Posture Alignment of Adolescent Idiopathic Scoliosis: Photogrammetry in Scoliosis School Screening

Patrícia Jundi Penha, PhD, Nárima Lívia Jundi Penha, Bárbarah Kelly Gonçalves De Carvalho, MS, Rodrigo Mantelatto Andrade, MS, Ana Carolina Basso Schmitt, PhD, and Sílvia Maria Amado João, PhD

Abstract

Objective: The objective of this study was to describe the posture patterns of adolescents diagnosed with adolescent idiopathic scoliosis (AIS) in a scoliosis school screening (SSS).

Methods: Two-dimensional photogrammetry was used to assess the posture of 37 adolescents diagnosed with scoliosis (scoliosis group, SG) (Cobb angle ≥10°) and 76 adolescents with a false positive diagnosis (false positive group, FPG) (Cobb angle <10°, angle of trunk rotation ≥7°). In total, 2562 10- to 14-year-old adolescents were enrolled in the SSS, which was performed in public schools in the cities of Amparo, Pedreira, and Mogi Mirim in the state of São Paulo, Brazil. Their posture was analyzed using Postural Analysis Software. Continuous variables were tested using Student t test, and categorical variables were tested using a $\chi 2$ test. The SG, FPG, simple curve group, and double curve group were all compared. Bivariate analysis was used to identify associations between postural deviations and scoliosis. The adopted significance level was $\alpha = .05$.

Results: The SG (2.7 ± 1.9°) had greater shoulder obliquity than the FPG (1.9 ± 1.4°) ($P = .010$), and this deviation was associated with scoliosis (odds ratio [95% CI] $P = 1.4$ [1.1-1.8] 0.011). The SG had asymmetry between the right- and left-side lower limb frontal angle, shoulder sagittal alignment, and knee angle. The double curve group (3 ± 1.7°) presented a greater value of the vertical alignment of the torso than the simple curve group did (1.9 ± 1°; $P = .032$).

Conclusions: Adolescents diagnosed with AIS in an SSS had greater shoulder obliquity and asymmetry between the right and left sides. Shoulder obliquity was the only postural deviation associated with AIS. (J Manipulative Physiol Ther 2017;40:441-451)

Key Indexing Terms: *Posture; Adolescent; Scoliosis; Mass Screening*

Introduction

Posture asymmetries associated with adolescent idiopathic scoliosis (AIS) are common; they are associated with the risk of progression of scoliosis[1,2] and the limitation of functional activities.[2-5] The common posture deviations are right and left height asymmetry of the pelvis, scapulae, shoulders, and head.[6,7] Most studies describe posture by using 3-dimensional (3D) posture techniques, such as Optotrak (Northern Digital Inc., Waterloo, Canada), Vicon (Vicon Motion Systems, Oxford, UK), Motion Analysis (Motion Analysis Corporation, Santa Rosa, CA), and surface topography systems.[6-11] Although these techniques are reliable and reproducible, they require expensive equipment and systems that are not accessible to most clinicians.

Two-dimensional (2D) photogrammetry can be used for clinically quantitative posture assessment by calculating body angles and distances using photographs.[2,12-14] 2D photogrammetry is a quick, easy, and accessible tool for most clinicians.[2,12-14] Fortin et al[2] evaluated the reproducibility and inter-rater reliability of the use of 2D photogrammetry to assess the posture of people with idiopathic scoliosis. The authors verified a good level of test-retest reliability for all posture indices, good inter-rater reliability for 29 out of 32 posture indices, and moderate inter-rater reliability for 3 posture indices.[2] According to Fortin et al,[2] the most reproducible indices were the waist angles, the trunk list, and the knee valgus and varus, whereas the least reliable were the tibiocalcaneal angles, the Q angles, and the frontal lumbar angle.

This study assumes (1) that 2D photogrammetry can be a useful tool for the clinical assessment of AIS,[2] (2) that correction of posture is an important goal of physiotherapy interventions for people with idiopathic scoliosis,[2] and (3) that there were few previous studies using photogrammetry for the posture analysis of people with idiopathic scoliosis.[15] Based on these assumptions, the objective of this study was to

Department of Physical Therapy, Speech and Occupational Therapy, University of São Paulo, São Paulo, Brazil.

Corresponding author: Patrícia Jundi Penha, PhD, Rua Veneza, 343 Jardim, Itália, Amparo, SP, Brazil 13901-100. Tel.: + 55 11 30918424. (e-mail: *ft.patriciapenha@gmail.com*).

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use 2D photogrammetry to describe the posture patterns of adolescents diagnosed with AIS in a scoliosis school screening (SSS).

Methods

Setting

This descriptive, cross-sectional study was carried out in public schools located in 3 cities of the state of São Paulo, Brazil.

Participants

The study sample population was composed of adolescents of both sexes between the ages of 10 and 14 who were participating in an SSS as described in the SOSORT consensus paper.[16] All 2562 adolescents (1072 boys and 1490 girls) were examined in SSSs undertaken between 2012 and 2015; 129 with positive scoliometer measurements (with an angle of trunk rotation [ATR] ≥7°) were referred for x-ray examination, but 16 did not appear for the exam. Thus, 113 adolescents were investigated, a number high enough to meet the proposed objectives, considering the maximum percentage of postural changes was 97.4% and the minimum was 5.4%, with a margin of error of 0.05 in 95% of possible samples. Standing radiographs were used to confirm that 37 had scoliosis (SG: 32 girls and 5 boys) and 76 had normal spine curvatures (ATR ≥7° and a Cobb angle <10°; FPG, 49 girls and 27 boys). The SSS exclusion criteria were a leg length discrepancy ≥1.5 cm[17,18] or any problems interfering with the ability to perform an Adams test (a forward bend test) properly.[19]

After being given an explanation of the procedure used in this study to assess the adolescents' posture, each adolescent and his or her legal representative signed an informed consent form (Resolution 196/96). This study was approved by the Ethics Committee of the School of Medicine of the University of Sao Paulo (research number: 254/12).

Procedure

First the adolescents were assessed using a scoliometer in an Adams test. The mark zero of the scoliometer was placed on all the vertebral body levels at thoracic, thoracolumbar, and lumbar, and the higher value of ATR was recorded.[20,21] Those with positive scoliometer measurements (ATR ≥7°) were examined by radiograph and were photographed for the purpose of 2D photogrammetry. AIS was confirmed when an adolescent's Cobb angle was >10°.

Each adolescent's posture was assessed using 1 digital Sony Cyber-shot camera, model DSC-WX100 (Sony, Tokyo, Japan), 1 tripod, 15-mm polystyrene balls, double-sided adhesive tape, a 70 × 74 cm rubber mat, white chalk, 1 plumb line marked with 3 polystyrene balls, and a reliable tool, Postural Analysis Software/Software of Postural Analysis (PAS/SAPO).[22,23] The camera was mounted on the tripod at a height of 1 m and placed 252 cm away from the participant being photographed.[13,22] For photo calibration purposes, the plumb line was affixed to the ceiling and marked with 3 polystyrene balls with a distance of 50 cm between each ball.[22] The participants were tested in the classroom, and efforts were made to control the temperature, noise, and distractions.

Six 2D photographs (1 anterior, 1 posterior, and 2 each right and left lateral views, 1 with the elbow extended and 1 with the elbow bent and with the hand placed at the opposite shoulder level) were taken while each participant was standing on the rubber mat.[21,22] The lateral-view photographs with the elbow bent were used only to measure the vertical alignment of the torso and knee angle. To ensure the same positions for the feet in all 6 photographs, all participants were instructed to position themselves on the mat while an outline was drawn around their feet using chalk.[22] After each photograph was taken, the mat was rotated 90° from its initial position in order to photograph a different view, and participants were instructed to place their feet on the outlines marked on the mat.[22] Marks were made on the floor so that the mat would always be placed in the same position.[22]

A number of bone references were marked on each adolescent: the earlobes, the prominence of the seventh cervical vertebra (C7), the acromia, the inferior angle of each scapula, the anterior superior and posterior superior iliac spines, the greater trochanter of femurs, the head of the fibulae, the tibial tuberosity, the superior pole of the patella, the mid-calf at fibulae height, the lateral malleoli, the middle point of the calcanei, and the insertion of each Achilles tendon.[13,21,22]

In an attempt to minimize data collection errors, the research assistant received comprehensive training to ensure the correct placement of the anatomic markers, the positioning of the participant, and camera placement. Each screening exam lasted for 2 to 5 minutes and data acquisition lasted for 20 to 25 minutes on average per participant, including marker placement.

The posture variables are described in Table 1.[24-26] Figures 1, 2, and 3 illustrate the angles measured by each view. Most of the posture variables were measured by the PAS/SAPO protocol.[22] However, the sagittal alignment of the shoulder, the horizontal alignment of the scapula, the knee angle, and the leg and rear foot angles were measured using the free marking points of PAS/SAPO.

Statistical Analysis

The data were analyzed using descriptive statistics. The variables analyzed indicated a normal distribution, as verified by the Anderson-Darling test. The continuous variables were tested using Student *t* test: horizontal

Table 1. *Postural Variables and the Anatomic Landmarks Used to Measure Them*

Segment	Plane	Anatomical Landmarks	Postural Variables
Head	Frontal	The angle between the 2 earlobes and a horizontal line[21,22]	The horizontal alignment of the head[22]
	Sagittal	The angle between the vertebral prominence of C7, the external auditory meatus, and a horizontal line[13,21]	The horizontal alignment of the head (C7)[22]
Shoulder	Frontal	The angle between each acromion and a horizontal line[21,22]	The horizontal alignment of the acromia[22]
	Sagittal	The distance between the C7 spinal process and each acromion (adapted methodology of Peterson et al[24])	The shoulder sagittal alignment
Scapula	Frontal	The angle between the two inferior angles of each scapula and a horizontal line[22]	The horizontal alignment of the scapulae[22]
Trunk	Sagittal	The angle between each acromion, the greater trochanter of the femur, and a vertical line[22]	The vertical alignment of the torso[22]
		The angle between each acromion, the lateral malleolus, and a vertical line[22]	The vertical alignment of the body[22]
Pelvis	Frontal	The angle between each anterior superior iliac spine and a horizontal line[21,22]	The horizontal alignment of the anterior superior iliac spines[22]
	Sagittal	The angle between each anterior superior iliac spine, the posterior superior iliac spine, and a horizontal line[13]	The horizontal alignment of the pelvis[22]
Knee	Frontal	The angle between each anterior superior iliac spine, the superior pole of the patella, and the tibial tuberosity[22]	The lower limb frontal angle[22]
	Sagittal	The angle between the greater trochanter of each femur, the head of the fibula, and the lateral malleolus[25]	The knee angle[22]
Ankle	Frontal	The angle between a vertical line through each Achilles tendon, the middle point of the calcaneus, and a vertical line through the mid-calf[26]	The leg and rear foot angle[22]

The angles were measured in degrees; the distances were measured in centimeters.

alignment of the head, acromia, anterior superior iliac spine (ASIS), pelvis, the head (C7), lower limb frontal angle, leg/rear foot angle, shoulder sagittal alignment, vertical alignment of the torso and the body, and knee angle. The categorical variables were tested using a χ^2 test: frequency of inclinations to the left and to the right of head, shoulder, scapula, and ASIS, frequency of antepulsion, knee hyperextension, pelvic anteversion, and trunk extension. A paired *t* test was used to compare the right and left sides of the adolescents' bodies for the following variables: lower limb frontal angle, leg/rear foot angle, horizontal alignment of the head (C7), shoulder sagittal alignment, vertical alignment of the torso and the body, and knee angle.

The SG, the FPG, the simple curve group (SCG), and the double curve group (DCG) were compared. Bivariate analysis was used to identify possible associations between postural deviations and scoliosis. The significance level adopted was α = .05. Stata Version 13.0 and Microsoft Excel 2010 software were used for the statistical calculations.

Results

Prevalence rates were 2.2% for girls, 0.5% for boys, and 1.5% for all sample. Table 2 shows the characteristics of the sample group, and Table 3 shows the continuous values of the main postural deviations.

Figure 4 shows the postural pattern of the frontal plane found in the SG and the FPG: head inclination to the right (SG 43.2% and FPG 42.1%; *P* = .682), elevation of the right shoulder (SG 56.8% and FPG 42.1%; *P* = .212), elevation of the right scapula (SG 48.6% and FPG 51.3%; *P* = .688), and elevation of the right anterior superior iliac spine (SG 51.3% and FGP 59.2%; *P* = .189). The horizontal alignment of the acromia was different in the SG and the FPG (*P* = .010). The SG had a higher value for this deviation. The lower limb frontal angle had a difference between the right and left limbs only for the SG (*P* = .039). Scoliosis was significantly related to the horizontal alignment of the acromia (odds ratio 1.4, *P* = .011) (Fig 4).

The posture pattern of the sagittal plane of the SG and the FPG was characterized by body antepulsion (SG 91.9% and FPG 97.4%; *P* = .263), knee hyperextension (SG 70.3% and FPG 64.5%; *P* = .682), pelvic anteversion (SG 97.3% and FPG 100%; *P* = .150), and trunk extension (SG 54% and FPG 59.2%; *P* = .178). The shoulder sagittal alignment of the SG and the knee angle of the SG and the FPG had a difference between the right and left sides. The SG had greater left than right shoulder protrusion (shoulder sagittal alignment). Both groups had greater left than right knee hyperextension (knee angle) (Fig 5).

Figure 6 represents the posture patterns found in the SCG and the DCG for the frontal plane. The SCG had the same proportion of right and left shoulder obliquity (46.7%), and the DCG had similar proportions of right and left head inclination (36.4% right and 31.8% left). The SCG presented a higher proportion of left scapula elevation (46.7%), whereas the DCG presented a higher proportion of right scapula elevation (54.6%). There was no difference between the horizontal alignment of the scapulae in the SCG and the DCG. The only difference between the right

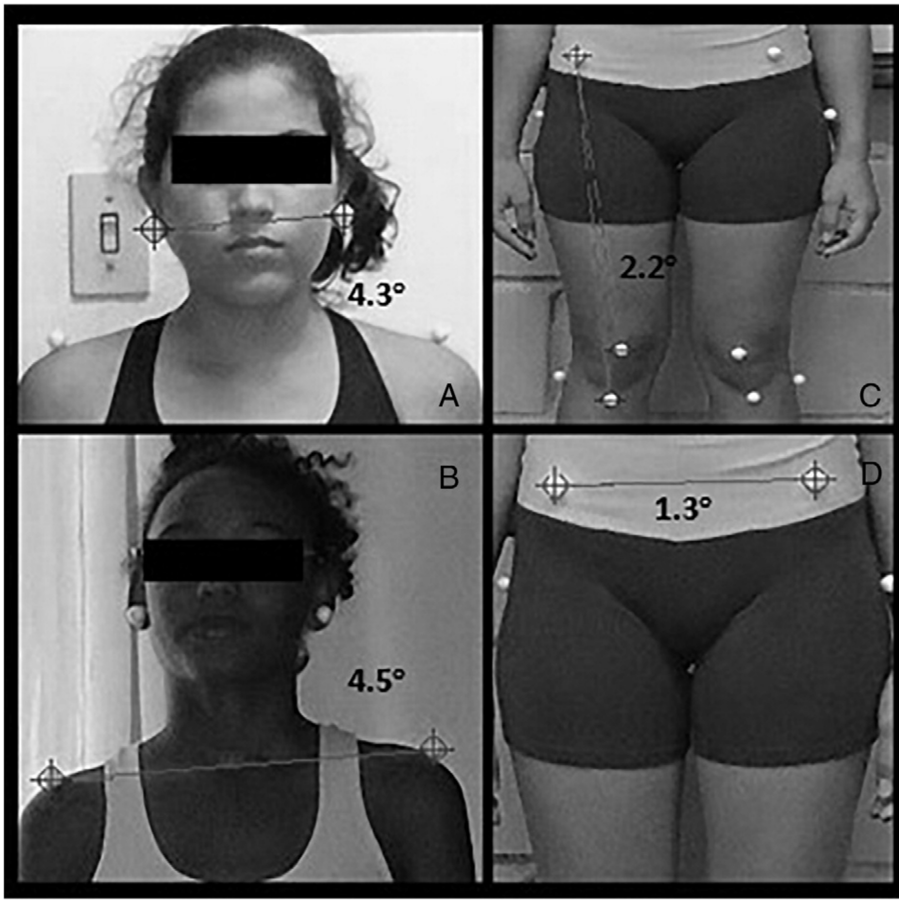

Fig 1. *Illustration of postural variables measured in the frontal plane (anterior view): the horizontal alignment of the head (A), the horizontal alignment of the acromia (B), the lower limb frontal angle (C), and the horizontal alignment of the anterior superior iliac spine (D).*

and left sides in the SCG and the DCG was the lower limb frontal angle in the DCG (*P* = .025) (Fig 6).

Figure 7 shows the posture patterns of the sagittal plane of the SCG and the DCG. Both groups had body antepulsion (SCG 93.3% and DCG 90.9%; *P* = .672), knee hyperextension (SCG 66.7% and DCG 72.7%, *P* = .692), pelvic anteversion (SCG 100% and DCG 95.5%; *P* = .403), and trunk extension (SCG 66.7% and DCG 45.5%; *P* = .204). The DCG had similar proportions for both trunk flexion and extension but higher values of vertical alignment of the torso compared with the SCG.

In the comparison between right and left sides, the SCG presented higher values of left than right vertical alignment of the torso (*P* = .046). On the other hand, the DCG had greater left than right shoulder protrusion (*P* = .010) and higher values of left than right knee hyperextension (*P* = .004) (Fig 7).

Discussion

The purpose of this study was to describe the posture of adolescents diagnosed with AIS in SSS. The most prominent posture deviation related to scoliosis in the studied adolescents was shoulder obliquity, which was evaluated by measuring the horizontal alignment of the acromia (odds ratio 1.4, *P* = .011). The SG had higher shoulder obliquity than the FPG (value of shoulder obliquity, SG 2.7° [1.9] and FPG 1.9° [1.4]) [*P* = .010]). No previous studies were identified that described the association between posture deviations assessed by 2D photogrammetry and the chance of having scoliosis.

Zabjek et al[7] assessed 57 people with AIS and verified shoulder obliquity by using 2 3D systems. However, these authors did not describe the quantitative value of this measurement. Masso and Gorton[6] assessed 33 patients with right thoracic curves and verified shoulder obliquity by using an optoelectronic system. These authors reported that the right shoulder was more elevated than the left shoulder in 64% of patients. In the present study, 56.8% of the adolescents with scoliosis also presented greater right shoulder elevation. Although the Cobb angles of Masso and Gorton's[6] sample (60° [14°]) were higher than those in this study (17.9° [6.9°]), the value of shoulder obliquity that

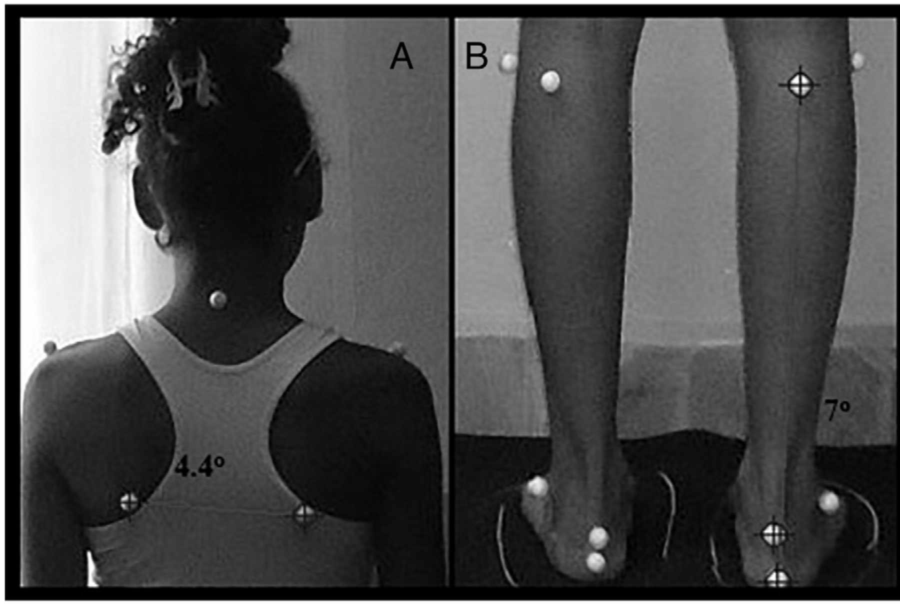

Fig 2. *Illustration of postural variables measured in the frontal plane (posterior view): (A) the horizontal alignment of the scapula, and (B) the leg and rear foot angle.*

they reported (3° [3°]) was similar to the results in the present study (2.7° [1.9°]). Thus, shoulder obliquity is present even in adolescents with small magnitudes of scoliotic curves. The studied adolescents with idiopathic scoliosis also had higher asymmetry between their right and left sides. These asymmetries were found in their lower limb frontal angle, shoulder sagittal alignment, and knee angle.

Shoulder protraction was evaluated by measuring the adolescents' shoulder sagittal alignment; the SG presented with greater left shoulder protrusion (8.3 cm [2.5]) than right shoulder protrusion (7.4 cm [2.1]) (P = .018). Masso and Gorton[6] also evaluated the shoulder protraction of people with scoliosis and used it to evaluate trunk rotation; their results indicated a higher value for their scoliosis group than their control group (6° [4°] and 2° [2°]; P = .000, respectively).

No previous studies were found that evaluated and discussed the posture of the lower limbs of people with AIS. In the present study, adolescents with idiopathic scoliosis had greater deviation of the left lower limb frontal angle and more hyperextension of the left knee. These lower limb posture deviations could be related to pelvic rotation, which is well documented in people with idiopathic scoliosis.[11,27] The posture of the adolescents was assessed in an orthostatic position. In a closed kinetic chain like the orthostatic position, pelvic rotation causes postural and biomechanical adjustments of the lower limbs,[28] which could explain the asymmetries identified in the lower limb frontal angle and the knee hyperextension of the adolescents in this study.

When comparing the posture patterns of the SCG and the DCG, the latter had greater asymmetry between the right and left sides (lower limb frontal angle, shoulder sagittal alignment, and knee angle), and the left side was more asymmetric than the right. This result was the same as the result of the comparison between the SG and the FPG and could be explained by the fact that double curves were more prevalent in the sample group in this study (SCG, n = 15; DCG, n = 22).

The DCG (3° [0.4°]) had greater trunk deviation (vertical alignment of the torso) than the SCG (1.9° [0.3°]) (P = .032), but this difference occurred only in the right profile. When comparing the right and left profiles, only the SCG presented statistically significant differences (P = .046), with a higher value of the left vertical alignment of the torso (3° [0.5°]) than the right vertical alignment of the torso (1.9° [0.3°]). In this sample, the pattern of trunk extension was the most common deviation found in all the analyzed groups. These differences of magnitudes in the vertical alignments of the torso could be explained by trunk axial rotations. Zabjek et al[7] and Stokes and Moreland[29] found trunk axial rotations of 4° and 5°, respectively, relative to the base of support in the participants they studied, although these authors used different techniques for posture assessment (a 3D sequential digitization system and Raster stereo photography, respectively). Zabjek et al[11] also verified significant differences in scapula rotation when comparing people with idiopathic scoliosis and people from a control group. According to these authors,[11] scapula rotation indicates superior trunk rotation in relation to the pelvis and to the base of support.

In this study, photo acquisition took 20 to 25 minutes on average per participant. Fortin et al[2] spent the same amount

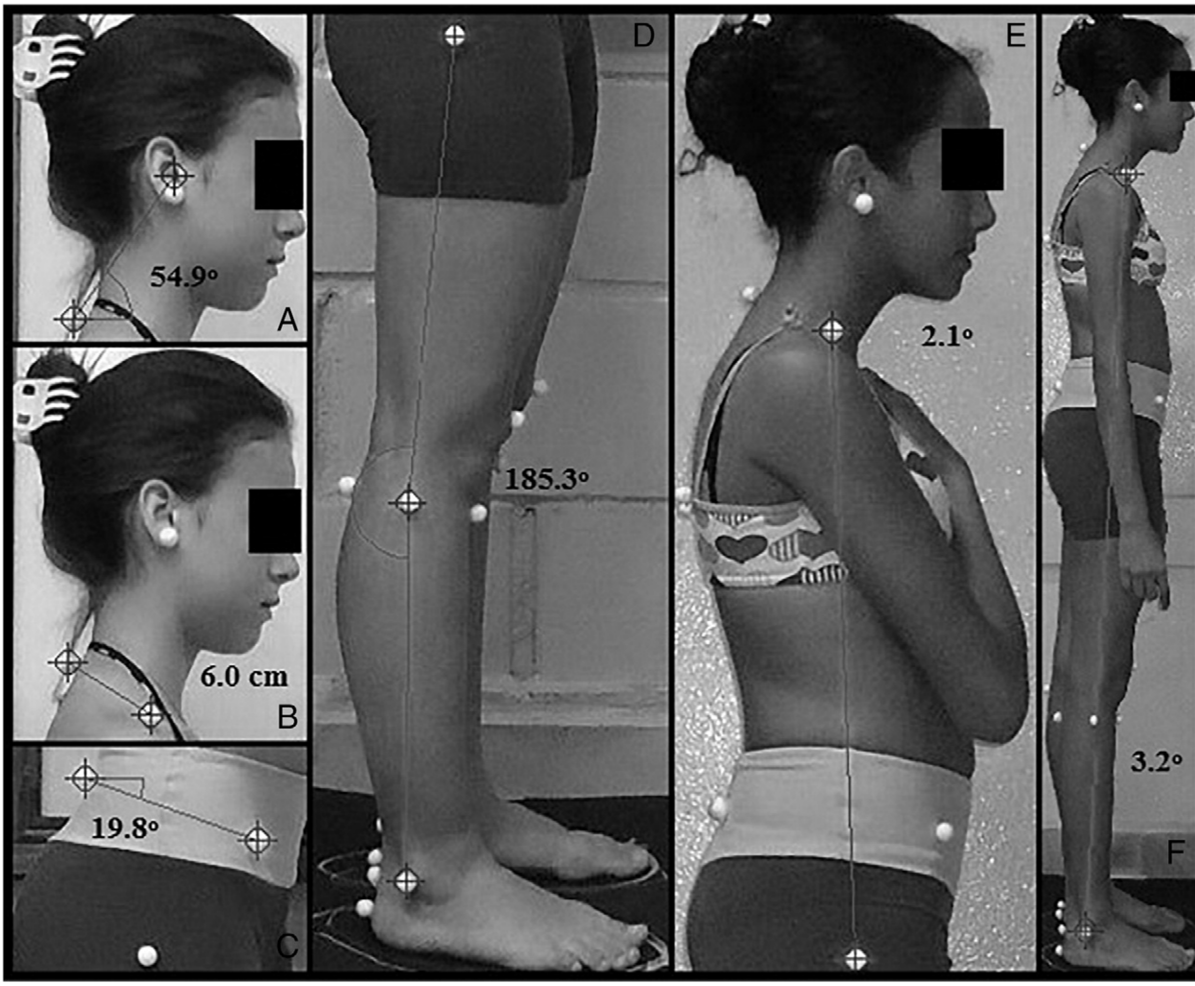

Fig 3. *Illustration of postural variables measured in the sagittal plane: the horizontal alignment of the head (C7) (A), the shoulder sagittal alignment (B), the horizontal alignment of the pelvis (C), the knee angle (D), the vertical alignment of the torso (E), and the vertical alignment of the body (F).*

Table 2. *Characteristics of the Studied Adolescents With Idiopathic Scoliosis (the SG) and the Adolescents With Normal Spine Curvatures (the FPG) According to Anthropometric and Clinical Variables*

Variable	SG (n = 37) x (SD)	FPG (n = 76) x (SD)	*P*
Age (y)	12.8 (1)	12.4 (1.1)	.059
Weight (kg)	50.4 (9.1)	49.6 (11.1)	.708
Height (m)	1.6 (0.1)	1.6 (0.1)	.639
Body mass index (kg/m^2)	19.7 (3.6)	19.4 (3.4)	.692
Cobb angle (degrees)	17.9 (6.9)	4.5 (3.2)	<.000 [a]

FPG, false positive group; *SD,* standard deviation; *SG,* scoliosis group;
[a] Statistical difference ($P < .05$). Student *t* test. For statistical analysis, only the Cobb angle for the primary curve was considered.

of time for photo acquisition. However, Glinkowski et al[30] developed a new 3D back surface topography measurement system for posture and scoliosis using a structured light method; their average examination time per participant ranged from 2 minutes and 43 seconds to 4 minutes and 51 seconds.

Knowledge about postural deviations and the magnitudes associated with scoliosis allows physical therapists to elaborate specific postural reeducation to enhance aesthetics—one of the main causes of quality of life impairment in adolescents with idiopathic scoliosis—and to prevent future biomechanical problems. Furthermore, special attention should be paid to the asymmetry of shoulder height in the clinical setting and in SSS because this asymmetry is an important characteristic of posture that is associated with AIS.

Limitations and Future Studies

Some measurement errors may have been caused by the dispersion of the positioning of the polystyrene balls and the mat rotation on which the adolescent was positioned for photographing. These errors could be minimized by the use

Table 3. *Comparison of the Quantitative Postural Assessments of the SG, the FPG, the SCG, and the DCG*

Posture variables, angle (°)	SG (n = 37) x (SD)	*P*	FPG (n = 76) x (SD)	SCG (n = 15) x (SD)	*P*	DCG (n = 22) x (SD)
Horizontal alignment of the head	2.4 (2.2)	.680	2.6 (2.1)	2.7 (1.7)	.514	2.2 (2.6)
Horizontal alignment of the acromia	2.7 (1.9)	.010*	1.9 (1.4)	2.4 (1.6)	.394	2.9 (2.1)
Horizontal alignment of the scapulae	4.6 (4)	.571	4.2 (3.3)	3.3 (3.2)	.090	5.6 (4.3)
Horizontal alignment of the ASIS	1.7 (1.6)	.137	2.2 (1.7)	1.5 (1.2)	.432	1.9 (1.8)
RLL frontal angle	2.3 (0.9)	.543	2.2 (0.8)	2.3 (0.9)	.907	2.3 (1)
	P = .039 [a]					*P* = .025 [a]
LLL frontal angle	2.6 (1.1**)**	.087	2.3 (1)	2.3 (0.9)	.113	2.9 (1.1)
Leg/rear foot right angle	7 (4.6)	.959	7 (4.9)	7.6 (5.1)	.502	6.5 (4.2)
Leg/rear foot left angle	6.9 (5)	.970	6.9 (4.2)	6.5 (4.3)	.725	7.1 (5.5)
R horizontal alignment of the head (C7)	52.6 (6.2)	.543	51.9 (5.3)	51 (5.9)	.196	53.7 (6.2)
L horizontal alignment of the head (C7)	51.6 (5.7)	.601	51.1 (5.4)	49.4 (4)	.052	53.1 (6.3)
R shoulder sagittal alignment, length (cm)	7.3 (2.1)	.845	7.4 (1.9)	7.6 (2.2)	.590	7.2 (2)
	P = .018 [a]					*P* = .010 [a]
L shoulder sagittal alignment, length (cm)	8.3 (2.5)	.205	7.7 (2.2)	7.9 (2.2)	.433	8.6 (2.8)
R vertical alignment of the torso	2.6 (1.5)	.419	2.3 (1.7)	1.9 (1)	.032 [a]	3 (1.7)
				P = .046 [a]		
L vertical alignment of the torso	3.2 (1.6)	.163	2.6 (2.1)	3 (1.8)	.540	3.3 (1.5)
R vertical alignment of the body	2.3 (1.4)	.407	2.5 (1.4)	2.6 (1.1)	.344	2.1 (1.5)
L vertical alignment of the body	1.8 (1.2)	.024 [a]	2.4 (1.4)	1.9 (1.2)	.930	1.8 (1.2)
R horizontal alignment of the pelvis	14.6 (6.2)	.235	13.2 (5.7)	14.1 (6.6)	.712	14.9 (6.1)
L horizontal alignment of the pelvis	14.3 (6.2)	.703	13.8 (6)	14.7 (6)	.782	14.1 (6.5)
R knee angle	183.2 (5.1)	.522	182.5 (5.5)	182.4 (6)	.478	183.7 (4.5)
	P = .001 [a]		*P* < .000 [a]			*P* = .004 [a]
L knee angle	186.8 (6.4)	.071	184.8 (5.1)	185.2 (6.2)	.214	187.9 (6.4)

ASIS, anterior superior iliac spine; *C7,* prominence of the seventh cervical vertebra; *DCG,* double curve group; *FPG,* false positive group; *L,* left; *LLL,* left lower limb; *R,* right; *RLL,* right lower limb; *SCG,* simple curve group; *SD,* standard deviation; *SG,* scoliosis group.

[a] Statistical difference ($P < .05$).

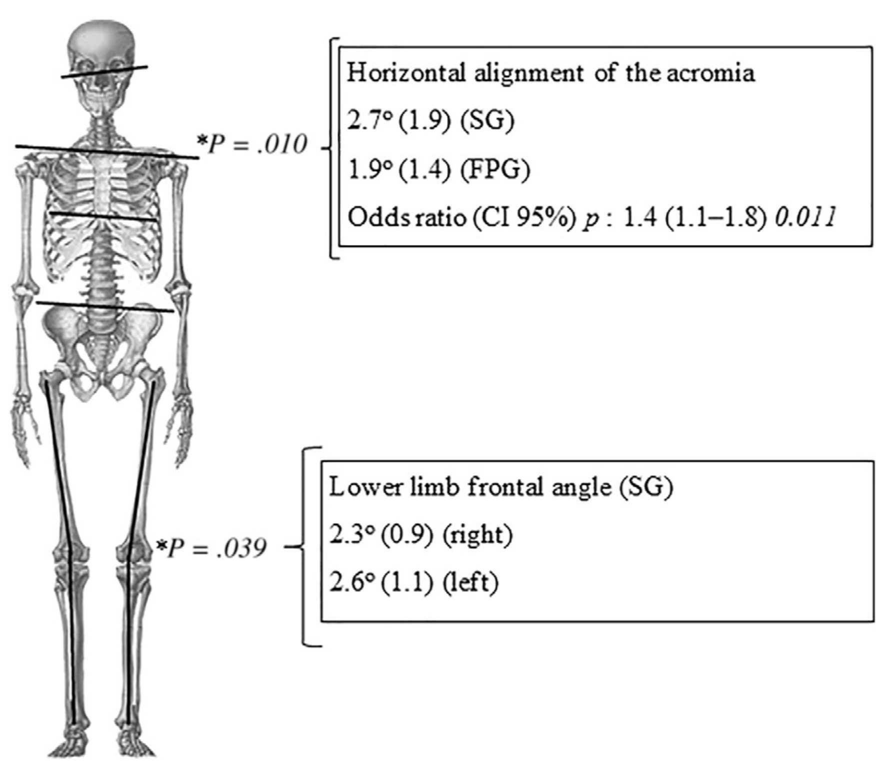

Fig 4. *Body schema of posture in the frontal plane for the scoliosis group (SG) and false positive group (FPG). CI, confidence interval.*

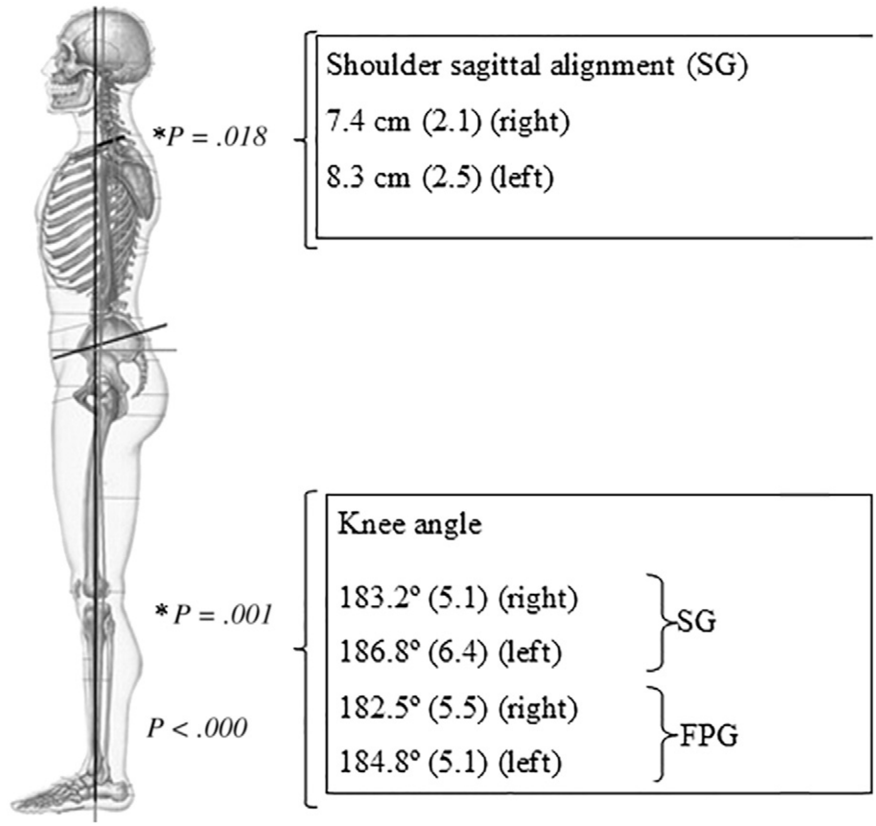

Fig 5. *Body schema of posture in the sagittal plane for the scoliosis group (SG) and false positive group (FPG).*

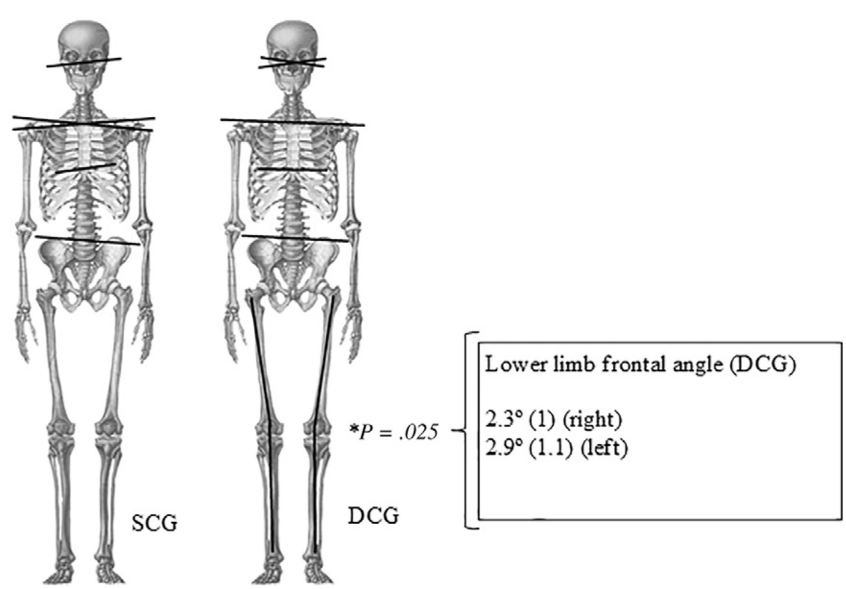

Fig 6. *Body schema of the frontal plane posture of the SG, comparing the simple curve group (SCG) with the double curve group (DCG).*

of automatic recognition and localization of anatomic landmark methodologies and systems that capture images simultaneously[31] in studying the posture of adolescents with AIS in SSS.

3D images allowed the possibility of measuring the rotational components, which are important characteristics observed in individuals with AIS. Although the instrument (PAS/SAPO) employed in the present study

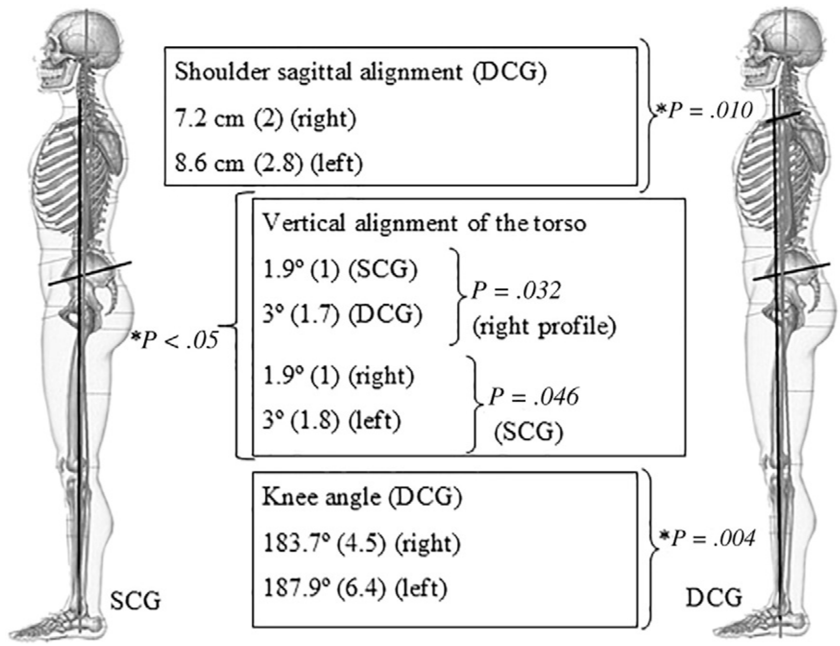

Fig 7. *Body schema of sagittal plane posture of the scoliosis group, comparing the simple curve group (SCG) with the double curve group (DCG).*

only allowed a 2D characterization of the postural aspects of the scoliosis, it proved to be a reliable tool.[2,23,32]

The long time spent in photographic acquisition was also a limitation of this study. Future studies should use the new 3D back surface topography measurement system, the structured light method, to test the time effectiveness of this methodology in SSS.

The small sample size (n = 5) of boys with scoliosis in the present study restricted the ability to analyze sex differences related to posture. Future studies should ensure a sufficient sample size of male participants to investigate postural sex differences in scoliosis because the literature already has reported information about these differences in the population of children without scoliosis.[33]

Conclusions

Adolescents diagnosed with AIS in an SSS had greater shoulder obliquity and asymmetry between the right- and left-side lower limb frontal angle, shoulder sagittal alignment, and knee angle. Adolescents with double curve scoliosis presented a greater value of the vertical alignment of the torso than the adolescents with single curve scoliosis. Shoulder obliquity was the only postural deviation associated with AIS.

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Contributorship Information

Concept development (provided idea for the research): P.J.P., S.M.A.J.
Design (planned the methods to generate the results): P.J.P., N.L.J.P., B.K.G.C., R.M.A.
Supervision (provided oversight, responsible for organization and implementation, writing of the manuscript): S.M.A.J.
Data collection/processing (responsible for experiments, patient management, organization, or reporting data): P.J.P., N.L.J.P., B.K.G.C., R.M.A.
Analysis/interpretation (responsible for statistical analysis, evaluation, and presentation of the results): A.C.B.S.
Literature search (performed the literature search): P.J.P.
Writing (responsible for writing a substantive part of the manuscript): P.J.P.
Critical review (revised manuscript for intellectual content, this does not relate to spelling and grammar checking): S.M.A.J.

Practical Applications

- Shoulder obliquity was the postural variable associated with adolescent idiopathic scoliosis.
- Adolescents with idiopathic scoliosis had greater posture asymmetry between their right and left sides than adolescents without idiopathic scoliosis.
- Adolescents with idiopathic scoliosis had posture asymmetries that indicate trunk rotation.
- The evaluation of shoulder obliquity should be considered for inclusion in the routines used to assess scoliosis in adolescents in clinical and scholastic environments.

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