European Journal of Orthopaedic Surgery & Traumatology (2019) 29:25–29
https://doi.org/10.1007/s00590-018-2264-1

ORIGINAL ARTICLE • SPINE - IMAGING

Impact of patient position on coronal Cobb angle measurement in non-ambulatory myelodysplastic patients

Norman Ramirez[1] · Jorge Padilla[2] · Sigfredo Villarin[2] · Francisco Irizarry[2] · Ivan Iriarte[2] · Jeffrey Sawyer[3]

Received: 8 May 2018 / Accepted: 5 June 2018 / Published online: 18 June 2018

Abstract

Objective The purpose of this study was to assess the impact of patient position on the magnitude of the coronal Cobb angle measurements in relation to the change of position using plain radiograph on non-ambulatory children with myelodysplasia.

Summary of background data Whole-spine radiographs with the patient sitting generally are preferred for the diagnosis and monitoring of progression of scoliosis in neuromuscular patients. Supine, supine traction, and sitting push-up positions have been used as substitutes, although there is no general consensus validating if these positions correlate with the sitting position. The magnitude of the Cobb angles in neuromuscular scoliosis may vary greatly depending on the position of the patient.

Methods Radiographs of 39 myelodysplastic, non-ambulatory children were evaluated to assess the impact of change in positions (unsupported sitting, sitting push-up, supine, and supine traction) on coronal Cobb angle measurement using plain whole-spine radiographs.

Results The mean difference in thoracic Cobb angle measurements between sitting and all other positions ranged from 6° to 12°. At the lumbar level, the Cobb angles ranged from 12° to 16°.

Conclusions Statistically significant differences in the Cobb angle measurements were identified between plain radiographs of the whole spine with the patient in the unsupported sitting position compared to sitting push-up, supine, and supine traction positions. The data support that the magnitude of the Cobb angles in neuromuscular scoliosis varies greatly depending on the position of the patient.

Level of evidence III.

Keywords Neuromuscular scoliosis · Coronal Cobb angle · Myelodysplasia · Spine radiograph

Introduction

Diagnosis and monitoring of progression of scoliosis in patients with neuromuscular disorders require posterior-anterior whole-spine radiographs, on which the curve magnitude is measured with the Cobb angle method [1–3]. Although the whole-spine view with the patient sitting generally is preferred, situations frequently are encountered that make this difficult to achieve. This occurs frequently with non-ambulatory children with myelodysplasia, which has led to the use of varying positions to obtain the radiographic image of the whole spine. Supine, supine traction, and sitting push-up positions have been used as substitutes, although there is no general consensus validating if these positions correlate with the sitting position [1]. Earlier studies of patients with idiopathic scoliosis investigated the correlation of the Cobb angle with position changes by comparing radiographic images taken with the patient upright position to those taken with the patient supine [4–9]. However, no literature to our knowledge has addressed the impact of change in position on the Cobb angle measurement within a population of non-ambulatory children with myelodysplasia.

The magnitude of the Cobb angle in neuromuscular scoliosis may vary greatly depending on the radiographic

IRB approval: Hospital De La Concepcion, Research Ethics Committee.

✉ Norman Ramirez
normanpipe@aol.com

1 Pediatric Orthopedic Surgeon, Hospital De La Concepcion - San German, Puerto Rico, PO Box 6847, Mayaguez, PR 00681, USA

2 Ponce Health Sciences University, Ponce, PR, USA

3 University of Tennessee-Campbell Clinic, Memphis, TN, USA

technique and the position of the patient [1], and, since no standardized method exists, there is variability in patient positioning in the literature, which may affect the results of these studies, as well as make it impossible to compare outcomes of studies when different measurement techniques were used. The purpose of this study was to evaluate the impact of change in position on the coronal Cobb angle measurement in a population of non-ambulatory children with myelodysplasia.

Methods

This was a cross-sectional study of 39 myelodysplastic, non-ambulatory children who were evaluated to assess the impact of patient position (unsupported sitting, sitting push-up, supine, and supine traction) on the magnitude of the coronal Cobb angle using plain whole-spine radiographs. The research protocol was approved by the Institutional Review Board at Hospital de la Concepcion - San German, Puerto Rico. Subjects included in this study were patients from the *Clinics of Children with Special Health Care Needs* data bank in Puerto Rico (January 2011 to December 2015). The study population consisted of non-ambulatory myelodysplastic children who were at least 7 years of age. Other inclusion criteria were: (1) willingness and ability to cooperate with radiographic studies, (2) no prior surgical interventions or treatments, (3) a thoracic or high lumbar motor level lesion, and (4) lifelong non-ambulatory status. Patients who failed to satisfy any of these criteria were excluded from the study. Subjects and their legal guardians were given a complete explanation of the process and associated hazards. In order to participate in the study, the subjects were required to provide written consent prior to commencement of the study. All images were evaluated and measured independently by two physicians (attending pediatric orthopedic surgeons), who were blinded to patient demographic information.

Spine radiographs of patients in different positions (unsupported sitting, sitting push-up, supine, and supine traction) were evaluated electronically with a radiographic ruler. These patient positions were chosen because they are the most commonly used techniques described in the literature. Data validation was performed using standard nomenclature by designating the most caudal vertebra with a costovertebral joint as T-12 and the most caudal lumbar vertebra as L-5. The coronal deformity (scoliosis) was evaluated using the Cobb method (using the most tilted vertebrae above and below the apex of the curve) [2]. The Cobb angles of thoracic and lumbar curves were compared with the patient in varying positions (Fig. 1).

The data were analyzed using SPSS version 23 and MedCalc version 17.4 statistical software programs. Frequency distributions, means, and standard deviations were used to describe the general characteristics (sex, age) of the study subjects. Values for Cobb angles were compared for plain radiographs in different positions, using t-tests, simple linear regression, and the 95% confidence interval (CI). A simple linear regression was performed to assess the impact of patient age on Cobb angle measurements in different positions. A p value of less than 0.05 was considered statistically significant.

Results

Population

Eighteen boys (46.2%) and 21 girls (53.8%), with a mean age of 14.2 ± 4.4 years, fit the inclusion criteria (39 patients) and had radiographic imaging. The level of the last intact laminar arch was determined with posterior-anterior plain radiographs; 90% of patients had the last intact laminar arch at the thoracic level. The distribution was as follows: T6, 4; T7, 5; T8, 3; T9, 4; T10, 6; T11, 6; T12, 7; and L1, 4.

Coronal Cobb angle

Thoracic Cobb angle measurements taken on plain radiographs showed a statistically significant mean difference between the sitting position and the other three positions: supine ($-9.7° \pm 12.9$ SD, $p = 0.0019$), supine traction ($-11.5° \pm 14.2$ SD, $p = 0.0001$), and sitting push-up ($-5.9° \pm 13.4$ SD, $p = 0.0369$). A statistically significant linear correlation was found between sitting and supine Cobb angles. The linear regression analysis of the thoracic Cobb angles comparing sitting and supine positions resulted in the following equation: $y = 3.5 + 0.7x$. The slope of the equation suggests that for every 1-degree increment in the sitting position there is a simultaneous increase in the mean supine Cobb angle of 0.7°.

The comparison of the sitting push-up and supine traction positions demonstrated a statistically significant mean difference ($4.6° \pm 10.3$ SD, $p = 0.0442$). However, there was no significant mean difference between supine and supine traction ($-2.6° \pm 9.9$ SD, $p = 0.2312$) positions or between supine and sitting push-up ($0.4° \pm 19.5$ SD, $p = 0.9219$) positions (see Table 1). The patient age did not correlate with the thoracic coronal Cobb angle changes among the different body positions ($p = 0.819$).

Lumbar Cobb angle measurements had a similar pattern when the sitting position was compared to the three other positions: a statistically significant mean difference was seen with sitting compared to supine ($-11.7° \pm 26.7$ SD, $p = 0.0425$), supine traction ($-16.0° \pm 18.9$ SD, $p = 0.0001$), and sitting push-up ($-12.8° \pm 26.1$ SD, $p = 0.0222$) positions. A statistically significant linear

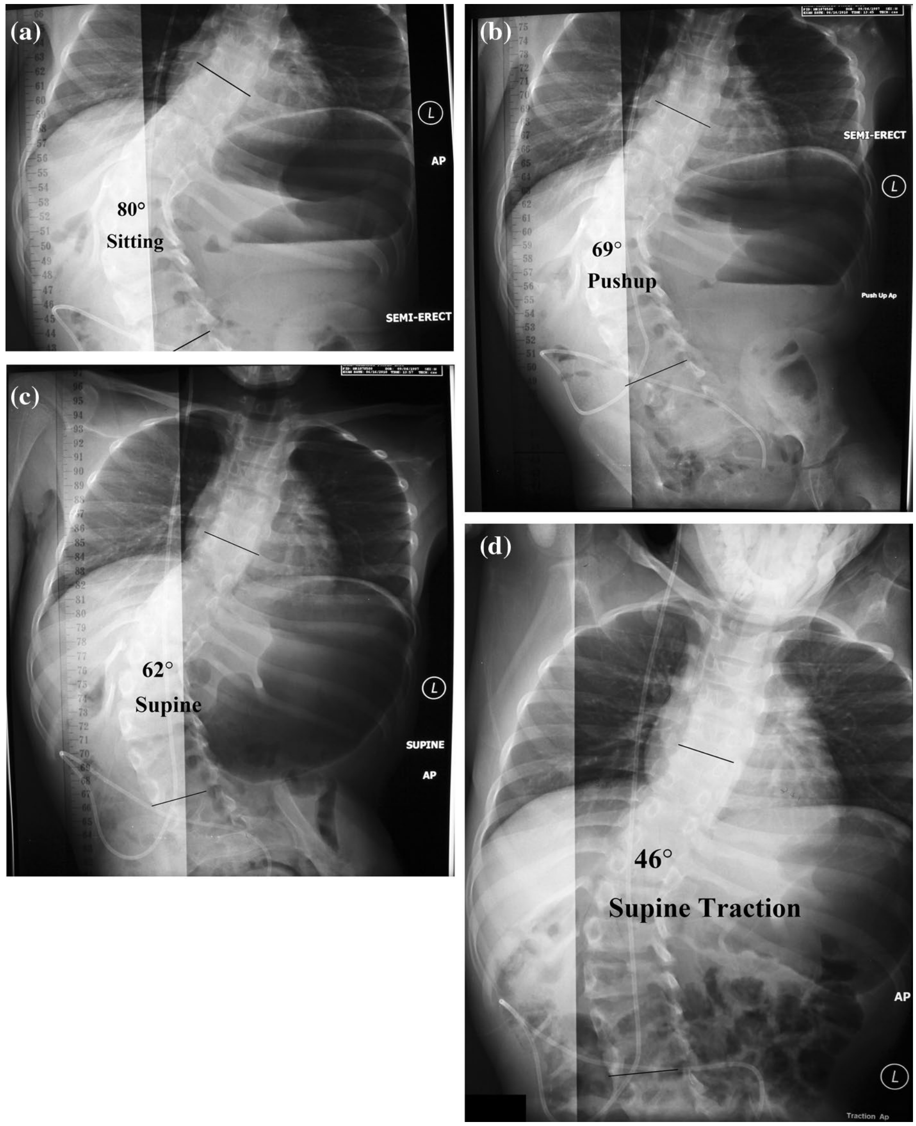

Fig. 1 Patient #31: 13 y/o male patient non-ambulatory myelodysplasia with a low thoracic motor level with hydrocephalus and VP shunt. Thoracolumbar curve from thoracic #6 to lumbar # 4. **a** Sitting X-ray demonstrates a Cobb angle of 80°. **b** Sitting push-up Cobb angle 69°. **c** Supine Cobb angle 62°. **d** Supine traction Cobb angle 46°

Table 1 Thoracic Cobb angles position evaluation ($N=39$)

	Mean ± SD	Mean difference ± SD	*p* value	95% CI
Sitting versus supine $N=39$	40.1° ± 24.6 versus 30.4° ± 19.3	− 9.8° ± 12.93	0.0019	− 15.51 to − 4.04
Sitting versus traction $N=38$	41.2° ± 23.6 versus 29.6° ± 20.9	− 11.6° ± 14.2	0.0001	− 16.86 to − 6.27
Sitting versus push-up $N=35$	37.4° ± 19.5 versus 31.5° ± 20.9	− 5.9° ± 13.4	0.0369	− 11.45 to − 0.39
Traction versus push-up $N=38$	28.5° ± 19.6 versus 33.1° ± 20.9	4.6° ± 10.4	0.0442	0.13 to 9.09
Supine versus traction $N=35$	28.7° ± 18.0 versus 26.0° ± 18.0	− 2.7° ± 9.9	0.2312	− 7.17 to 1.84
Supine versus push-up $N=36$	29.3° ± 17.8 versus 29.8° ± 19.1	0.5° ± 19.5	0.9219	− 9.54 to 10.48

correlation was found between sitting and supine Cobb angles. The linear regression analysis of the lumbar Cobb angles comparing sitting and supine positions resulted in the following equation: $y = 12.4 + 0.6x$. The slope of the equation suggests that for every 1-degree increment in the sitting position there is a simultaneous increase in the mean supine Cobb angle of 0.6°.

There was no statistically significant difference between mean Cobb angles in the supine position and angles in the supine traction (− 5.7° ± 29.6 SD, $p = 0.3630$) and sitting push-up (− 1.9° ± 9.5 SD, $p = 0.3992$) positions and none between the supine traction and sitting push-up (2.4° ± 32.2 SD, $p = 0.7201$) (see Table 2) positions. The patient age did not correlate with the lumbar coronal Cobb angles changes reported among the different body positions ($p = 0.064$).

Discussion

Scoliosis is frequent in patients with neuromuscular diseases, [1, 10] presents at an early age and tends to progress rapidly during growth, likely secondary to poor neuromuscular control. In comparison with idiopathic scoliosis, neuromuscular scoliosis tends to progress beyond skeletal maturity, is resistant to bracing, and is associated with more frequent complications. The entire thoracolumbar spine generally is affected in neuromuscular scoliosis, and the deformity frequently extends to the pelvis. This causes pelvic obliquity, which affects the ability to sit and walk [1, 10]. In ambulatory patients, the preferred radiographic imaging method to monitor the progression of scoliosis is plain radiographs with the patient standing; however, a general consensus for imaging in non-ambulatory patients is not clearly defined [1, 3, 10]. As a result, radiographs in non-ambulatory patients with neuromuscular scoliosis often are obtained in different positions such as sitting, sitting push-up, supine, and supine traction [1]. How these varying positions affect the measurement has not been evaluated.

The Cobb angle method is the most commonly used method for evaluating curve magnitude and severity in all types of scoliosis [2]. Previous studies on patients with idiopathic scoliosis evaluating the effect that the change of position has on the magnitude of the Cobb angle demonstrated a mean difference of 7° to 11° (comparing standing and supine positions) [4–9]. These findings are caused by the varying effects of the gravitational load on the patients' spine with each position. This difference in the measurement of the coronal Cobb angle secondary to position change may have a negative effect on clinical decision making if it is not accounted for in the clinician's evaluation of progression of the scoliosis. In this study, we found that the mean Cobb angles measured with the patient sitting were significantly greater than those with the patient in the sitting push-up, supine, and supine traction positions, which likely is secondary to the effects of gravitational loading as noted in previous studies [4–6]. The data demonstrate that the mean difference in thoracic Cobb angle measurements between sitting and all the other positions ranged from 6° to 12°. At the lumbar level, the Cobb angles ranged from 12° to 16°; however, a positive linear correlation was found between these positions, which indicates that as the Cobb angle increases in the sitting position it simultaneously increases in the other positions as well (sitting push-up, supine, and supine traction). Depending on the level of the curvature, the correlation range of the slope varies from 0.58 up to 0.67, lumbar and thoracic, respectively.

One of the weaknesses of this study is that this is a relatively small group of patients; however, myelodysplasia itself is rare, occurring in 3.7/10,000 births [11], and this study was limited to non-ambulatory patients. While it has been shown that measurement of Cobb angles in patients with neuromuscular curves and congenital curves may be more difficult than in patients with idiopathic scoliosis, the variability between our measurements in different positions is greater than the expected measurement error, even in this difficult population to measure.

Our findings are clinically relevant because many decisions, including the decision to perform surgical intervention, which is extremely high risk in this patient population, are based on radiographic curve parameters including progression. Our data show that sitting radiographs provide the most reliable measure of true curve magnitude due to the gravitational load on the spine compared to other supine methods. These correlations provide some estimates for comparison of films for a given patient taken in different positions and highlight the need for standardization in the radiographic assessment of scoliosis in non-ambulatory myelodysplastic patients.

Table 2 Lumbar Cobb angles position evaluation ($N = 39$)

	Mean ± SD	Mean difference ± SD	p value	95% CI
Sitting versus supine $N = 39$	57.5° ± 38.7 versus 45.8° ± 30.9	− 11.7° ± 26.7	0.0425	− 22.98 to 0.43
Sitting versus traction $N = 38$	58.5° ± 39.5 versus 42.5° ± 41.7	− 16.0° ± 19.0	0.0001	− 23.24 to − 8.83
Sitting versus push-up $N = 35$	60.4° ± 40.8 versus 47.6° ± 35.5	− 12.8° ± 26.2	0.0222	− 23.60 to − 2.00
Traction versus push-up $N = 38$	46.9° ± 45.6 versus 49.3° ± 36.5	2.4° ± 32.2	0.7201	− 11.47 to 16.34
Supine versus traction $N = 35$	46.9° ± 31.1 versus 41.2° ± 39.1	− 5.7° ± 29.6	0.3630	− 18.55 to 7.07
Supine versus push-up $N = 36$	50.8° ± 33.4 versus 48.9° ± 35.8	− 1.9° ± 9.5	0.3992	− 6.69 to 2.80

Conclusions

This study demonstrated statistically significant differences between plain radiographic imaging of the whole spine with the patient sitting compared to all alternative positions and highlights the need for standardized radiographic measurements for non-ambulatory myelodysplastic patients. The results of this study may provide a framework for future study to evaluate the effect of patient positioning on patients with other neuromuscular conditions such as cerebral palsy, muscular dystrophy, and spinal cord injury.

Acknowledgements The authors thank the Children's Spine Foundation for the grant awarded to perform the study. We also give recognition to John M Flynn MD (deceased) who gave the initial support.

Funding Funding was provided by Children Spine Foundation Grant #18.

Compliance with ethical standards

Conflict of interest The authors declared that they have no conflict of interest.

References

1. Halawi M, Lark R, Fitch R (2015) Neuromuscular scoliosis: current concepts. Orthopedics 38:e452–e456
2. Cobb JR (1948) Outline for the study of scoliosis. In: Edwards JW (ed) Instructional course lectures. The American Academy of Orthopedic Surgeon, Ann Arbor, pp 261–275
3. Gupta M, Wijesekera S, Sossan A et al (2007) Reliability of radiographic parameters in neuromuscular scoliosis. Spine 32:691–695
4. Brink RC, Colo D, Schlösser TPC et al (2017) Upright, prone, and supine spinal morphology and alignment in adolescent idiopathic scoliosis. Scoliosis Spinal Disord 12:6
5. Keenan BE, Izatt MT, Askin GN et al (2014) Supine to standing Cobb angle change in idiopathic scoliosis: the effect of endplate pre-selection. Scoliosis 9:16
6. Vavruch L, Tropp H (2016) A comparison of Cobb angle: standing versus supine images of late-onset idiopathic scoliosis. Polish J Radiol 81:270–276
7. Torell G, Nachemson A, Haderspeck-Grib K et al (1985) Standing and supine Cobb measures in girls with idiopathic scoliosis. Spine 10:425–427
8. Lee MC, Solomito M, Patel A (2013) Supine magnetic resonance imaging Cobb measurements for idiopathic scoliosis are linearly related to measurements from standing plain radiographs. Spine 38:E656–E661
9. Wessberg P, Danielson BI, Willen J (2006) Comparison of Cobb angles in idiopathic scoliosis on standing radiographs and supine axially loaded MRI. Spine 31:3039–3044
10. Trivedi J, Thomson JD, Slakey JB et al (2002) Clinical and radiographic predictors of scoliosis in patients with myelomeningocele. J Bone Joint Surg Am 84(8):1389–1394
11. Canfield MA, Mai CT, Wang P, O'Halloran A, Marengo LK, Olney RS et al (2014) The association between race/ethnicity and major birth defects in the United States, 1999–2007. Am J Public Health 104:e1–e10