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RESEARCH PAPER (ORIGINAL)

Photogrammetric Analysis of Posture and Associated Risk Factors in School-Aged Children and Adolescents

Análise por Fotogrametria da Postura e Fatores de Risco Associados em Crianças e Adolescentes Escolarizados

Análisis por Fotogrametría de la Postura y Factores de Riesgo Asociados en Niños y Adolescentes Escolarizados

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Abstract

Theoretical framework: Several spinal problems and misalignments begin during puberty and can be associated to poor posture.
Objetives: To characterise the posture of children and adolescents by searching for associations with sociodemographic, behavioural, anthropometric, and clinical variables.
Methodology: Cross-sectional analytical study using *photogrammetry* in a sample consisting of 135 participants, aged between 6 and 18 years.
Results: The weight of the backpack was inadequate (>15% of body weight) in 10% of cases. The prevalence of low back pain associated to the type of footwear and Adam's test was 37.8%. Students with positive Adam's test are older, heavier, taller, more sedentary, and carry excessive weight in their backpacks. Significant gender differences were observed in the anterior view for both Q-angles, with girls tending to physiologic genu valgum). In the right and left lateral views, the results in the Adam's test varied significantly, with participants with positive Adam's test tending to a forward head posture.
Conclusion: The results underline the importance of implementing programs directed to postural education

Keywords: Photogrammetry; posture; child; adolescent; risk factors

Resumo

Enquadramento: Muitos problemas e desalinhamentos vertebrais têm a sua origem na puberdade, podendo estar associados à má postura.
Objetivos: Caracterizar a postura de crianças e adolescentes procurando associações com variáveis sociodemográficas, comportamentais, antropométricas e clínicas.
Metodologia: Estudo analítico/transversal realizado por fotogrametria numa amostra constituída por 135 participantes, com idades entre os 6 e os 18 anos.
Resultados: O peso da mochila é inadequado (>15% da massa corporal) em 10 % dos casos. A prevalência de lombalgia foi de 37,8% associando-se ao tipo de calçado e teste de Adams. Estudantes com Adams positivo são mais velhos, mais pesados, mais altos, mais sedentários e transportam mais peso nas mochilas. Diferenças significativas entre sexos foram observadas na vista anterior para ambos os ângulos quadricipitais, tendendo as raparigas para genu valgo fisiológico. Nas vistas laterias direita e esquerda os resultados variaram de forma significativa de acordo com o teste de Adams, tendendo os participantes com Adams positivo para a anteriorização.
Conclusão: Os resultados evidenciam a importância da implementação de programas direcionados à educação postural.

Palavras-chave: Fotogrametria; postura; criança; adolescente; fatores de risco

Resumen

Marco contextual: muchos problemas y desalineamientos vertebrales tienen su origen en la pubertad y pueden estar asociados a una mala postura.
Objetivos: caracterizar la postura de niños y adolescentes buscando asociaciones con variables sociodemográficas, comportamentales, antropométricas y clínicas.
Metodología: estudio analítico de corte transversal realizado por *fotogrametría* en una muestra de 135 participantes con edades comprendidas entre los 6 y los 18 años.
Resultados: el peso de la mochila es inapropiado (>15 % del peso corporal) en el 10 % de los casos. La prevalencia del dolor de espalda fue del 37,8 %, *asociándose* con el tipo de calzado y la prueba de Adams. Los alumnos con Adams positivo son mayores, presentan más peso y talla, son más sedentarios y cargan mochilas más pesadas. Se observaron diferencias significativas de género en la vista anterior para ambos ángulos cuadricipitales, con tendencia en las niñas al valguismo fisiológico. En ambas vistas de perfil los resultados variaron significativamente según la prueba de Adams. Los participantes con Adams positivo tendían a la anteriorización.
Conclusión: los resultados destacan la importancia de implementar programas dirigidos a la educación postural.

Palabras clave: Fotogrametría; postura; niño; adolescente; factores de riesgo

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Introduction

Intervertebral discs and ligaments, units that make up the vertebral building, undergo processes of deterioration throughout the life cycle and have no intrinsic effective mechanisms of regeneration (Smith, Nerurkar, Choi, Harfe, & Elliott, 2011). Many postural problems develop during childhood and adolescence, which is a period of body development (Lafond, Descarreaux, Normand, & Harrison, 2007). On the one hand, growing up may have a deleterious effect on posture when the development of the muscles does not keep up with the rapid bone formation; on the other hand, children and adolescents are prone to developing risk behaviours that lead to postural changes (Detsch & Candotti, 2001). Finally, the musculoskeletal system, still in a process of maturation and adaptation, is more susceptible to deformation and has less load-bearing capacity.

It is therefore important to assess posture in this age group, since the prevalence of spinal deformities is high and the early diagnosis of these situations seems to provide good results either through the implementation of adequate postural correction programs or through a timely treatment.

We have designed an observational, cross-sectional and analytical study with a sample of 135 children and adolescents from a school cluster of the district of Braganza (Portugal). The study was conducted between October 2013 and March 2014. To meet our main objective of assessing student posture using photogrammetry, the following specific objectives were formulated: a) To characterize the study participants using sociodemographic variables; b) To describe how the school material is carried and the weight of the backpacks; c) To assess sedentary behaviours and determine the level of physical activity; d) To determine the prevalence of back pain; e) To assess deviations using Adam's test; and f) To compare the results of posture analysis using photogrammetry with reference values and other independent variables.

Background

In the traditional view of Kendall (1999), posture results from the interconnection of several static and dynamic factors and the consonance between the nervous and musculoskeletal systems to provide an adjusted balance in space. In the ideal model of postural alignment, and from a side view, the plumb line should be in a slightly anterior position to the external malleolus and the knee joint axis, as well as pass slightly posterior to the axis of the hip joint, the lumbar vertebral bodies, the shoulder joint, the majority of the cervical vertebrae and the external auditory meatus (Kendall, 1999). However, designing an ideal posture is a difficult task, given that this is also an individual characteristic, associated with self-image, genetic, psychological and physiological factors, and motor and postural habits (Detsch & Candotti, 2001). During childhood and adolescence, the posture adapts to the peak of body growth. In these phases, the posture searches for the harmonious balance between the new proportions of the body and the image perceived by the young person. The quantitative data available for understanding youth posture are scarce, and the importance of different integrative studies is all too obvious (Santos, Silva, Sanada, & Alves, 2009).

One of the methods of quantitative postural evaluation consists in photogrammetry, using photographic analysis software (examples: SAPO, Corel Draw, Posture Pro) where postural changes are objectively quantified, enabling an effective comparison between individuals and between the various stages of individual evolution (Ferreira, 2005). The knowledge resulting from photogrammetric studies may explain the early detection and intervention on disorders of the growing musculoskeletal system (Santos et al., 2009).

The state of the art allows identifying risk factors for posture and back pain. With regard to posture, we underline the long periods of time that children and adolescents spend sitting (Prins, Crous, & Louw, 2008), their high Body Mass Index (BMI), poor physical activity and marked sedentary behaviours (Kratenová, Zejglicová, Malý, & Filipová, 2007), the weight of the backpacks (Ries, Martinello, Medeiros, Cardoso, & Santos, 2012), and the presence of hump deformities (Minghelli et al., 2009). With regard to risk factors of back pain in adolescents, Cruz and Nunes (2012), in a recent thematic review, identified gender as the most significant risk factor, followed by age, as back pain increases as people get older.

Research Questions

We have formulated the following analytical objectives/ research hypotheses:
H1- The prevalence of back pain over the last year was higher in girls;
H2- The participants who use heels greater than or equal to 5 cm report more back pain over the last year;
H3- The participants with positive Adam's test have a higher prevalence of back pain;
H4- Less active children and adolescents have a higher prevalence of back pain;
H5- The means obtained in anthropometric variables vary significantly according to the categories of the variable Adam's test;
H6- The mean angle values in the anterior and posterior view vary significantly according to the categories of the dichotomous variable back pain;
H7- The mean angle values of postural angles in right and left lateral views vary in the categories of the variable Adam's test.

Methodology

An analytical, cross-sectional and quantitative study was conducted. The research focused on students of a school cluster of the district of Braganza (Portugal) with the following levels of education: Basic (1st to 9th grade) and secondary education (*N*= 1300). The only inclusion criteria were: Prior authorization from parents and belonging to the stratum/class of the sample. Using a stratified random sampling, the sample included 135 children and adolescents aged between 6 and 18 years (11.88±3.67 years) attending different grades, with most of them being girls (51.1%).

As data collection tool, we used a structured questionnaire divided into three parts. The first part concerned the sociodemographic variables, sports inside and outside the school, assessment of sedentary behaviours and prevalence of back pain over the last year. The second part examined the Physical Activity Level (PAL) through the short version of the International Physical Activity Questionnaire (IPAQ) proposed by Craig et al. (2003) which classifies the PAL at three levels: Low, moderate and high. The last part included anthropometric variables, the weight of the backpack and the results of the Adam's test. This test is the standard procedure for early detection of misalignments and hump deformities. In the Adam's test, the classic recommendations were followed: The examiner is placed in posterior position; the participant is positioned in anterior trunk flexion with the upper limbs forward until the point of maximum curvature, palms of both hands touching each other, feet together and knees extended. The test was considered positive if any hump deformity, gap and/or thoracolumbar curvatures were found in the torso side view. Back pain over the last 12 months was assessed on a Likert-type scale (0=*never*; 1=*rarely*; 2=*sometimes*; 3=*often*, 4=*very often*) and considered prevalent if participants reported back pain as *often* or *very often*.

The weight of the backpack, including the school material, was calculated using a digital scale. The percentage regarding its weight was obtained by dividing the weight of the backpack (kg) by the body mass (kg). The backpacks were considered appropriate if the weight was equal to or less than 10% of the body mass; acceptable if the weight did not exceed 15% of the body mass; and inadequate if the weight was higher than 15% of the body mass, as according to the literature (Limon, Valinsky, & Ben-Shalom, 2004).

Posture was assessed using the photogrammetry software PAS SAPO (Postural Assessment Software) developed by the University of Sao Paulo (Ferreira, 2005) and whose reliability is well documented (Ferreira, Duarte, Maldonado, Burke, & Marques, 2010). This software allows importing and calibrating images, marking points in the photo according to protocol, measuring intervals and marking points to determine angles. The SAPO also generates reports of analyses that can be saved and exported to Windows. In the anterior and lateral views, we followed the points defined by the SAPO protocol; in the posterior view, we analysed the horizontality of the shoulders by marking the points.

The points were marked with white round stickers, using surface palpation, in accordance with the protocol. Each participant was placed in the orthostatic position and the same sentence was always used as verbal stimulus *Please stay as straight as possible*. Four photographs were taken for each patient, one in each anatomical view. An exercise mat was used to keep the same support. To minimize errors, the photos were taken by the same researcher. The camera (8 megapixels) was set on a tripod, levelled, and set 1 meter above the ground and at a distance of 3 meters from the subject to be photographed.

The following formal procedures should be highlighted: We contacted the physical education teachers to ask for the photos to be taken during the classes. In each class, the days of assessment were scheduled, and the students were asked to bring swimwear (if possible) or knee length shorts and fitted sweaters. The following ethical procedures should be highlighted: The study protocol was sent to the Board of the School Clusters which, after authorisation from the Pedagogical Council, authorized the research study. The students received a document with information/authorization to be read and signed by the parents/guardians. All students were informed about the objectives of the study and voluntarily agreed to participate.

Data were subsequently entered in the software SPSS (Statistical Package for the Social Sciences), version 20. We used non-parametric tests (Chi-square), the simple linear regression model (outliers) and a parametric test (t-test) for independent samples (with Levene's test for homogeneity of variances). The results were analysed and discussed using the significance level of $p < 0.05$.

Results

In Table 1, we characterize the participants ($n=135$) using sociodemographic and behavioural variables and show how these variables work in each of the categories of the dichotomous variable back pain, analysing possible associations using the chi-square test (c^2). Thus, 51 students (37.8%) reported having felt back pain very often over the last year. The school material was essentially carried in the backpack with straps on both shoulders (71.9%). Only 4.4% used the trolley. In behavioural terms, most participants spent 1 to 2 hours per day on the computer, but, on the other hand, a significant percentage (56.3%) of students practiced sports outside of the school. The LPA obtained in the IPAQ was classified as high (51.9%), moderate (41.5%), and low (6.7%). Back pain was found to be associated with the type of footwear and the results of the Adam's test and obtained a prevalence of 34.8% in boys and 40.6% in girls.

Table 1
Association between sociodemographic and behavioural variables and the variable back pain

		Sample *n* (%)	Back pain		p^1
			Yes *n* (%)	No *n* (%)	
Gender	Male	66 (48.9%)	23 (34.8%)	43 (65.2%)	0.492
	Female	69 (51.1%)	28 (40.6%)	41 (59.4%)	
How the backpack is carried	Straps on both shoulders	97 (71.9%)	31 (32.0%)	66 (68.0%)	-
	Strap on one shoulder	25 (18.5%)	13 (52.0%)	12 (48.0%)	
	Trolley	6 (4.4%)	3 (50.0%)	3 (50.0%)	
	In the hand	2 (1.5%)	1 (50.0%)	1 (50.0%)	
	Left in the locker	1 (0.7%)	1 (100.0%)	0 (0.0%)	
	Shoulder bag	4 (3.0%)	2 (50.0%)	2 (50.0%)	
Type of footwear	Sports shoes	104 (77.0%)	34 (32.7%)	70 (67.3%)	0.026
	Heel ≤5cm	31 (23.0%)	17 (54.8%)	14 (45.2%)	
Adam's Test	Positive	63 (46.7%)	33 (52.4%)	30 (47.6%)	0.001
	Negative	72 (53.3%)	18 (25.0%)	54 (75.0%)	
After-school sports	Yes	76 (56.3%)	31 (40.8%)	45 (59.2%)	0.413
	No	59 (43.7%)	20 (33.9%)	39 (66.1%)	
Computer time per day	0	12 (8.9%)	3 (25.0%)	9 (75.0%)	-
	1 to 2 hours	109 (80.7%)	45 (41.3%)	64 (58.7%)	
	3 to 4 hours	13 (9.6%)	3 (23.1%)	10 (76.9%)	
	5 hours or more	1 (0.7%)	0 (0.0%)	1 (100.0%)	
Level of Physical Activity	Low LPA	9 (6.7%)	4 (44.4%)	5 (55.6%)	0.471
	Moderate LPA	56 (41.5%)	24 (42.9%)	32 (57.61%)	
	High LPA	70 (51.9%)	23 (32.9%)	47 (67.1%)	

[1]Pearson's chi-square test; LPA= Level of Physical Activity

We found a mean BMI close to 20 Kg/m^2, for a standard deviation of 3.20 Kg/m^2 (Table 2). We obtained the following distribution, using the classification of the World Health Organization (WHO): Severe thinness (8.1%), moderate thinness (9.1%), mild thinness (23.7%), normal range (50.4%), and overweight (8.1%).

The mean age of participants who scored positive in Adam's test was significantly higher than the mean age of the other students (13.32±2.95 years; 10.63±3.79 years) which suggests that hump deformities and asymmetries are more marked in the period of development after childhood. In the same way, the participants who scored positive in Adam's test had higher and statistically significant mean scores in terms of weight (53.56±15.68 Kg; 41.40±14.18 kg), height measured in centimetres (159.48±12.40; 144.93±18.28) and BMI (20.68±3.59 Kg/m^2; 19.10±2.63 Kg/m^2). In short, and on average, participants who scored positive in Adam's test were older, heavier, taller, had higher BMI, and carried heavier backpacks.

The relative percentage of the backpack weight in this sample was 9.52 (±3.83%). We found that 60% of the students had appropriate backpacks, 30% had acceptable backpacks, and 10% had backpacks unsuitable for carrying more than 15% of body weight, which is considered to be a risk factor in the literature.

Table 2
Values found for anthropometric variables and backpack weight
Comparison between the mean values and the results of the Adam's test

	Sample (M±SD)	Adam's Test		p^1
		Positive (M±SD)	Negative (M±SD)	
Age (Years)	11.88±3.67	13.32±2.95	10.63±3.79	0.000
Weight (Kg)	47.08±15.68	53.56±14.87	41.40±14.18	0.000
Height (cm)	151.72±17.36	159.48±12.40	144.93±18.28	0.000
BMI (Kg/m^2)	19.84±3.20	20.68±3.59	19.10±2.63	0.004
Backpack weight (Kg)	4.15±1.46	4.67±1.32	3.71±1.43	0.000
% of backpack weight	9.52±3.83	9.41±3.74	9.63±3.93	0.742

[1]Independent sample t-test; M= Mean; SD= Standard deviation

The following tables show the descriptive statistics for the anterior view, the right lateral view, the left lateral view, and the posterior view, resulting from the postural assessment using SAPO software. We would like to clarify that the values with a negative sign refer to a deviation of the posture to the left side, whereas the positive numbers are anti-clockwise and relate to a postural deviation to the right side. Thus, in the posture in the anterior view (Table 3), the Horizontal Alignment of the Head (HAH), measured by the alignment of the right and left tragi, obtained an average deviation of 0.39º to the right. The Horizontal Alignment of the Acromia (HAA) also showed a deviation to the right, which translates into a predominant elevation of the left shoulder (0.75º±1.46º).

In the Horizontal Alignment of Antero-Superior Iliac Spines (HAASIS), a mean of 0.37º to the right was observed, indicating a predominance of elevation of the left anterior-superior iliac spine.

For both Right and Left Q-angles (RQA and LQA), we obtained significant differences between gender, with girls tending to greater angle values (valgus).

The inferential analysis of the variable *back pain* showed significant differences in the anterior view for the Horizontal Alignment of the Acromia (HAA); and in the posterior view for the Horizontal Alignment of the Shoulders (HAS). These results suggest asymmetries and misalignments in the scapulohumeral joint.

Table 3

Values for the postural angles in anterior view for the total sample and the categories of the variable back pain

	Reference value[1]	Sample (M±SD)	Back pain		*p*[2]
			Yes (M±SD)	No (M±SD)	
Anterior view					
HAH (°)	0	0.39±1.93	0.21±1.93	0.51±1.93	0.384
HAA (°)	0	0.75±1.46	0.94±1.34	0.45±1.60	0.049
HAASIS (°)	0	0.37±1.20	0.32±1.15	0.40±1.23	0.703
ATATASIS (°)	0	-0.39±1.62	0.32±1.15	0.40±1.23	0.208
FALRL (°)	N/A	-1.20±3.22	-1.47±2.73	-1.05±3.48	0.463
FALLL (°)	N/A	-2.02±3.36	-2.89±2.94	-1.60±3.51	0.069
LDLL (°)	0	0.22±0.57	0.15±0.53	0.26±0.59	0.251
HATT (°)	0	1.64±2.60	1.49±2.40	1.73±2.73	0.603
RQA (°)	15	17.48±4.56	17.26±4.08	17.62±4.85	0.659
LQA (°)	15	17.79±4.68	17.74±4.28	17.82±4.93	0.928
Posterior view					
HAS (°)	0	0.82±0.80	1.05±0.77	0.62±0.78	0.002

[1]SAPO-generated, [2]Independent sample *t*-test; M= Mean; SD= Standard Deviation; HHA= Horizontal Alignment of the Head; AHA= Horizontal Alignment of the Acromia; HAASIS= Horizontal Alignment of Anterior-Superior Iliac Spines; ATATASIS= Angle between the two Acromia and the two Anterior-Superior Iliac Spines; FALRL= Frontal Angle of Lower Right Limb; FALLL= Frontal Angle of Lower Left Limb; LDLL= Length Difference between Lower Limbs; HATT= Horizontal Alignment of Tibia Tuberosity; RQA = Right Q-Angle; LQA= Left Q-Angle; HAS= Horizontal Alignment of the Shoulders; N/A= Not available

The boxplot in the anterior view highlights the variables where alignment was more perfect (average values close to zero degrees). Thus, the Length Difference between Lower Limbs (LDLL) was practically inexistent. The parameters Right Q-Angle (RQA) and Left Q-Angle (LQA) were the measures with most extreme values and outliers.

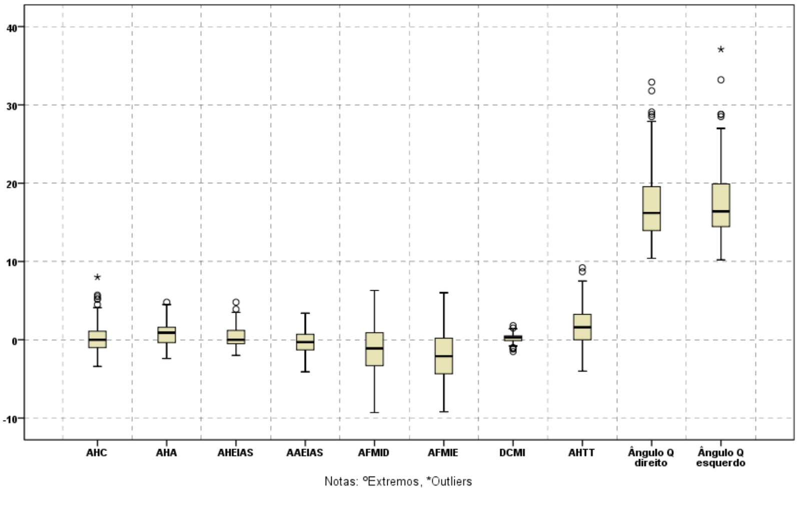

Figure 1. Boxplot of the measures in anterior view.

In Table 4, we highlight the forward head posture of the Vertical Alignment of the Head in relation to Acromion (VAHA) both to the right lateral view (5.28±6.83) and the left lateral view (6.29±5.68). However, it is interesting to note that, despite the head being generally bent forward in both lateral views, the vertical alignment of the trunk (defined by an imaginary line that starts in the acromion and

ends in the hip joint) obtained negative values, i.e. posterior bending, probably due to a compensatory rectification of the trunk in relation to the forward head posture.
In this way, children and adolescents with positive Adam's test showed greater asymmetries. In this group, a greater flexion/bent of the head forward was observed, with statistical significance in both lateral views. We also found more negative mean values for the Q-Angles (QA), in both lateral views, in participants with positive Adam's test, which suggests marked extension of the hip joint. The results also indicate a lower curvature of the cervical spine (straighter) in children and adolescents with positive Adam's test expressed in the higher mean angles obtained for the vertical alignment of the head with the seventh cervical vertebra (VAHCC7).

Table 4
Values for the postural angles in the right and left lateral views for the total sample and according to the categories of the variable Adam's test

	Reference value[1]	Sample (M±SD)	Adam's Test		p^2
			Positive (M±SD)	Negative (M±SD)	
Right lateral view					
HAHCC7 (°)	N/A	54.65±5.59	53.51±5.14	55.65±5.80	0.026
VAHA (°)	0	5.28±6.83	6.92±6.33	3.85±6.96	0.009
VAT (°)	N/A	-2.79±3.15	-3.22±3.19	-2.41±3.10	0.135
HA (°)	N/A	-4.36±5.01	-5.99±4.90	-2.93±4.69	0.000
VAB (°)	N/A	0.23±1.63	0.27±1.71	0.20±1.56	0.800
HAP (°)	N/A	-11.99±5.29	-11.75±4.59	-12.19±5.77	0.623
KA (°)	N/A	-1.16±4.13	-1.00±4.23	-1.30±4.07	0.682
Left lateral view					
HAHCC7 (°)	N/A	52.72±8.15	52.59±5.54	52.84±9.94	0.852
VAHA (°)	0	6.29±5.68	8.32±5.68	4.51±5.09	0.000
VAT (°)	N/A	-1.85±3.00	-1.87±2.75	-1.83±3.22	0.938
HA (°)	N/A	-4.85±4.53	-5.83±4.11	-3.99±4.72	0.018
VAB (°)	N/A	1.71±1.65	2.19±1.54	1.29±1.64	0.001
HAP (°)	N/A	-13.06±5.05	-13.26±4.96	-12.88±5.15	0.664
KA (°)	N/A	-1.80±4.45	-2.10±4.47	-1.53±4.45	0.463

[1]SAPO-generated, [2]Independent sample t-test; M= Mean; SD= Standard Deviation; SD= Side View; HAHCC7= Horizontal Alignment of the Head (C7); VAHA= Vertical Alignment of the Head (Acromion); VAT= Vertical Alignment of the Trunk; HA= Hip Angle; VAB= Vertical Alignment of the Body; HAP= Horizontal Alignment of the Pelvis; KA= Knee Angle; N/A= Not available

Discussion

We consider that the sample under analysis is relatively homogeneous in terms of gender, given that there was only a slight preponderance of girls (51.1%). The age of the participants ranged between 6 and 18 years and the arithmetic mean was 12 years. It is known that this period of development is structuring, not only in biological maturation and psycho-motor development, but also in terms of lifestyles. At this stage, the family, as primary responsible for the promotion of healthy behaviours, shares this role with the school. In this context, with teachers and peers, both children and adolescents consolidate their preferences for sports, eating habits and other behaviours. One of these healthy behaviours is the proper use of backpacks, an important aspect in school health. Studies conducted in schools have associated the use of backpacks with back pain, especially when the weight is more than 15% of body weight and the backpack is carried with the straps on one shoulder (Limon et al., 2004). In our study, 10% of backpacks were inadequate. Another study that we consulted found that 18% of backpacks were inadequate (Ries et al., 2012).
In our study, 71.9% of participants reported carrying the backpack on both shoulders, which indicates

good habits concerning the way they carry the school material. However, even when properly used, the overweight of the backpack influences posture, particularly in children and adolescents with an inappropriate weight (Ries et al., 2012).

Back pain had a prevalence of 37.8% for the last year. In a recent systematic literature review with the aim of studying the prevalence and risk factors of low back pain in adolescents, a prevalence of 37% at the present time, 38% in the last month, and 46.5% over the life cycle were obtained (Cruz & Nunes, 2012). By summarizing the literature findings we can say that back pain is common in children and adolescents, more prevalent in girls and in most cases it has no specific aetiology. Since adolescent back pain only rarely results from malignant, infectious or degenerative processes (Smith & Leggat, 2007), we are led to believe that it results from incorrect posture and an immature osteoarticular system.

Back pain was more prevalent in participants who wore heels. A possible explanation for our findings is that heels change the centre of gravity, which forces the body to constant biomechanical rebalances and musculoskeletal overload during gait.

Using the Adam's test, 46.7% people were identified as having some type of asymmetry in spine alignment or hump deformity. Our results are higher than those reported by some authors (Schiaffino, 2010) and lower than those reported in other studies (Minghelli et al., 2009). It should be noted that this test, although non-invasive, quick and simple to evaluate the spine and screen large populations, has no specific sensitivity for the diagnosis of scoliosis, which necessarily involves x-rays and the analysis of the angular measures using the Cobb method (Ferreira et al., 2010).

We concluded that there is an association between the variables of the Adam's test and back pain by crossing them using a chi-square contingency table (c^2). We found no consistent studies that had analysed this association; however, it is acceptable for us to suggest that greater asymmetry in the development of the paraspinal muscle leads to a higher prevalence of pain.

Given that the sample consisted of healthy children and adolescents, our findings do not differ much from normality as regards postural angles. However, and in line with Amantéa, Novaes, Campolongo, and Barros (2004), small anomalies lead to postural disharmony, and a small tension in a muscle chain is responsible for tensions and associated misalignments.

Thus, in the anterior view, as regards the Horizontal Alignment of the Acromia (HAA), for a reference value of 0^o, we found an average misalignment of 0.75^o ($\pm 1.46^o$), which indicates a slight tendency to tilt the head to the right. The results for the lower limbs, particularly the analysis of Q-angles, showed a tendency in girls for slightly valgus limbs (♂ 16.01 ± 4.48 versus ♀ 18.88 ± 4.48), which is in line with the literature, since most studies we consulted had found higher Q-angles for women. Marangon and Damázio (2012) believe that this is due to the fact that women have a wider pelvis which makes the femur medially deviate to a higher angle. Sendur, Gurer, Yildirim, Ozturk, and Aydeniz (2006) report a mean value of 15^o and classify Q-angles $<6^o$ as markedly varus knees and Q-angles $>27^o$ as valgus knees.

In lateral views, and as regards the Vertical Alignment of the Head with the Acromion (VAHA), the tendency to a forward head posture was quite visible. It is known that forward head posture emerges as a predominant pattern in literature review, with some studies indicating that the increase of forward head posture in school-aged children may be due to the use of backpacks (Ries et al., 2012).

Conclusion

Based on the objectives that have guided the empirical trajectory, we concluded that the sample was composed of a homogeneous group given its equitable distribution by gender. The results obtained in terms of BMI were satisfactory as the weight of most participants fell within ideal values. Despite this, at a lower percentage, there are records of overweight and severely thin children. As regards the way in which the school material is carried/backpack weight, it is important to highlight that most backpacks were carried with straps on both shoulders, indicating correct behaviours and stable and symmetrical transport of the school material. However, the relative weight of the backpacks was above the recommended values in 10% of cases. In the assessment of spinal deviations using Adam's test, we noted that the test was positive in approximately 47% of the participants, associated with age, height, BMI, and backpack weight, i.e. the participants with positive Adam's test were older, heavier, taller and carried heavier backpacks.

In terms of postural variables, the results suggest a tendency to forward head posture in lateral views and a tilt of the head to the right in anterior view. The girls in this sample had physiological genu valgus. In children and adolescents with positive Adam's test, the misalignments were more marked, especially in the following variables: Horizontal alignment of tibial tuberosities, horizontal alignment of head in C7, vertical alignment of the head, trunk and body, Q-angle and horizontal alignment of the shoulders.

Given the complexity of this issue, this study has some limitations but it can pave the way for new findings and more in-depth studies in the scientific area of Nursing. The results of this study may be used in future studies and help in the development of intervention programs on postural education in school health aimed at the prevention and early treatment of changes.

We would like to highlight the following research difficulties: The younger children had difficulties understanding the items of the IPAQ so we decided conduct interviews, simplifying the questions. To mark the points, the stickers were visible in the digital photos, with the exception of the external malleolus in anterior view. Another difficulty was to find more reference values for the age range. The postural values of reference can be consulted on the SAPOWeb platform, which is a digital database that allows consulting reports of analyses performed using SAPO. A greater dissemination of these methods of postural analysis will allow for a better interpretation of the results.

Despite the difficulties experienced, we agree with Ferreira (2005) that the measures obtained using this software are more objective than qualitative assessment (Ferreira, 2005). Therefore, we believe that our work would not be so objective if we had used the traditional grid mirror (symmetrograph) to analyse posture.

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