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# Early signs of scoliosis in preschool children

*Sinais precoces de escoliose em crianças pré-escolares*

*Las señales precoces de escoliosis en niños en edad preescolar*

**Débora Beckner de Almeida Leitão Prado Vieira[1], Camila Mayumi Beresoski[2], Mariana Zingari Camargo[1], Karen Barros Parron Fernandes[3], Claudia Patrícia Cardoso Martins Siqueira[4], Dirce Shizuko Fujisawa[4]**

**ABSTRACT |** The high incidence of postural deviations in child population, estimated at 20%, is not only a concern, but also a public health problem. This study aimed to identify signs of scoliosis in children in preschool age from Londrina, Brazil. The study included 377 children aged between 5 and 6 years, of both sexes. The postural exam was divided in: (1) obtaining anthropometric data, the frontal pelvic balance and Adams test; (2) in case of a positive response to Adams test, a computerized photogrammetry was performer subsequently. The prevalence of early signs of scoliosis was of 26.3% in the population evaluated. However, they were characterized as scoliotic attitude, since the highest angle identified was 7.33° and the median ranged from 3.2° to 5.6°. Also, the scoliotic attitude may be related to growth, since an association was identified between the positive response to the Adams test and pelvic asymmetry in the frontal plane, and the majority of the curvatures were of the "C" type. Based on the results, there was a high prevalence of scoliotic attitude, indicating the need for postural monitoring programs for children in pre-school, to control the growth and resolution or worsening of the early signs of scoliosis.

Keywords | Child; Scoliosis; Preschooler; Physical Therapy Modalities.

**RESUMO |** A alta incidência de desvios posturais na população infantil, estimada em 20%, além de preocupante, é um problema de saúde pública. O presente estudo teve como objetivo identificar sinais de escoliose em crianças na idade pré-escolar da rede de ensino municipal de Londrina (PR). Participaram do estudo 377 crianças, entre 5 e 6 anos de idade, de ambos os sexos. O exame postural foi dividido em: (1) obtenção dos dados antropométricos, equilíbrio pélvico frontal e teste de Adams; (2) em caso de resposta positiva ao teste de Adams, seguiu-se a realização da fotogrametria. A prevalência de sinais precoces de escoliose foi de 26,3%, na população avaliada. Tais sinais caracterizam-se como atitude escoliótica, uma vez que o maior ângulo identificado foi de 7,33° e as medianas variaram entre 3,2° e 5,6°. A atitude escoliótica pode estar relacionada ao crescimento, visto que foi identificada a associação entre a resposta positiva ao teste de Adams com a assimetria pélvica no plano frontal, e que a maioria das curvaturas foi do tipo em "C". A partir dos resultados encontrados, observa-se alta prevalência de atitude escoliótica, indicando a necessidade de programas de acompanhamento postural em crianças na fase pré-escolar para monitorar o crescimento e a resolução ou agravamento dos sinais precoces.

Descritores | Criança; Escoliose; Pré-Escolar; Modalidades de Fisioterapia.

**RESUMEN |** La alta incidencia de desvíos de postura en la población infantil, que se estima en el 20%, además de motivo de preocupación, es un problema de salud pública. Este estudio tuvo por objetivo identificar señales de escoliosis en niños en edad preescolar de la red municipal de enseñanza en Londrina, PR, Brasil. Han participado del estudio 377 niños, entre 5 a 6 años de edad, de ambos los géneros. Se ha dividido el examen postural en:

Study performed at the Physiotherapy Department at the State University of Londrina (UEL) – Londrina (PR), Brazil.
[1]Physiotherapist, Master in Rehabilitation Sciences for the UEL/UNOPAR Associated Program – Londrina (PR), Brazil.
[2]Physiotherapist, Specialist in Functional Orthopedic-Trauma Physiotherapy at the UEL University Hospital (UH) – Londrina (PR), Brazil.
[3]Doctor Professor at the Center for Research in Health Sciences from the Norte do Paraná University (UNOPAR) – Londrina (PR), Brazil.
[4]Doctor Professor from the UEL Physiotherapy Department – Londrina (PR), Brazil.

Correspondence to: Débora Beckner de Almeida Leitão Prado Vieira – Rua Manuel Ricardo de Holanda, 225 – Jardim Araxá – CEP: 86061-170 – Londrina (PR), Brasil – E-mail: deborabeckner@hotmail.com
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(1) obtención de los datos antropométricos, equilibrio pélvico frontal y prueba de Adams; (2) realización de la fotogrametría para el caso de respuesta positiva a la prueba de Adams. La prevalencia de señales precoces de escoliosis ha sido del 26,3% en la población evaluada. Estas señales se han caracterizado como una actitud de escoliosis, pues lo mayor ángulo identificado ha sido de 7,33° y las medianas sufrieron variación entre 3,2° y 5,6°. La actitud de escoliosis puede relacionarse al crecimiento, puesto que se ha identificado la asociación entre la respuesta positiva a la prueba de Adams con una asimetría pélvica en el plano frontal, y que la mayoría de las curvaturas ha sido del tipo "C". A partir de los resultados, se observa una alta prevalencia de escoliosis, lo que indica la necesidad de programas de supervisión postural en niños en edad preescolar con el fin de monitorear el crecimiento y la resolución o empeoramiento de las señales precoces.

Palabras clave | Niño; Escoliosis; Preescolar; Modalidades de Fisioterapia.

## INTRODUCTION

During childhood there is a high incidence of postural deviations, estimated to be 20%[1], which besides being worrisome is a public health problem. Signs of scoliosis begin during childhood, which can evolve during growth and become permanent if not treated[2]. Such signs can appear in children around 5 and 6 years of age, but the spinal curve is labile, reducible in its decubitus position, in its lateral,clinical and radiological inclination[3], and the signs are characterized as a scoliotic attitude[4]. A thorough postural evaluation is necessary so as to verify whether this attitude is associated with problems in the lower limbs, pelvis, shoulder girdle, torso, upper limbs or if they have functional causes[1,5]. While children are aged between 7 and 10 years, the same time as their growth spurt, there is potential for scoliotic attitude to develop, this is because the child is subject to postural alteration in everyday life as he already is during his school phase[6,7].

The changes in children's lives, namely their habits and the way they spend their time can be more sedentary, with more time spent sitting in an vicious improper position, which begins before school life. Figures vary regarding the incidence of postural changes in children, the results depend on the study type, the evaluated population, the identification method and the quality of the required curve[8,9].

Studies have investigated the postural changes in children using a broad age range; however, evaluating the preschool population is necessary, since early identification makes it possible to treat in addition to this being the time when these individuals are transitioning into school. Thus, the objective of this study was to identify signs of scoliosis in preschool children from the education network in Londrina (PR), Brazil.

## METHODOLOGY

This is a cross-sectional study of prevalence performed in eight schools in different regions of the city with an equivalent number of children. The sample size calculation was based on the 3,666 preschool students from the municipal network (2011), according to the Londrina City Education Department (EMS/PR), resulting in a sample of 360 children (acceptable sampling error of 0.05). Exclusion criteria were children who were unable to understand instructions, those who couldn't stand in an orthostatic position or individuals with an acute or chronic illness.

The parents or guardians of the children involved authorized their participation by signing a term of free and informed consent. Teachers and students were made aware about the study and the procedures involved. The study was approved by University Hospital's Ethics Committee at the UEL. After the data collection period was concluded, the parents, guardians and the children's teachers were given lectures regarding healthy postural habits. Children with postural deviations were referred to basic health units.

A Marte® electronic scale (model LC 200) and measuring tape were used to evaluate the anthropometric data. 1m$^2$ SVF (satin vinyl foam) mats and a 25 × 35cm SVF rectangle of a different color were required during the frontal pelvic exam and the Adams' test which demarcated feet support; a 30 × 20cm wooden bench was used by the examiner. The following were used during the photogrammetry: 9m$^2$ black fabric, double-sided masking tape, white flexible plastic rods, a digital camera (Samsung, 10.2 megapixels, with 1600 × 1200 pixel resolution) and an aluminum tripod (Lightweight Tripod, VF – WT3510A). The environmental conditions were prepared with a black background on the wall, a line for

the child's feet on the floor (20cm away from the wall) and with the camera positioned 89cm tall and 2.5m from the background. The images were digitized and analyzed using ImageJ software (free and open source software developed by Wayne Rasband at the National Institute of Mental Health, USA).

The examination began with the anthropometric data, a Lateral pelvic-tilt test (LPT) and the Adams' test; photogrammetry followed whenever the Adams' test gave a positive result. The LPT and Adams' test were performed by two trained evaluators; when a dubious response was obtained, a third was requested.

During the LPT the child remained in an orthostatic position, with their feet parallel and heels in alignment. The evaluator, seated behind the child, supported his hands, firmly downward, on the basis of the iliac crests with the radial edges of his two hands held flat. The evaluator maintains his sight horizontally at the iliac crest height, checking the asymmetry. In the case of any misalignment being observed, the lower side signaled the shortening of the corresponding lower limb, and the asymmetry demarcation in the record scored higher for the iliac crest as a rule. The classification was balanced, right asymmetrical or left asymmetrical pelvis.

During the Adams' test, the children remained standing, with their feet parallel and heels in alignment. The evaluator asked the child to slowly bend over from the base of their back, with their arms dangling towards the ground as much as possible[5]. The anterior tilt was followed by the evaluator, and any observation of asymmetry and gibbosity, as opposed to flatteness, was considered a positive response and indicative of scoliosis. The classification was negative or positive (right/left and lumbar/thoracic)[5]. Any children who received a positive result from the Adams' test performed photogrammetry so as to establish the angle of the curvature.

During photogrammetry, the child's heels were positioned on marks made by the masking tape which was on the black fabric, and the child then looked ahead towards a fixed point. The measuring tape was fixed parallel to the child's body (arm) for subsequent image calibration. Thoracic and lumbar angles were separately evaluated by means of plastic rods which were allocated at the spinous processes of C7, T6, T12, L3 and L5.

Angular analysis was performed using the ImageJ program to achieve good reliability and acceptability[6,10]. The intersections between the C7, T6 and T12 were traced in the software, thereby determining the angle for right, left or aligned in the thoracic spine. The same was done for points T12, L5 and L3 so as to determine the lumbar angle. One sole single evaluator placed the markers and analyzed the angles were in each task.

The confidence interval was 95%, with a 5% significance ($p<0.05$). The Chi Square test was used to analyze the influence of age or sex on the Adams' test and LPT result, as well as the relationship between the two. The unpaired *t*-test was used to compare height and weight in relation to the Adams' test. The Mann-Whitney test was used to compare the angles in the thoracic and lumbar region in relation to age or sex. The Spearman test evaluated the correlation between weight and height and angulation in the thoracic and lumbar region.

## RESULTS

377 children made up the sample, 169 of which being (44.8%) female and 208 (55.2%) male; 179 (47.5%) were five years old and 198 (52.5%) six; mean height was 1.17m (±0.06m) and mean body weight was 22.2 kg (±4.2kg).

278 children were tested negative during the Adams' test with 99 being positive (Table 1). Pelvis asymmetry was identified on the right in 61 of the children (16%) and on the left (22%) in 82. There was no statistically significant difference for the Adams' test and the LPT in terms of weight and height (Table 2). From the 143 children who had an asymmetrical pelvis, 53 had a positive Adams' test. There was no association between a positive Adams' test and pelvic asymmetry (Chi Square=13.88, p=0.001) (Table 3).

There was a curvature of the scoliosis in a "C-shape" that prevailed in children with a positive Adams' test. The presence of a hump on the on the "C-shaped" curvatures was 29 to the right and 63 to the left, while for the "S-shaped" were all thoracic to the right and lumbar to the left (Table 4).

The medians of the curvatures in the thoracic region were 3.2° (2.0°–4.3°) to the right and 3.9° (2.0°–5.4°) to the left. Those from the lumbar region were 5.6° (1.6°–7.3°) to the right and 4.1° (1.4°–7.0°) to the left. From the 99 children who had a positive Adams' test, ten did not show any curvatures during the photogrammetry (angle=0°). There was no statistically significant difference in the Adams' test for age (p=0.954), sex (p=0.839), height (p=0.839) or weight (p=0.682). No statistically significant difference was observed between the angulation in the thoracic (p=0.67) or lumbar

Table 1. Adams' Test and the LPT by age and sex

| Variables | | Adams' Test | | p |
|---|---|---|---|---|
| | | Positive (%) | Negative (%) | |
| Age | 5 years | 48 (12.8) | 131 (34.7) | 0.82 |
| | 6 years | 51 (13.6) | 147 (39.0) | |
| Sex | Female | 44 (11.7) | 125 (33.1) | 0.88 |
| | Male | 55 (14.6) | 153 (40.6) | |
| Total | | 99 (26.3) | 278 (73.7) | |
| **Variáveis** | | **EFP** | | **p** |
| | | **Asymmetric (%)** | **Balanced (%)** | |
| Age | 5 years | 77 (20.4) | 102 (27.1) | 0.05 |
| | 6 years | 66 (17.5) | 132 (35.0) | |
| Sex | Female | 63 (16.7) | 106 (28.1) | 0.92 |
| | Male | 80 (21.2) | 128 (34.0) | |
| Total | | 143 (37.9) | 234 (62.1) | |

Table 2. Adams' test and the LPT by height and weight

| | Adams' Test | | p |
|---|---|---|---|
| | Positive (mean±SD) | Negative (mean±SD) | |
| **Weight (kg)** | 22.2±4.3 | 22.3±4.2 | 0.88 n.s. |
| **Height (m)** | 1.17±0.06 | 1.17±0.06 | 0.54 n.s. |
| | **LPT** | | |
| | **Balanced (mean±SD)** | **Asymmetric (mean±SD)** | **p** |
| **Weight (kg)** | 22.4±4.3 | 22.0±4.1 | 0.30 |
| **Height (m)** | 1.17±0.06 | 1.17±0.06 | 0.96 |

Table 3. LPT in relation to Adams' test

| | | LPT | | | p |
|---|---|---|---|---|---|
| | | Balanced (%) | Asymmetric (%) | Total (%) | |
| Adams' | Negative | 188 (67.6) | 90 (32.4) | 278 (100.0) | 0.001* |
| | Positive | 46 (46.5) | 53 (53.5) | 99 (100.0) | |
| | Total | 234 (62.1) | 143 (37.9) | 377 (100.0) | |

* Statistically significant (Chi square)

Table 4. Type and location of curvatures and positive response to the Adams' test

| Type of curvature | n (%) | Segment | n (%) |
|---|---|---|---|
| C | 92 (92.9) | Right thoracic | 10 (10.1) |
| | | Left thoracic | 11 (11.1) |
| | | Right lumbar | 8 (8.1) |
| | | Left lumbar | 16 (16.2) |
| | | Right Thoraco-lumbar | 11 (11.1) |
| | | Left Thoraco-lumbar | 36 (36.4) |
| S | 07 (7.1) | Right thoracic and left lumbar | 7 (7.1) |
| | | Left thoracic and right lumbar | – |
| **Total (%)** | 99 (100) | **Total (%)** | 99 (100) |

region (p=0.68) in the groups of children with balanced or asymmetric LPT or, in angulations in the thoracic or lumbar region, when only the group of children with asymmetry of the pelvis were analyzed (p=0.51). There was no association between asymmetry of the pelvis and side of the curvature (p=0.82).

No observation was recorded of any association between age or sex and the angulations in the thoracic and lumbar spine (Table 5). There was also no observed association between height and thoracic angulation (p=0.83). There was an inverse correlation between height and lumbar angulation (rS=-0.21, p=0.04 – Spearman's rank correlation), with greater angulation in children of smaller stature.

Table 5. Angulations of the thoracic and lumbar region by sex and age

| Angulations | | | | |
|---|---|---|---|---|
| **Age** | **Thoracic** Median (1ST Q – 3RD Q) | **p** | **Lumbar** Median (1ST Q – 3RD Q) | **p** |
| 5 years | 3.65 (1.33 – 5.24) | 0.13 | 3.61 (1.63 – 5.52) | 0.05 |
| 6 years | 2.19 (1.32 – 4.47) | | 2.07 (1.11 – 5.91) | |
| **Sex** | **Thoracic** Median (1ST Q – 3RD Q) | **p** | **Lumbar** Median (1ST Q – 3RD Q) | **p** |
| Female | 3.38 (1.43 – 4.99) | 0.77 | 2.32 (1.09 – 5.32) | 0.33 |
| Male | 3.15 (1.27 – 5.05) | | 3.57 (1.22 – 5.72) | |

## DISCUSSION

Studies designed to identify postural deviations have been made up of a wide age range, between 5 and 18 years old. Different prevalence rates of scoliosis have been observed in such tests using the Adams' test, namely from 1.4%[11] to 64.62%[12] between the ages of 10 to 14-15 years. This study verified a prevalence of 26.3% in pre-school children, which is similar to the 23.5% found in the literature for the age group between 6 and 14 years old[13]. Despite the results being similar, the age groups are different, so a higher prevalence of deviations during the growth-spurt phases is to be expected[14]. This study found positive responses during the Adams' test, which may not mean the presence of scoliosis, but only the presence of its early signs.

As regards to sex, there was evidence in the literature that referred to a 38.9% prevalence of gibbosity in girls and 13.9% in boys aged between 8 and 15 years[15], which differs from this study, which found a higher prevalence in boys.

Height and weight showed themselves to have no positive association with the Adams' test, as was the case in the literature[16]. However, children of smaller stature presented higher curvature angles, which is seen as an associated factor that has an influence on postural changes[17].

The medians of the thoracic and lumbar curvatures ranged from 3.2° to 5.6° in preschool children. Another study[18] confirmed and established the angulation of the curvatures by means of radiological examination that followed the Adams' test, obtaining a prevalence of 17.3% in the age range between 11 to 17 years old and angles of the curvatures ranging from 5° to 10°. Thus, if there are no preventive measures take, advancing age can lead to increased angles of the curvatures during childhood. While there was no radiological examination included in this study, the Adams' test is commonly used for screening scoliosis due to its simplicity, low cost, non-invasive characteristic and for being recommended by the Scoliosis Research Society[19].

Studies have shown that photogrammetry can provide a good level of reliability and trustworthiness[20,21]. This study did not evaluate either the intra- and inter-examiner reliability of the clinical examination or the photogrammetry, which constitutes a limitation. The radiograph and the Cobb angle are considered the gold standard in scoliosis characterization, but its role in prevalence research is contentious[22]. Exposing a child to radiation and the costs involved have been the driving force behind new postural evaluation methods[23].

In a study which had a broad age range of between 9 and 18 years, 62.9% were found to have lateral deviations, with 88.1% of these being type "C" and 11.9% type "S"; 54.7% of the gibbosity was found in the dorsal region, 17% in the lumbar and 28.3% in both[24]. There was a higher incidence of torso inclination to the right, during photogrammetry, in 44 children between the age of 7 and 10 years[25]. A different study[26] found 88.7% of children aged between 7 and 8 years with lateral deviation in the photogrammetry, with 53% of these having a curvature to the left, however the authors state that there was a lack of standardization in the employed research methodology, and that this compromised the data crossing.

One study[27] described lumbar curves that represented 31.6%, with 75% of these being to the left, and thoraco-lumbar curves amounting to 23.6%, with 77.8% of these being to the left. Such findings are in agreement

with our study, which noted that most of the curvatures were "C-shaped".

Despite the fact that 90% of the child population have a lower limb length inequality, any difference less than 20 mm is not likely to cause any symptoms[28]. A limb length discrepancy can occur in growing children but is a matter for concern when this continues into maturity. Pelvic misalignment was observed in 84.2% of patients with scoliosis[27]. In students between 9 and 18 years old, there was an observed elevation of the anterior superior iliac spine in 22.2% of those who presented lateral deviation[24].

This study adopted the Adams' test as it was proposed in the literature, without using a wedge, in case there was a lower-limb length discrepancy. Evaluating the asymmetry in the length of lower limbs through the LPT, as suggested by Bienfait[1], shows that a wedge should be used with children, since scoliotic attitudes may be related to a growth disorder. The association between the results from the Adams' test and the LPT indicates the influence of lower limb length and therefore highlights the scoliotic attitude. The results indicate that a positive Adams' test positive is probably related to growth and early development of postural habits. The results also indicate that observed postural changes are early signs of scoliosis, which require monitoring throughout the growth spurts. Curvatures in children under 5 years of age are benign in most cases; in 90% of cases there is spontaneous regression, while the remaining 10% may be progressive, mainly due to the risk of worsening along with adolescent growth[29]. Preventive measures should be instituted by way of guidance and the development of suitable postural habits[30]. It is important that Intervention programs are developed in schools, since increased knowledge and the learning of healthy postural habits are known to be beneficial[31].

## CONCLUSION

The prevalence of scoliosis signs was 26.3% and the medians ranged between 3.24° and 5.58°. Scoliotic attitude may be related to growth, since most curvature were "C-shaped" and there was an association between a positive Adams' test and pelvic asymmetry in the frontal plane.

Postural monitoring programs should begin during children's preschool phase at the latest, this will allow the growth and evolution of early scoliosis signs to be monitored and healthy postural habits to be developed. It is worth stressing that future research could be developed on the effect using a wedge in cases of pelvic asymmetry and that children should be monitored during their growth spurt.

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