)	26,49 (2,92)	31,07 (6,79)	27,73 (4,44)	34,19 (6,85)	32,09 (8,21)

(m) meters; (kg) kilogram; ♂male; ♀female

Data collection was conducted individually with the student wearing appropriate clothing in a reserved room at the school. For data acquisition, we used a digital camera (Sony DSC-W320) fixed to a 0.81m high tripod and 2.55m away from the child's position. The level bubble of the tripod was used to assure that the tripod was leveled, and a bubble level ruler was used to assure the horizontal position of the camera.

Spherical reflective markers were positioned on body spots that should be visualized in more than one view of the chin, glabella, earlobes, acromion process, greater trochanters, and knee joint line. Flat reflective markers were positioned over the inferior angle of the scapulae, posterosuperior iliac spines (PSIS), anterior superior iliac spines (ASIS), and lateral malleolus.

After placing the markers, the participant was positioned so that the plane to be analyzed was perpendicular to the optical axis of the camera. Then, photographic records were captured, in which, according to the study by Santos et al.[19] before the images were collected for each view, the child walked for a few seconds and stopped at the spot within the camera view, standing at a comfortable position. This strategy was used to obtain the most natural possible body posture. Also, according to Sacco et al.[20] participants were photographed with the elbows flexed at 90º in the right lateral view and extended in the anterior and posterior views.

The images were analyzed with the Postural Assessment Software (SAPo), given its validity[20] and intra-rater and inter-rater reproducibility.[19,21,22] According to the study by Sacco et al.[20] an examiner familiarized with SAPo, analyzed the static posture of all participants. The examiner was instructed to comply with the following procedure: open the image, adjust the zoom to 100%, mark the anatomical spots of the angle to be analyzed with the free-angle measuring tool, and collect the angle measurements in degrees, which should be positive counterclockwise.

The anterior view angles retained for analysis were head tilt, horizontal alignment of the acromion processes, horizontal alignment of the ASIS, the angle between the two acromion processes, and the two ASIS. In the lateral view, the angles recorded and analyzed were the horizontal alignment of the head, sagittal alignment of the lower limb, ankle angle, vertical alignment of the body, and sagittal alignment of the body. At last, in the posterior view, the angles selected for analysis were the PSIS's horizontal alignment and the scapulae's horizontal alignment. All these angular measures were evaluated according to Ferreira et al. references.[23]

Regarding the statistical analysis, the data normality was tested with the Shapiro-Wilk test and the homogeneity of variance with Levene's test. Although normality was not found for the horizontal alignment of the ASIS variables for the age group of 8 years nor the sagittal alignment of the body for the age group of 6 and 7 years, a two-way ANOVA was applied to compare the static posture between both sexes and the age groups. This approach was chosen because only two variables were not considered parametric among 11 variables and because ANOVA is considered a robust statistical analysis even when normality is not established.[24]

When homogeneity was not found, the Games-Howell post hoc analysis was performed as recommended by Field to identify differences between age groups.[25] In the other cases, the Bonferroni post hoc test was used. The significance level adopted for all tests was $\alpha < 0.05$. All statistical analyses were conducted with SPSS software (version 22.0 for Windows).

RESULTS

The present study analyzed the static posture of children by comparing sex and age groups and evaluating the interaction between sex and age group. Table 2 presents the results of the angles analyzed for each sex. A significant difference was found only in the ankle angle in the sex comparison.

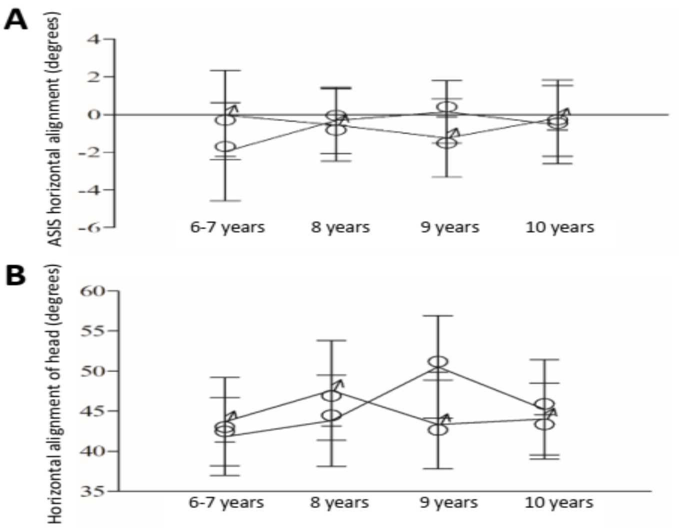
Figures 1 and 2 illustrate the results of the variables that achieved a significant interaction effect. For such variables, the analysis considered both factors, gender and age group.

Table 3 demonstrates the results of the angles analyzed for each age group. A significant difference was found in the horizontal alignment of the acromion processes and the head in comparing age groups of 6 and 7 years and 9 years of age.

Table 2. Mean (standard deviation) or the analyzed angles according to sex in the static posture for the anterior, lateral, and posterior views

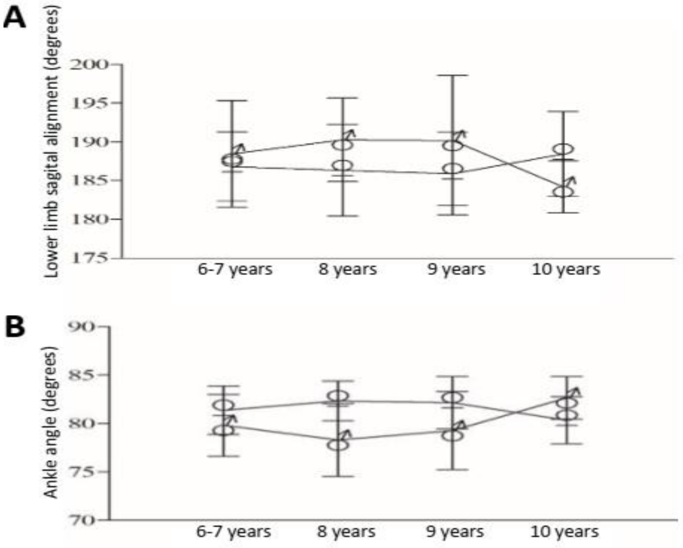
Variables (degrees)	Male (n= 62)	Female (n= 68)
Head tilt	89,92 (2,86)	89,88 (3,31)
Horizontal alignment of acromion processes	-0,65 (2,32)	-0,34 (2,12)
ASIS horizontal alignment	-0,52 (2,13)	-0,65 (2,17)
Angle between acromion processes and ASIS	0,01 (2,95)	0,35 (3,42)
Horizontal alignment of the head	44,43 (5,53)	45,71 (6,63)
Sagittal alignment of the lower limb	188,27 (6,76)	187,02 (5,27)
Ankle angle	80,06 (3,64)*	81,38 (2,55)*
Body vertical alignment	-1,99 (1,54)	-1,67 (1,49)
Body sagittal alignment	190,20 (4,30)	189,62 (3,59)
PSIS horizontal alignment	-1,04 (2,84)	-0,83 (2,20)
Horizontal alignment of scapula	-1,10 (3,21)	-0,93 (2,83)

** Statistically significant difference between both sexes (p=0.005); ASIS, anterior superior iliac spines; PSIS, Posterosuperior iliac spines*



♂male; ♀female

Figure 1. Effect of the interaction between age group and horizontal alignment of ASIS (A) and the horizontal alignment of the head (B)



♂male; ♀female

Figure 2. Effect of the interaction between sex and age groups in the sagittal alignment of the lower limb (A) and the ankle angle (B)

Table 3. Mean (standard deviation) of the analyzed angles, according to age group in the anterior, lateral, and posterior views

Variables (degrees)	6-7 years (n= 33)	8 years (n= 22)	9 years (n= 37)	10 years (n= 38)
Head tilt	90,58 (2,87)	88,69 (3,57)	89,35 (3,03)	90,55 (2,83)
Horizontal alignment of acromion processes	0,30 (2,95)*	-0,69 (2,04)	-1,15 (1,91)*	-0,41 (1,62)
ASIS horizontal Alignment	-0,97 (2,64)	-0,44 (1,80)	-0,53 (1,97)	-0,40 (2,04)
Angle between acromion processes and ASIS	1,25 (4,10)	-0,12 (2,55)	-0,59 (3,13)	0,21 (2,49)
Horizontal alignment of the head	42,79 (5,20)†	45,89 (6,16)	47,04 (6,94)†	44,76 (5,55)
Sagittal alignment of the lower limb	187,65 (5,81)	188,47 (5,86)	187,97 (7,22)	186,76 (5,14)
Ankle angle	80,57 (2,94)	80,14 (3,66)	80,76 (3,66)	81,25 (2,58)
Body vertical alignment	-1,47 (1,63)	-2,14 (1,32)	-1,86 (1,47)	-1,90 (1,56)
Body sagittal alignment	190,92 (3,89)	189,50 (5,49)	189,86 (3,56)	189,27 (3,20)
PSIS horizontal alignment	-0,89 (2,56)	-1,47 (2,44)	-0,45 (2,78)	-1,12 (2,26)
Horizontal alignment of the scapula	-0,88 (3,66)	0,26 (2,07)	-1,09 (2,85)	-1,78 (2,85)

** Statistically significant difference of acromion processes horizontal alignment between age groups of 6-7 and 9 years (p=0.037); † statistically significant difference of horizontal alignment of the head between age groups of 6-7 and 9 years (p=0.016); ASIS, anterior superior iliac spines; PSIS, Posterosuperior iliac spines*

DISCUSSION

The assessment of static body posture of children allows the identification and prevention of the development of musculoskeletal disorders in the early phases of life.[14] Therefore, the present study quantitatively analyzed the static posture variables of children, comparing body posture between sex and age groups.

Our results found only significant differences in the ankle angle when both sexes are compared. However, as interactions between sex and age groups were found for this variable, the evidence is that the ankle angle differs between boys and girls in the age groups of 8 and 9 years. This result can be explained by the sagittal alignment of the lower limb.

In these age groups, girls have a smaller angle, indicating that they may have a less flexed knee, making the ankle angle different between both sexes. Although girls present a smaller angle or a lesser flexed knee when compared to boys, on average, they do not present hyperextension, comprising the typical postural deviation among girls, according to Penha et al.[26] Furthermore, our study agrees with Penha et al.[26] as the frequency of knee hyperextension for the ages of seven to ten years in girls was, respectively, 67%, 64%, 55%, and 48%, demonstrating less knee flexion. Also, Chagas & Rodrigues[27] emphasize that their research suggested a higher prevalence of knee deviations in females and hip deviations in males.

The horizontal alignment of the acromion processes was different between age groups of 6-7 years and 9 years old. This difference indicates that, on average, the right shoulder of children from the older group tends to be higher than the left. This result may be due to school furniture.[1,19]

In the school where this study was conducted, younger students use chairs and tables that are more appropriate for their body dimensions, while older students use classroom chairs with writing pads. This chair can lead to an asymmetry in the position of the shoulders. Furthermore, Penha et al.[26] associate the presence of this asymmetry with the children's dominant side, as it promotes uneven muscle hypertrophy, causing an elevation of the dominant shoulder.

The horizontal alignment of the head also showed a difference between 6-7 and 9 years of age. However, this angle also showed a significant interaction between sex and age. Therefore, the angles seem to be similar regardless of the sex in the age group of 6-7 years and 8 years. At nine years of age, girls present a greater angle when compared to boys, and this may be due to a rectification of the cervical spine. This result agrees with Penha et al.[11] who reported a higher percentage of cervical spine rectification among girls.

Another variable that showed a significant correlation between sex and age group was the horizontal alignment of the ASIS. At 6-7 years of age, girls have asymmetry, in which the left side is lower, while boys are symmetric on average. Oppositely, at age 9, this result is inverted, whereas, at 10 years of age, both groups present a similar average result, close to perfect symmetry, that is, an angle close to 0°.

According to Lafond et al.[14] vertical alignment within the ideal references indicates good musculoskeletal health. Hence, we considered that the students included in our study have good musculoskeletal health, as they present satisfactory horizontal alignment of the head and vertical alignment of the body.

Nevertheless, it is also important to emphasize that three body angles contradict this perfect alignment: the sagittal alignment of the lower limb, the ankle angle, and the sagittal alignment of the body. On average, the first angle exceeded 180°, and the second was narrower than 90°, indicating that their knees are slightly flexed, leading to a smaller ankle angle.

This result may be due to the restricted flexibility of the hamstrings. This issue has been discussed in some studies that indicate most students do not reach the minimum flexibility criteria established as reference,[28-30] considering that the hamstrings' flexibility influences body posture.[31,32] This can be explained by the dependence of the hip and knee joint on the thigh posterior muscles actuation,[33] as the shortening of this musculature causes postural changes in the lower limb.

The third angle, the sagittal alignment of the body, was greater than 180° on average. This finding indicates that the hip is positioned anterior to the body, that is, it represents pelvic antepulsion. Pelvic antepulsion is a typical posture among girls.[26]

Lafond et al.[14] also identified an anterior displacement of the head, shoulders, hips, and knees during childhood. In other words, this characteristic agrees with our results concerning the three variables mentioned above.

Other research, also in line with the findings of this publication, evaluated the development of children during preschool and school stages and indicated the forward head position and the presence of shoulder protrusion during this period. These deviations can be justified by the musculoskeletal maturation adaptive to the sagittal balance, which can be favored or worsened according to the postural habits.[15]

It is essential to highlight that all those responsible for the evaluated students, the teachers, and the school administration were given reports of each student, specifying those who required specialized attention. Also, professional lectures were conducted on healthy postural habits for students and teachers. These reports and lectures can help teachers become agents for preventing bad postural habits, postural deviations, and back pain.

Additionally, it is also important to recognize the limitations of the present study, such as the absence of a flexibility test, assessment of students from other schools in the city, hindering the postural characterization of children in entire the region, the lack of information on the dynamic posture during classes and outside the school environment, and on the physical fitness of children. This information could help the understanding of our results.

Studies on postural habits in children outline possible postural deviations and the most prevalent postural problems in this population. Moreover, they are meaningful for physical rehabilitation, helping health professionals to improve the therapeutic prescription according to their knowledge of such deviations.

CONCLUSION

In the present study, ankle angle differences were found between both sexes and interactions between sex and age groups. Regarding age, the horizontal alignment of the acromion processes and the horizontal alignment of the head were different between 6-7 and 9 years old.

The horizontal alignment of the head, the horizontal alignment of the ASIS, and the sagittal alignment of the lower limb also showed a significant interaction between sex and age.

Based on our findings, we concluded that the participants have good musculoskeletal health, as, on average, most of the results demonstrate vertical alignment and a horizontal symmetry of the analyzed angles. Among the eleven variables analyzed in posture, three (sagittal alignment of the lower limb, ankle angle, and sagittal alignment of the body) presented alignments different from healthy references, on average.

New research is essential for health professionals, including physical education trainers and physiotherapists, given the importance of preventing and diagnosing postural deviations at younger ages, enabling correct postural standards in adult life.

Therefore, it is recommended to conduct similar studies to gather more data on the static posture of children. Another suggestion would be to evaluate the effect of theoretical and practical interventions on the static posture of children, in addition to verifying the effect of other variables, such as the weight of school supplies, dynamic posture, flexibility, nutritional habits, and physical activity level, verifying which of these variables have the most significant effects on posture.

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