Quantitative Postural Analysis of Children With Congenital Visual Impairment

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Abstract

Objectives: The aim of this study was to compare the postural alignment of children with visual impairment with that of children without visual impairment.

Methods: The sample studied was 74 children of both sexes ages 5 to 12 years. Of these, 34 had visual impairment and 40 were control children. Digital photos from the standing position were used to analyze posture. Postural variables, such as tilt of the head, shoulder position, scapula position, lateral deviation of the spine, ankle position in the frontal plane and head posture, angle of thoracic kyphosis, angle of lumbar lordosis, pelvis position, and knee position in the frontal and sagittal planes, were measured with the Postural Assessment Software 0.63, version 36 (SAPO, São Paulo, Brazil), with markers placed in predetermined bony landmarks.

Results: The main results of this study showed that children with visual impairment have increased head tilt ($P <$ .001), shoulder deviation in frontal plane (P = .004), lateral deviation of the spine ($P <$ .001), changes in scapula position (P = .012), higher thoracic kyphosis (P = .004), and lower lumbar lordosis ($P <$ .001).

Conclusions: Visual impairment influences postural alignment. Children with visual impairment had increased head tilt, uneven shoulders, greater lateral deviation of the spine, thoracic kyphosis, lower lumbar lordosis, and more severe valgus deformities on knees. (J Manipulative Physiol Ther 2018;41:62-70)

Key Indexing Terms: *Posture; Child; Visual Impairment*

Introduction

Vision plays a fundamental role in body development because it is a primary source of stimulus that enables direct interaction with the external environment. The ability to move and explore the environment enables the acquisition of key experiences that allow the global development and adaptation of the child to the environment.[1-5]

Although the body needs information from various sensory and proprioceptive organs, vision plays the most important role because it encodes and processes information from all other senses. Thus, in the early years of life, the child is more dependent on visual information than on somatosensory and vestibular information.[6]

Some variations in posture in children are associated with growth stages, and changes in body proportions can lead to problems with balance. The deviations in postural alignment could be considered normal at the developmental phase of the musculoskeletal system, but the same deviations may be considered inappropriate at a subsequent developmental phase.[7]

Evaluation and postural education are important aspects of rehabilitation for diagnosis and treatment planning, as well as for monitoring the progress and results of physical therapy treatment.[7]

According to Lafond et al, in clinical practice, assessment of the standing posture of children and adolescents can be very useful for early detection of developmental musculoskeletal changes. This early detection helps plan interventions to prevent or delay the establishment of postural abnormalities.[8]

In children with visual impairments, temporal as well as spatial information is processed with lower speed, and motor development is less understood than in children with normal vision.[2]

The literature demonstrates that children with visual impairments may undergo more changes in posture than only in the alignment of the head and the cervical spine. There is no standard approach to assessing posture. However, the use of photographs as a tool for postural assessment has been supported by many researchers.[9-13] This technique has a quantitative character that allows the measurement of angles and distances between bone references, joints, planes, and axes.[11]

Considering that children with normal vision usually exhibit postural changes during growth, that children with visual impairment may have postural changes related to

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lack of information, and that the knowledge of most frequent postural changes in children with visual impairment can be critical to diagnosing and treating musculoskeletal disorders and to monitoring patient progress in physiotherapy treatment, it is necessary to investigate the postural pattern in children with visual impairments.

Therefore, the objective of the present study was to quantitatively characterize the posture of children with congenital visual impairment. Our hypothesis was that children with congenital visual impairment would have more postural changes compared with children with normal vision.

Methods

Sample

The study included 74 children, 34 with visual impairments and 40 with normal vision. The sample size calculation of the 34 children with congenital visual impairment, based on head tilt, was carried out using G-Power 3.0 software (available at: http://www.gpower.hhu.de/en.html), considering a moderate effect size (F = 0.25), a statistical power of 80%, and a significance level of 5%.

Children with visual impairments were selected from the Low Vision sector of Hospital das Clínicas, Universidade de São Paulo, Institute of Blind Padre Chico, and the Brazilian Association of Assistance to the Visually Impaired. Sixteen girls (47%) and 18 boys (53%), ages 5 to 12 years, were included in the study. With regard to the group with visual impairments, the participants were blind (visual acuity lower than 3/60 gift or visual field lower than 10th), had severe visual impairment (visual acuity <6/60 present and ≥3/60), or had moderate visual impairment (visual acuity <6/18 present and ≥6/60).[6]

The children in the control group were selected from the network of municipal public schools of São Paulo, Brazil, and 17 girls and 23 boys, ages 5 to 12 years, were included in the study. For both groups, the exclusion criteria were the presence of neuromuscular, musculoskeletal, and cardiorespiratory diseases, and body mass index greater than the 85th percentile. Children involved in sports at a frequency greater than twice a week and/or up to 3 hours weekly were also excluded.

Procedure

Initially, parents or legal guardians signed a free and informed consent form. The study was approved by the Ethics Committee for Research Development Review, CAPPesq Clinical Hospital of the board of the Faculty of Medicine, University of São Paulo (São Paulo, Brazil).

An initial evaluation form containing information about weight, height, age, eye pathology, body mass index, race, dominance, and institution or school, was filled out.

Postural evaluation was performed with the use of digital photographs of the individual in the orthostatic position, in the sagittal and frontal planes. In the sagittal plane, each individual was photographed twice, first with arms positioned along the body and then with shoulder adduction and internal rotation and elbow flexion, resting hands on the thorax contralaterally, to facilitate measurement of the thoracic and lumbar curvatures, pelvic tilt, and knees.[7]

Children were dressed in bathing suits and positioned on a wooden base, with feet equidistant from the middle line of the wooden base.

A digital camera (Cyber-shot W-55; Sony, Tokyo, Japan) was placed on a tripod with at 1 m height, at a distance of 2.5 m from the wooden base. Reference points on the head, trunk, and limbs were marked with self-adhesive labels of 13 mm and 9 mm Styrofoam balls, as previously described by Penha et al.[7]

The following points were marked: external acoustic meatus, acromion, inferior angle of the shoulder blades; anterosuperior iliac and posterosuperior spine; spinous cervical region (C5 and C7); thoracic (T1, T3, T6, T9, and T12) lumbar (L3 and L5), sacral (S2) spine; lateral malleolus; the midpoint between the malleoli (Achilles tendon); the midpoint of the calcaneus; midpoint of the lower third of the leg; head of the fibula; and the greater trochanter of the femur.

Two previously trained evaluators performed the photographic procedures, and then the photos were imported into the Postural Assessment Software 0.63, version 36 (SAPO, São Paulo, Brazil). The Postural Assessment Software was developed to assist with posture assessment from digitalized pictures and determined coordinates of the anatomical points on the photographs. The measurements used for posture analysis included distances (in centimeters) and angles (in degrees), taken from a combination of anatomical points. The photo alignment was held from markers located on the plumb line. For each participant, 4 photos were analyzed (anterior, posterior, left, and right views). The analysis was conducted as follows: opening the photo, 40% zoom, calibrating image using the plumb line, marking anatomical points, and producing a report on the placement of the points in terms of x (horizontal) and y (vertical) coordinates.

Postural Data Analysis

Tilt of the Head in the Frontal Plane. Pictures were taken in the frontal plane. A line passing through the ear canal perpendicular to the plumb line and another line between the right and left ear canals were traced. The angle between the 2 lines was measured.

Head Posture. Pictures in the left and right sagittal planes, with arms placed along the body, were considered independent. A horizontal line going through C7 perpendicular to the plumb line and another line diagonal to C7 in

Table 1. *Visual Impairment Causes*

Visual Impairment Causes	n	%
Primary congenital glaucoma	15	44.1
Retinochoroiditis macular toxoplasmosis	7	20.6
Retinopathy of prematurity	3	8.9
Ocular malformation	2	5.9
High myopia	2	5.9
Hereditary diseases of the retina and macula	2	5.9
Optic atrophy	1	2.9
Crystalline ectopic	1	2.9
Idiopathic congenital nystagmus	1	2.9
Total	34	100.0

the direction of the external auditory meatus were traced. The angle between the 2 lines was calculated. For this measurement, the supplemental angle obtained was considered.

Shoulder Angle in the Frontal Plane. Pictures were taken in the frontal plane. The gap between the shoulders was analyzed. The angle between the horizontal line through the right acromion, perpendicular to the plumb line, and the line between the right and left acromions was measured.

Shoulder Angle in the Sagittal Plane. The angle between the horizontal line through the acromion and the diagonal of the acromion to the spinous process of C7 was defined as the shoulder angle in the sagittal plane. The measurement was made in the right and left sagittal planes, and the sides were considered independent.

Lateral Deviation of the Spine. Photos were taken on the posterior frontal plane. The measurement was performed according to the method proposed by Watson and Mac Donncha[9] but in a modified form. A horizontal line through S2 and another orthogonal line following the spinous processes of the vertebrae were drawn. The lateral deviation angle was measured at the intersection of the vertical line with the other line that was part of the S2 spinous process, moving away or deviating more from the vertical. This alteration was classified according to the location and side of the convexity of the curve.

Posture of the Scapula. Photos were taken on the posterior frontal plane. The scapula was considered winged by visually evaluating its inferior angle and medial edge. The distance between the lower angle and the spinous process of the sixth thoracic vertebrae was measured.[14]

Thoracic Kyphosis. Three points were scored, 1 at greater concavity of the lumbar spine, another in greater concavity of the cervical spine, and finally the most convex point of the thoracic spine. When this was not visible because of the winged scapula, the inferior angle was used. Two straight

Table 2. *Postural Variables in the Frontal Plane*

Postural Variables	Segment Side	VIG Mean (SD)	CG Mean (SD)	*P*
Head tilt (degrees)	-	5.3 (3.2)	1.7 (1.3)	<.001 [a]
Shoulder position frontal (degrees)	-	2.4 (1.9)	1.4 (1.1)	.004 [a]
Spine lateral deviation (degrees)	-	2.4 (1.6)	1.0 (1.4)	<.001
Scapula position (cm)	R	5.6 (1.5)	5.9 (1.0)	.012 [a]
	L	5.6 (1.7)	6.0 (1.0)	.571
Knee position – frontal (cm)	-	2.9 (3.4)	2.7 (2.4)	.046 [a]
Ankle position (degrees)	R	6.8 (4.2)	7.0 (3.2)	.795
	L	8.0 (4.0)	7.4 (3.6)	.471

CG, control group; *L*, left; *R*, right; *SD*, standard deviation; *VIG*, visual impairment group.

[a] One-way analyses of variance for repeated measures. *P* < .05 indicated significant difference.

Table 3. *Postural Variables on Sagittal Planes*

Postural Variables (Degrees)	Segment Side	VIG Mean (SD)	CG Mean (SD)	*P*
Head position	R	138.4 (9.3)	135.5 (5.8)	.303
	L	138.8 (7.7)	135.4 (5.8)	.188
Sagittal shoulder position	R	33.7 (14.0)	30.9 (10.1)	.756
	L	33.8 (12.7)	31.2 (11.5)	.792
Thoracic kyphosis	R	37.3 (7.0)	31.0 (5.4)	.454
	L	36.2 (5.9)	30.0 (4.7)	.004 [a]
Lumbar lordosis	R	38.0 (8.2)	41.3 (6.6)	<.001 [a]
	L	36.1 (8.2)	40.1 (6.3)	.065
Sagittal knee position	R	181.0 (7.5)	178.7 (6.0)	.823
	L	179.8 (7.4)	176.8 (5.8)	.06
Pelvis position	R	13.9 (4.8)	13.7 (4.2)	.86
	L	13.6 (4.5)	13.0 (3.8)	.582

CG, control group; *L*, left; *R*, right; *SD*, standard deviation; *VIG*, visual impairment group.

[a] One-way analyses of variance for repeated measures. *P* < .05 indicated significant difference.

lines were drawn between the points of concavity of the curvature to the point, and the angle between the 2 straight obeisants was considered the thoracic kyphosis angle.[15,16] The pictures were taken in the sagittal plane from the right and left sides and were considered independent.

Lumbar Lordosis. The angle between the points of greatest convexity of the thoracic spine and buttocks were measured, with the apex in the greatest concavity point of the lumbar spine.[15,16] The photos were taken in the sagittal plane from the right and left sides and were considered independent.

Table 4. *Mean, SD, ICC of Intrarater Analysis, and SEM of Postural Variables Comparison on Frontal Plane of VIG and CG for the Different Moments of Measurement*

Postural Variables	Segment Side	Group	Before Mean (SD)	After Mean (SD)	SEM	ICC	Reliability
HI (degrees)	-	VIG	5.3 (3.2)	5.2 (3.2)	0	0.85	Very good
		CG	1.7 (1.3)	1.6 (1.3)	0	0.93	Excellent
FSP (degrees)	-	VIG	2.4 (1.9)	2.5 (1.8)	0.14	0.90	Excellent
		CG	1.4 (1.1)	1.4 (1.1)	0	0.98	Excellent
SLD (degrees)	-	VIG	2.4 (1.6)	2.3 (1.6)	0	0.97	Excellent
		CG	1.0 (1.4)	1.0 (1.4)	0	0.97	Excellent
SP (cm)	R	VIG	5.6 (1.5)	5.8 (1.6)	0.07	0.88	Very good
		CG	5.9 (1.0)	5.9 (1.0)	0	0.99	Excellent
	L	VIG	5.6 (1.7)	5.8 (1.6)	0.07	0.94	Excellent
		CG	6.0 (1.0)	6.1 (1.1)	0.07	0.98	Excellent
FKP (cm)	-	VIG	2.9 (3.4)	2.9 (3.3)	0.07	0.99	Excellent
		CG	2.7 (2.4)	2.9 (2.4)	0	0.95	Excellent
AP (degrees)	R	VIG	6.8 (4.2)	6.0 (3.3)	0.63	0.81	Very good
		CG	7.0 (3.2)	6.8 (3.1)	0.07	0.92	Excellent
	L	VIG	8.0 (4.0)	8.0 (4.1)	0.07	0.89	Very good
		CG	7.4 (3.6)	7.8 (4.1)	0.35	0.89	Very good

AP, ankle position; *CG*, control group; *FKP*, frontal knee position; *FSP*, frontal shoulder position; *HI*, head inclination; *ICC*, intraclass correlation coefficient; *L*, left; *R*, right; *SD*, standard deviation; *SEM*, standard error of measurement; *SLD*, spine lateral deviation; *SP*, scapula position; *VIG*, visual impairment group.

One Knee in the Frontal Plane. Intercondylar and intermalleolar distances were measured, with pictures in the previous frontal plane. The knees were considered valgus when the distance was intermalleolar, varus when the distance was intercondylar, and normal when there was no distance.

One Knee in the Sagittal Plane. We checked the angles between the lateral malleolus, head of the fibula, and greater trochanter of the femur. The measurement was made with photos in the sagittal plane from the right and left sides and was considered independent.

Pelvis Posture. Two lines were drawn, 1 for the anterosuperior and the posterosuperior iliac spines and another horizontal to the anterosuperior iliac spine. The angle of intersection of these 2 lines was measured. The measurement was performed on the right and left sagittal planes, and the sides were considered independent.

Ankle Posture. The angle formed with the intersection of the vertical line passing through the Achilles' tendon to the middle point of the leg and the other passing through the Achilles' tendon until the midpoint of the calcaneus were measured. The photographs were taken from the posterior frontal plane.

Reliability

We assessed intrarater and interrater reliability for the following variables: head frontal position; shoulder frontal and sagittal planes; scapula; thoracic kyphosis; lumbar lordosis; and the lateral deviation of the spine, pelvis, and knees in the frontal and sagittal planes and ankles in the frontal plane.

To evaluate reliability, the same examiner performed 2 evaluations of the images obtained in 100% of the sample at 2 different moments, with an interval of 1 month between the evaluations. To check for systematic error, we calculated the standard error of measurement (SEM). For reproducibility assessments, 2 examiners performed the same measurements of the images obtained in 100% of the sample. To check for systematic interrater error, the standard error predictive was calculated.[17]

Statistical Analysis

The data were presented by descriptive statistics (mean, standard deviation [SD], and percentages). The variables presented normal distribution determined by using the Shapiro Wilk test. Comparisons of postural variables were made by one-way analysis of variance (ANOVA) for repeated measures, followed by post hoc Tukey's tests, with $P = .05$ as the significance level.

Next, the intraclass correlation coefficient (ICC) was calculated using the results of the 2-way ANOVA for reproducibility (interanalysis) and 1-way ANOVA for repeated measurements for repeatability (intrarater analysis). Therefore, the degree of agreement between raters was measured.

We used the ICC with model and shape (2.1), when each participant was evaluated by the same set of evaluators[2] of

Table 5. *Mean, SD, ICC of Intrarater Analysis, and SEM of Comparison Between Postural Variables on Sagittal Plane of VIG and CG for Different Moments of Measurement*

Postural Angles (Degrees)	Segment Side	Group	Before Mean (SD)	After Mean (SD)	SEM	ICC	Reliability
HP	R	VIG	138.4 (9.3)	135.2 (8.9)	0.56	0.98	Excellent
		CG	135.5 (5.8)	136.7 (5.5)	0.21	0.86	Excellent
	L	VIG	138.8 (7.7)	138.7 (7.7)	0	0.96	Excellent
		CG	135.4 (5.8)	135.9 (5.8)	0	0.96	Excellent
SSP	R	VIG	33.7 (14.0)	33.6 (14.1)	0.14	0.97	Excellent
		CG	30.9 (10.1)	31.2 (9.8)	0.21	0.98	Excellent
	L	VIG	33.8 (12.7)	33.8 (12.6)	0.14	0.96	Excellent
		CG	31.2 (11.5)	31.3 (11.8)	0.21	0.95	Excellent
TK	R	VIG	37.3 (7.0)	36.7 (5.5)	1.00	0.93	Excellent
		CG	31.0 (5.4)	31.7 (5.3)	0.07	0.90	Excellent
	L	VIG	36.2 (5.9)	36.1 (6.0)	0.07	0.82	Very good
		CG	30.0 (4.7)	31.1 (5.1)	0.28	0.86	Very good
LL	R	VIG	38.0 (8.0)	38.0 (8.1)	0.07	0.86	Very good
		CG	41.3 (6.6)	40.7 (6.9)	0.21	0.92	Excellent
	L	VIG	36.1 (8.2)	37.8 (8.0)	0.14	0.91	Excellent
		CG	40.1 (6.3)	40.3 (7.0)	0.49	0.93	Excellent
SKP	R	VIG	181.0 (7.5)	180.2 (8.2)	0.49	0.90	Excellent
		CG	178.7 (6.0)	178.9 (5.5)	0.35	0.88	Very good
	L	VIG	179.8 (7.4)	178.1 (6.8)	0.42	0.74	Acceptable
		CG	176.8 (5.8)	177.6 (5.9)	0.07	0.85	Very good
PP	R	VIG	13.9 (4.8)	13.7 (4.9)	0.07	0.88	Very good
		CG	13.7 (4.2)	13.7 (4.0)	0.14	0.82	Very good
	L	VIG	13.6 (4.5)	13.4 (4.8)	0.21	0.93	Excellent
		CG	13.0 (3.8)	12.8 (4.3)	0.35	0.94	Excellent

CG, control group; *HP*, sagittal head position; *ICC*, intraclass correlation coefficient; *L*, left; *LL*, lumbar lordosis; *PP*, pelvis position; *R*, right; *SD*, standard deviation; *SEM*, standard error of measurement; *SKP*, sagittal knee position; *SSP*, sagittal shoulder position; *TK*, thoracic kyphosis; *VIG*, visual impairment group.

the same population of evaluators. To calculate the intrarater reliability (repeatability), we used the ICC with style and form (3.1), to calculate the variance between repeated measurements when each participant was assessed by the same examiner on 2 different occasions. The classification was made according to Wahlund et al.[18] ICCs less than 0.7 were considered not acceptable; ICCs that were greater than 0.71 and less than 0.79 were acceptable; ICCs greater than 0.8 and less than 0.89 were considered very good, and ICCs greater than 0.9 were excellent.

To check for systematic error reliability, we calculated the SEM of each evaluator to determine intrarater reliability. The SEM was calculated on the basis of the mean difference in SD between the 2 moments (2 repeated measures) divided by $\sqrt{2}$.[17] The systematic error of interrater reliability was checked for each evaluator, and the standard error of prediction was obtained. The standard error of prediction was calculated by multiplying the variability (SD) of the measurements obtained by each evaluator and $\sqrt{1\text{–ICC}}$.[2,17]

Excel 2003 (Microsoft Corp., Redmond, Massachusetts), Minitab v. 14 (Minitab Inc., State College, Pennsylvania), and Statistica v. 7 (TIBCO Software Inc., Palo Alto, California) were used for statistical analysis and mathematical treatment of data.

To verify the correlation between the variables, tilt of the head and lateral deviation of the spine, in the frontal plane Pearson's correlation tests were used.

Results

We evaluated 74 children, 34 with visual impairment and 40 without visual impairment (control group). In the group with visual impairment, 16 were girls (47%) and 18 were boys (53%). The mean age was 8 years for boys (age range 5-12 years) and 8 years and 7 months for girls (age range 5-12 years). Children with visual disabilities were blind (visual acuity lower than 3/60 or lower visual field than 10), had severe visual impairment (visual acuity <6/60 and ≥3/60), or had moderate visual impairment (visual acuity <6/18 and ≥6/60).

The causal pathologies were diagnosed by an ophthalmologist as follows: primary congenital glaucoma, macular

Table 6. *Mean, SD, ICC of Inter-rater Analysis and SEP and* P *Value of Comparison Between Postural Variables on Frontal Plane in VIG and CG for Raters Measurements*

Postural Variables	Segment Side	Group	Rater 1 Mean (SD/SEP)	Rater 2 Mean (SD/SEP)	ICC	Reliability
HI (degrees)	-	VIG	5.3 (3.2/1.5)	5.0 (3.4/1.5)	0.89	Very good
		CG	1.7 (1.3/0.9)	2.0 (1.4/1.0)	0.80	Very good
FSP (degrees)	-	VIG	2.4 (1.9/0.4)	2.5 (1.9/0.4)	0.97	Excellent
		CG	1.4 (1.1/0.8)	1.6 (1.1/0.8)	0.90	Excellent
SLD (degrees)	-	VIG	2.4 (1.6/0.3)	2.3 (1.5/0.3)	0.98	Excellent
		CG	1.0 (1.4/0.1)	1.0 (1.4/0.1)	0.99	Excellent
SP (cm)	R	VIG	5.6 (1.5/0.3)	5.9 (1.5/0.3)	0.98	Excellent
		CG	5.9 (1.0/0.5)	6.5 (1.8/0.9)	0.86	Very good
	L	VIG	5.6 (1.7/0.7)	5.8 (1.7/0.7)	0.90	Excellent
		CG	6.0 (1.0/0.3)	6.3 (1.8/0.6)	0.94	Excellent
FKP (cm)	-	VIG	2.9 (3.4/2.4)	3.6 (3.9/2.6)	0.77	Acceptable
		CG	2.7 (2.4/1.0)	3.7 (3.0/1.2)	0.91	Excellent
AP (degrees)	R	VIG	6.8 (4.2/2.6)	6.3 (3.1/1.9)	0.82	Very good
		CG	7.0 (3.2/2.4)	7.6 (2.8/1.7)	0.80	Very good
	L	VIG	8.0 (4.0/2.9)	7.3 (3.5/2.5)	0.73	Acceptable
		CG	7.4 (3.6/1.6)	6.6 (3.2/1.3)	0.89	Very good

AP, ankle position; *CG*, control group; *FKP*, frontal knee position; *FSP*, frontal shoulder position; *HI*, head inclination; *ICC*, intraclass correlation coefficient; *L*, left; *R*, right; *SD*, standard deviation; *SEP*, standard error of prediction; *SLD*, spine lateral deviation; *SP*, scapula position; *VIG*, visual impairment group.

retinochoroiditis toxoplasmosis, retinopathy of prematurity, ocular malformation, high myopia, inherited diseases of the retina and the macula, optic atrophy, and ectopic crystalline and idiopathic congenital nystagmus (Table 1).

The control group consisted of 17 girls with mean age of 8 years and 3 months (age range 5-12 years) and 23 boys with mean age of 8 years and 7 months (age range 5-12 years).

Table 2 shows data obtained through evaluation in the frontal plane, which was statistically significant for head tilt, shoulder posture, spine lateral deviation, and scapula posture, with the visually impairment group having higher rates.

In the sagittal plane, children with visual impairment had higher values of thoracic kyphosis and lower values of lumbar lordosis (Table 3).

Tables 4, 5, 6, and 7 show the results of reliability tests and systematic errors of intrarater and interrater reliability.

Discussion

This study aimed to compare the postural variables in the frontal and sagittal planes between children with visual impairment and those without visual impairment. Another objective was to determine whether there would be an association between the lateral deviation of the spine and the head posture.

The head tilt angles, shoulder posture, spine lateral deviation, knee posture in the frontal angle, thoracic kyphosis, and lumbar lordosis in the sagittal plane were different between the 2 groups.

However, the results found in this study are difficult to compare with those reported in the literature because most studies that assessed postures in children with visual impairment analyzed patterns and changes qualitatively. Other studies that evaluated posture quantitatively used different methodologies and analyzed the population of blind adults.[19-21]

The tilt of the head in the frontal plane was statistically different between the 2 groups. Although both groups showed asymmetry, the highest values were found in the visual impairment group.

Some previous studies reported that the abnormal head posture is a common finding in children with eye diseases. Inclination and rotation of the head, used to achieve better visual acuity and binocularity, are found in children who have, for example, incomitant strabismus, nystagmus, reduced visual field, oculomotor apraxia, refractive errors, and ptosis.[20,22-24]

The literature suggests that individuals with visual impairments have head protraction, which is in contrast to the finding of the present study.[21,25] No differences were found between the groups with regard to the head angle in the sagittal plane.

Sanchez et al[19] studied head tilt by using photogrammetry. They compared individuals with congenital blindness with those without congenital blindness and found no differences between the adult groups.[19]

Table 7. *Mean, SD, ICC of Inter-raters Analysis, and SEP of Comparison Between Postural Variables on Sagittal Plane in VIG and CG for the Raters Measurements*

Postural Variables (Degrees)	Segment Side	Group	Rater 1 Mean (SD/SEP)	Rater 2 Mean (SD/SEP)	ICC	Reliability
HP	R	VIG	138.4 (9.3/2.9)	135.6 (9.3/2.9)	0.95	Excellent
		CG	135.5 (5.8/1.1)	134.6 (5.8/1.1)	0.98	Excellent
	L	VIG	138.8 (7.7/3)	136.8 (8.0/3.2)	0.92	Excellent
		CG	135.4 (5.8/0.8)	135.6 (5.8/0.8)	0.99	Excellent
SSP	R	VIG	33.7 (14.0/9.2)	42.7 (24.5/6.0)	0.78	Acceptable
		CG	30.9 (10.1/4.5)	33.3 (10.0/4.4)	0.97	Excellent
	L	VIG	33.8 (12.7/3.1)	36.7 (12.6/3.0)	0.97	Excellent
		CG	31.2 (11.5/3.6)	33.6 (11.1/3.5)	0.95	Excellent
TK	R	VIG	37.3 (7.0/2.9)	36.6 (7.5/3.1)	0.91	Excellent
		CG	31.0 (5.4/2.5)	27.5 (3.2/1.4)	0.89	Very good
	L	VIG	36.2 (5.9/3.7)	36.1 (7.5/4.7)	0.80	Very good
		CG	30 (4.7/3.7)	31.0 (6.5/4.0)	0.76	Not acceptable
LL	R	VIG	38.0 (8.0/6.4)	37.8 (7.7/5.6)	0.69	Not acceptable
		CG	41.3 (6.6/4.1)	40.9 (7.0/4.4)	0.80	Very good
	L	VIG	36.1 (8.2/4.4)	37.6 (7.6/4.1)	0.85	Very good
		CG	40.1 (6.3/0.8)	40.6 (6.4/0.8)	0.90	Excellent
SKP	R	VIG	181.0 (7.5/2.5)	179.1 (7.7/2.6)	0.94	Excellent
		CG	178.7 (6.0/1.2)	178.2 (4.6/0.9)	0.98	Excellent
	L	VIG	179.8 (7.4/4.4)	178.3 (6.3/3.7)	0.82	Very good
		CG	176.8 (5.8/2.3)	177.5 (4.3/1.7)	0.92	Excellent
PP	R	VIG	13.9 (4.8/3.3)	13.9 (5.2/4.0)	0.70	Acceptable
		CG	13.7 (4.2/1.7)	14.0 (4.3/1.8)	0.91	Excellent
	L	VIG	13.6 (4.5/1.9)	14.1 (4.6/2.0)	0.91	Excellent
		CG	13.0 (3.8/1.4)	13.1 (4.6/1.7)	0.93	Excellent

CG, control group; *HP*, sagittal head position; *ICC*, intraclass correlation coefficient; *L*, left; *LL*, lumbar lordosis; *PP*, pelvis position; *R*, right; *SD*, standard deviation; *SEP*, standard error of prediction; *SKP*, sagittal knee position; *SSP*, sagittal shoulder position; *TK*, thoracic kyphosis; *VIG*, visual impairment group.

Amaya and De Cabrera compared the posture of children with congenital blindness and children with preserved vision. The evaluation was done qualitatively, and a higher incidence of head protraction was found among children with disabilities.[20]

However, it is important to mention that evaluation by visual observation is not a reliable method of assessment. Fedorak et al[26] argued that this method was not reliable for the evaluation of the cervical spine and had no correlation with photogrammetry, which was a much more reliable method to perform postural assessment. Methodologic differences among studies may explain the different findings.

With respect to the shoulder in the frontal plane position, significant asymmetry was found in the group with visual impairment, which is in line with the Amaya and De Cabrera data, as assessed by visual observation of children with congenital blindness.[20] The values of asymmetry in shoulder level were 1.4 degrees in children with preserved vision and 2.4 degrees in children with visual impairment, with both groups presenting the right shoulder lower than the left, which, according to Kendall et al,[27] is a change related to dominance; the dominant member is the lower one.

Ferreira et al[28] found that the right shoulder was lower in 68% of a sample of 122 adults analyzed, and Raine and Twomey[29] found the same results in 160 adult evaluated.

With regard to shoulder alignment in the sagittal plane, there was no significant difference between the 2 groups. This variable is not frequently studied, most likely because of the difficulties in measuring because distortions can be found the influence of the positioning of the shoulder girdle.[29]

The scapula was assessed to analyze the inferior angle and the medial edge of the sample. Penha et al found an incidence of 70% of winged scapula in girls 7 to 8 years of age.[14] Although the winging of the scapula is considered a common disorder in childhood as a result of poor scapulothoracic fixing, in the group of children with visual impairment, the percentage of winged scapula was higher than in the control group.

The visually impairment group showed increased thoracic kyphosis compared with the control group, but there are no data in the literature reporting quantitative evaluation of this variable. In a qualitative study, Mascarenhas et al found increased thoracic kyphosis in 59% of blind adults and in 22% of adults with low vision.[30]

The evaluation of lumbar curvature also showed significant differences between the 2 study groups. Children with visually impairment had lower lumbar lordosis in comparison with controls. Although decreased lordosis is expected as a compensation for increased thoracic curvature, which was also found in the study population, we should be careful when considering these data. The systematic error of the evaluation process of this measure was high between postural variables and the interrater reliability coefficient was considered not acceptable.[27]

Significant differences were found with regard to the lateral deviation of the spine. About 80% of children with visual impairment showed this postural change, with most of the curves having convexity to the left and located in the cervicothoracic region. The findings corroborate data from the study by Aulisa et al.[2] These authors evaluated 46 children by using the Cobb method and found an incidence of 59% of spine lateral deviation.[2]

Some authors argue that the lateral deviation of the spine is the result of deprivation of stimuli that are responsible for the development of the body and for the changes in head posture found in children with visual impairments because the head acts as a kinetic and postural reference for positioning the rest of the body.[2,31]

The rating of the knee in the frontal plane indicated that both groups had valgus knees, but according to the literature, this is an inherent change in the studied population.[32,33]

By analyzing all data about postural variables, we can see that although the rate of some changes in segmental posture was higher in the group of children with visual impairment, both the visual impairment group and the control group had some asymmetries and misalignments. These facts confirm the results obtained by Ferreira et al, who found a tendency toward bilateral asymmetry between segments. Those authors stated that the presence of slight asymmetries, supposedly, represents the normative standard for the standing posture.[28]

The assessment of body segments on a single plane compromises the analysis of 3-dimensional deviations, such as scoliosis, occurring in the transverse plane. Some studies[34] have assessed the spine on the 3 planes, especially to assess scoliosis. However, these studies used radiographs—an expensive methodology and frequently impracticable for health and ethical reasons.

As reported in the literature, some studies[2,20,22,31] only analyzed the assessments of head and spine postures. This study is the only one that used photogrammetry for identifying global postural deviations (head, shoulder, spine, pelvis, knee, and ankle) in children with congenital visual impairment.

Conclusions

Children with visual impairment have more head tilt, uneven shoulders, spine lateral deviation, thoracic kyphosis, reduced lumbar lordosis, and more severe valgus misalignment of knees compared with children without visual impairments. There is no association between head tilt and spine lateral deviation in the population of children with visual impairments.

The findings of this study can help determine physiotherapeutic approaches for these patients with orthopedic and postural changes. Thus, future controlled longitudinal studies are necessary to understand appropriate posture development in children with visual impairment.

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Contributorship Information

Design (planned the methods to generate the results): M.P, S.M.A.J.

Supervision (provided oversight, responsible for organization and implementation, writing of the manuscript): M.P., S.M.A.J.

Data collection/processing (responsible for experiments, patient management, organization, or reporting data): M.P., J.F.S., S.M.A.J.

Analysis/interpretation (responsible for statistical analysis, evaluation, and presentation of the results): M.P., J.F.S., S.M.A.J.

Literature search (performed the literature search): M.P., J.F.S., S.M.A.J.

Writing (responsible for writing a substantive part of the manuscript): M.P., J.F.S., S.M.A.J.

Critical review (revised manuscript for intellectual content, this does not relate to spelling and grammar checking): M.P., J.F.S., S.M.A.J.

Practical Applications

- Postural alterations may be observed in children with visual impairment.
- Postural alterations mainly include head tilt, uneven shoulders, spine lateral deviation, thoracic kyphosis, reduced lumbar lordosis, and valgus knees.
- On the basis of the data from the present study, physiotherapists may be able to better understand patient complaints of orthopedic and postural disorders.

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