Assessing a Novel Method of Calculation of the Cobb Angle for Scoliosis: Interexaminer Reliability and Student Satisfaction

Marcello L. Caso, DC, and John M. Clements, PhD

ABSTRACT

Objective: The objectives of this pilot study were to compare the interexaminer reliability of 2 different methods of Cobb angle measurement and to determine whether the participants considered 1 of the 2 methods easier to learn, understand, and apply.

Methods: Entry-level anatomy students who have familiarity with vertebral column anatomy but have not had previous radiology training were instructed on how to measure a Cobb angle. Each student measured 2 curves (thoracic and lumbar) on a single radiograph, first with the traditional method of Cobb angle measurement and second with a novel method of Cobb angle measurement using a digital level.

Results: The variance of measurements decreased by using the novel method from thoracic to lumbar measurements and for the moderate and severe scoliosis films. All decreases in variance were statistically significant except for the lumbar measurement variance for the severe scoliosis film. The novel method of Cobb angle measurement with these same participants showed interexaminer reliability. More than 78% of naive participants considered the proposed method easier to learn, understand, and apply when compared with the traditional method.

Conclusion: In this group of naive students, there was improved interrater reliability, greater satisfaction, and reduced measurement variances in some cases, with a novel method using a digital level to measure the Cobb angle compared with the traditional method of measurement. (J Manipulative Physiol Ther 2019;42:430-438)

Key Indexing Terms: *Scoliosis; Spinal Curvatures*

INTRODUCTION

A scoliosis is a lateral deviation of the spine that can be quantified by the Cobb angle, defined as "an angle measuring scoliosis as seen on a radiograph: for a given group of vertebrae, lines are drawn across the vertebral column on the upper surface of the upper vertebra and the lower surface of the lower vertebra. The angle measured may be either that between these two lines or that between lines drawn perpendicular to them."[1] The Cobb method is most commonly used for curve magnitude.[2] A Cobb angle greater than 10° is generally considered clinically significant.[3]

Measuring the Cobb angle requires the examiner to decide which vertebrae constitute the upper and lower limits of the deformity, so the vertebrae whose endplates are "most tilted" toward each other must be identified. The lines are then drawn along the chosen endplates, and the angle created by these 2 lines is then measured (Fig 1).[3] However, whether working on a hard-copy film or a computer monitor, the workspace often does not permit an extension of the lines far enough laterally; thus, 2 additional lines are drawn at 90°, or perpendicular, to the first 2 lines. The angle created by these additional lines is then measured as the Cobb angle (Fig 2).[3]

When assessing a patient, the physician should consider the age of the patient, pulmonary function testing, the Risser classification, the Cobb angle, and other factors to determine the appropriateness of the intervention.[4] The Cobb angle is an important measurement; therefore, accuracy and reproducibility are paramount. Yet, the Cobb Angle presents limitations, particularly in terms of interexaminer (interrater) reliability.[5,6]

Therefore, the purpose of this study is to test the interexaminer reliability and student satisfaction of learning a novel method of measuring the Cobb angle by using a digital level to assess the vertebrae whose endplates are "most tilted." This is a pilot test of a novel method of determining the Cobb Angle. Our intent is to show the potential of the method.

College of Medicine, Central Michigan University, Mount Pleasant, Michigan.

Corresponding author: Marcello L. Caso, DC, College of Medicine, Central Michigan University, 1280 East Campus Drive, Mount Pleasant, MI 48859. Tel.: +1 916 220 3498.
(e-mail: *marcellocaso@yahoo.com, caso1ml@cmich.edu*).

Paper submitted March 27, 2018; in revised form August 23, 2018; accepted November 2, 2018.

0161-4754

https://doi.org/10.1016/j.jmpt.2018.11.016

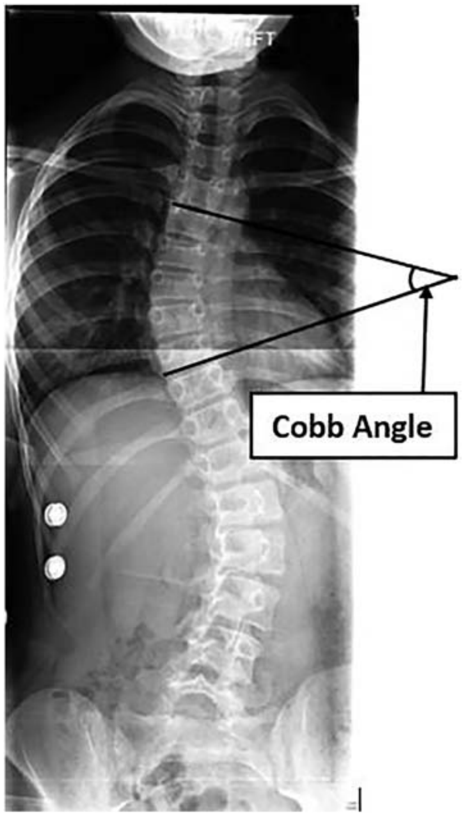

Fig. 1. *Representation of a Cobb angle. Note how the lines extend beyond the work surface (hard film or computer monitor). This figure was retrieved from the Open-i service of the National Library of Medicine at https://openi.nlm.nih.gov/detailedresult.php?img=PMC2527554_1748-7161-3-11-1&query=scoliosis+x-ray&req=4&npos=706 (last accessed July 14, 2017). License type Attribution 2.0.*

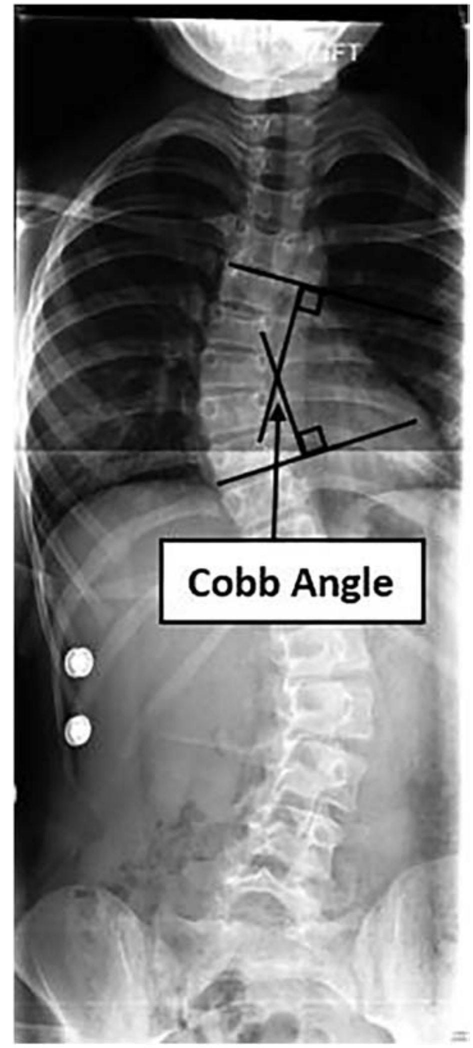

Fig. 2. *Alternate representation of the Cobb angle. Because the lines often extend beyond the work surface, 2 additional lines are drawn at 90° from the first 2, and the subsequent intersecting angle is measured. This figure was retrieved from the Open-i service of the National Library of Medicine at https://openi.nlm.nih.gov/detailedresult.php?img=PMC2527554_1748-7161-3-11-1&query=scoliosis+x-ray&req=4&npos=706 (last accessed July 14, 2017). License type Attribution 2.0.*

Materials and Methods

Study Participants

Participants in this study were 32 college-aged students studying entry-level anatomy. These students were chosen because they were familiar with the anatomy of the vertebral column, but not with radiology or the Cobb angle. As such, they had no preconceived notion about the efficacy of the traditional method or how it might compare with a novel method. If seasoned physicians had been the participants, a bias in favor of ingrained practices may have been introduced. The use of a naive participant group was essential because we asked, at the end of the experiment, "Which method did you find easier to learn, understand, and apply: method A or method B?"

The Institutional Review Board of Central Michigan University, which is affiliated with the authors, classified this study as exempt from review; the Institutional Review Board of California State University Sacramento, from which the students were chosen, accepted this determination. Participants provided written consent to take part in the study and were offered a token amount of course extra credit for their participation (less than 1% of their final grade).

Procedure

Participants in this study were given a brief introduction to the Cobb angle and informed simply that it was a way of quantifying a scoliosis angle. They were then shown how to measure it on a deidentified radiograph in the traditional way (method A) and then shown how to measure it on the same deidentified radiograph in the novel way (method B).

Multiple classification systems for scoliosis exist,[7,8] but in the interest of being straightforward, neither complex

Fig. 3. *Radiograph of a deidentified individual with a comparatively moderate scoliosis. This figure was retrieved from the Open-i service of the National Library of Medicine at https://openeni.nlm.nih.gov/detailedresult.php?img=PMC2527554_1748-7161-3-11-1&query=scoliosis+x-ray&req=4&npos=706 (last accessed July 14, 2017). License type Attribution 2.0.*

Fig. 4. *Radiograph of a deidentified individual with a comparatively severe scoliosis. This figure was retrieved from the Open-i service of the National Library of Medicine at https://openi.nlm.nih.gov/detailedresult.php?img=PMC2527554_1748-7161-3-11-1&query=scoliosis+x-ray&req=4&npos=706 (last accessed July 14, 2017). License type Attribution 2.0.*

classification nor descriptors such as "major" or "minor" were used. Participants were told only that it was an "S-shaped curve"; one curve was simply referred to as the "thoracic curve" and the other as the "lumbar curve." Because of potential overlap at the thoracolumbar junction, they were informed that for a curve confined mostly to the thoracic spine, it was acceptable to choose a lumbar vertebra as the inferior-most vertebra of the deformity. Similarly, if a curve was confined mostly to the lumbar spine, it was acceptable to choose a thoracic vertebra as the superior-most vertebra of the deformity.

An open access anteroposterior (AP) radiograph of a deidentified individual with a comparatively moderate scoliosis (Fig 3) was shown to 16 of 32 participants, and the remaining 16 participants were shown an open access AP radiograph of a deidentified individual with a comparatively severe scoliosis (Fig 4). It should be noted that, although variations might exist among different classifications, a

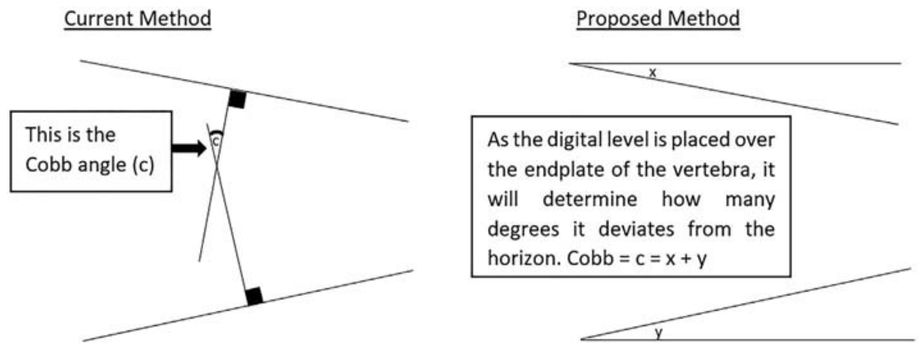

Fig. 5. *Schematic of current method of Cobb angle measurement and proposed method of Cobb angle measurement. As the digital level is placed over the endplate of the vertebra, it will determine how many degrees it deviates from the horizon. Cobb = c = x + y (vertebrae are not shown for simplicity and ease of interpretation).*

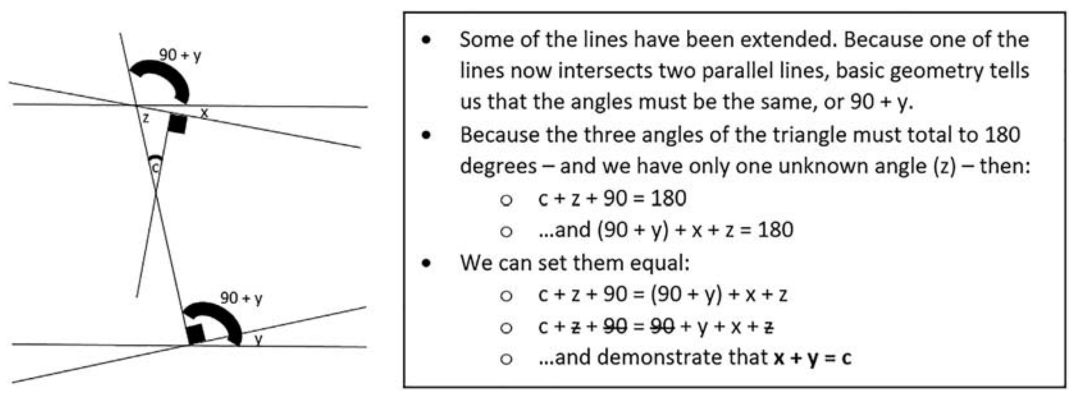

Fig. 6. *When the 2 are merged together, we see the geometric explanation of how the current and proposed methods yield the same value.*

"mild" scoliosis can be considered as one with a Cobb angle less than 30°, a "moderate" scoliosis can be considered as one with a Cobb angle of 30 to 45°, and a "severe" scoliosis can be considered as one with a Cobb angle of greater than 45°.[9]

For all 32 participants, instruction was provided on how to draw the lines (endplate lines and perpendicular lines) necessary to determine a traditional Cobb Angle (method A). One sample measurement was performed in front of them, but on a deidentified radiograph unrelated to the one they were to analyze (a different radiograph was used so that participants did not operate under the belief that their findings had to coincide with the demonstration). They measured the Cobb angles for both the thoracic and lumbar curves. In addition, they were not coached on which vertebrae would be the "best choice" for the upper and lower limits of the deformity, only to identify the "most tilted" vertebrae. Furthermore, if they were confused about subsequent steps, only minimal assistance was offered (essentially repeating what they were already told in the demonstration).

This experiment was not performed on a computer. Deidentified open access AP radiographs were enlarged and printed on 18 × 24–in poster-size paper and then leveled and taped up to a wall. This would approximate a full-spine, hard-copy radiograph. It is our assertion that performing this on a computer screen could have introduced another variable, specifically a radiologic software tools with which the participants were unfamiliar and could find daunting. Thus, we made it our aim to simply demonstrate the mathematical application of the process and compare the

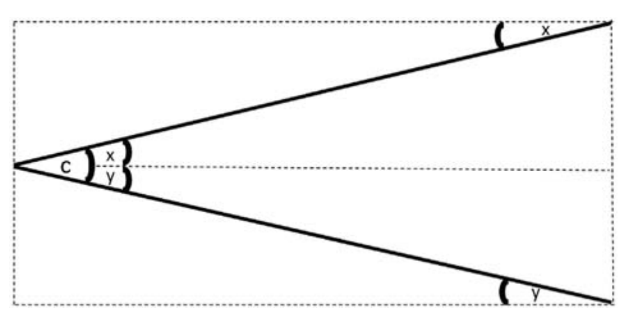

Fig. 7. *The solid lines represent those used to determine c, the Cobb Angle (previously described in Fig 1). The dashed lines represent 2 rectangles level with the horizon. Using the digital level at the upper and lower vertebrae yields angles x and y, respectively. These angles can be summed as x + y = c.*

Table 1. *Cobb Angle Measurements for Moderate Scoliosis*

Method	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14	S15	S16
Method A: Traditional Cobb Method (Participants 1-16)																
Thoracic curve																
Superior vertebra identified as most tilted	T6	T5	T4	T5	T6	T5	T5	T6	T3	T5	T3	T4	T4	T6	T4	T6
Inferior vertebra identified as most tilted	T11	L1	T11	T12	T12	T9	T12	L1	T8	L2	T10	T9	T7	T10	T9	T11
Measured Cobb angle	50	23	40	50	30	45	30	28	30	35	35	37	20	35	30	36
Lumbar curve																
Superior vertebra identified as most tilted	T12	L2	T11	T11	T12	L1	T12	L1	T9	L3	T11	T10	T9	T11	T10	L1
Inferior vertebra identified as most tilted	L3	L4	L3	L3	L5	L5	L5	L5	L3	L5	L5	L3	L2	L4	L4	L4
Measured Cobb angle	42	20	40	49	25	13	22	35	29	39	40	40	23	47	35	51
Method B: Proposed Cobb Method (Participants 1-16)																
Thoracic curve																
Superior vertebra identified as most tilted	T5	T4	T5	T5	T5	T5	T5	T5	T5	T4	T5	T5	T5	T5	T4	T5
Inferior vertebra identified as most tilted	T11	T11	T10	T11	T10	T10	T10	T10	T11	L1	T11	T10	T11	T10	T11	T10
Measured Cobb angle	48	48	42	48	45	50	42	40	41	35	43	45	43	39	32	40
Lumbar curve																
Superior vertebra identified as most tilted	T12	T12	T11	T10	T10	T11	T11	T12	T11	L2	T10	T10	T11	T11	T10	T11
Inferior vertebra identified as most tilted	L3	L3	L4	L3	L4	L4	L3	L5	L4	L5	L5	L4	L4	L3	L4	L4
Measured Cobb angle	36	47	45	48	45	47	39	30	44	38	50	42	41	39	31	41

ease of learning the 2 methods side by side. Participants drew the lines on the poster with markers and measured the resultant lines with a protractor. All participants used the same brand of writing utensil with the same size writing tip, thereby reducing any variation between line width and subsequent error in angle measurement.

Participants were then introduced to the proposed technique, identified only as method B. Again, 1 sample measurement was performed in front of them on a different radiograph. Before coming for data collection, participants were asked to download a free digital level of their choice on their cellular phones. (Many apps exist, and the researchers are working under the assumption that they are of comparable quality; we are not aware of any evidence that would suggest otherwise.)

Digital levels provide an enhanced level of accuracy by indicating exactly how many degrees one is deviating from the horizon compared with an air bubble in a typical level from a hardware store. The "most tilted" vertebra is generally a judgment call by the examiner. In our research, we examined whether objectively identifying the most tilted vertebrae with a digital level, rather than making this a judgment call, would improve interexaminer reliability for the vertebrae chosen and the calculated angle. Furthermore, once the most tilted vertebrae are determined, one can sum the 2 absolute values and report the angle. Whether on a printed film or on a computer monitor, this method effectively eliminates the need to draw intersecting lines, which could potentially be another confounding variable. This method is depicted in Figure 5. In using the proposed method, not only is the need for perpendicular lines eliminated, but there is no subjective guesswork in determining the most tilted vertebra. The examiner simply moves the digital level from one vertebra to the next and uses the highest absolute value—this is, by definition, the most tilted vertebra. The geometry of the current method and the proposed method are the same, as can be seen when the two schematics are merged in Figure 6.

Table 2. *Cobb Angle Measurements for Severe Scoliosis*

Method	S17	S18	S19	S20	S21	S22	S23	S24	S25	S26	S27	S28	S29	S30	S31	S32
Method A: Traditional Cobb Method (Participants 17-32)																
Thoracic curve																
Superior vertebra identified as most tilted	T5	T5	T3	T3	T4	T5	T5	T2	T3	T4	T3	T3	T4	T5	T3	T5
Inferior vertebra identified as most tilted	T11	T9	T11	T10	T12	T11	T10	T7	T12	T12	T12	T12	T12	T11	T12	T11
Measured Cobb angle	70	60	68	65	60	70	74	28	40	60	45	44	50	50	70	70
Lumbar curve																
Superior vertebra identified as most tilted	L1	T11	T12	T11	T12	T12	T12	T8	T12	L1	L1	T12	T10	T11	T10	T11
Inferior vertebra identified as most tilted	L4	L4	L4	L4	L4	L3	L4	L5	L4	L4	L4	L4	L4	L4	L4	L4
Measured Cobb angle	67	40	79	80	78	60	82	42	65	50	60	78	80	80	84	87
Method B: Proposed Cobb Method (Participants 17-32)																
Thoracic curve																
Superior vertebra identified as most tilted	T4	T4	T4	T3	T4	T5	T5	T4	T5	T4	T4	T4	T4	T5	T4	T4
Inferior vertebra identified as most tilted	T10	T10	T11	T10	T10	T11	T10	T10	T10	T10	T10	T10	T11	T11	T12	T10
Measured Cobb angle	64	70	67	51	73	62	76	63	68	64	70	72	68	69	75	73
Lumbar curve																
Superior vertebra identified as most tilted	T11	T11	T12	T12	T11	L1	T12	T11	T11	L1	T12	T11	T12	T11	T11	T11
Inferior vertebra identified as most tilted	L3	L4	L4	L4	L4	L5	L4	L4	L3	L4	L4	L4	L4	L4	L4	L4
Measured Cobb angle	83	88	77	60	86	71	79	85	83	66	58	87	84	67	85	88

Geometrically speaking, another way of looking at it is perhaps even more direct. As explained earlier, two perpendicular lines are usually drawn, and their intersecting angle is measured, but we must recall that this is only because of workspace limitation. In other words, the Cobb angle can be measured without perpendicular lines (Fig 1). If we simply bisect the Cobb angle, we see clearly that summing the absolute degree of tilt from the horizon of the 2 vertebrae in question yields the same value (Fig 7). Note that, with some digital levels, tilting to one side (usually the left) results in a negative value. Participants were advised to use the largest absolute value—in other words, to ignore the negative sign that could appear when tilting.

Participants were told to find the uppermost vertebra of the deformity by moving the digital level from the superior endplate of one vertebra to the next, noting the highest absolute value. They then found the lowermost vertebra by moving the digital level from the inferior endplate of one vertebra to the next, noting again the highest absolute value. These 2 highest absolute values were summed and recorded as the Cobb angle for method B. Again, both thoracic and lumbar curves were analyzed.

Statistical Analyses

One of the goals of the proposed method is to reduce the variance of the angle measurements using the new technique. A pilot study of these techniques yielded a mean variance of the traditional and proposed methods of 52.8 and 10.7, respectively, with standard deviations of 28.1 and 5.3, respectively. A priori power analysis assuming a 2-tailed *F* test to determine differences in variance between each set of images was conducted to determine sample size for this experiment. To determine the superiority of the proposed method in reducing variance over the traditional method by a margin size of 20, with 80% power and 5% α, a sample size of 12 was calculated to assess each film by the traditional and proposed methods. In

Table 3. *Two-Sample F-Test for Equality of Variances*

Film Number	Mean Variance	*P* Value
Film 1 (moderate scoliosis)		
Traditional thoracic variance	73.05	.04
Proposed thoracic variance	23.60	-
Traditional lumbar variance	125.85	.01
Proposed lumbar variance	33.60	-
Film 2 (severe scoliosis)		
Traditional thoracic variance	180.60	.005
Proposed thoracic variance	38.03	-
Traditional lumbar variance	230.13	.14
Proposed lumbar variance	104.60	-

Table 4. *Two-Sample* t*-test for Mean Differences*

Film Number	Mean (95% Confidence Interval)	*P* Value
Film 1 (moderate scoliosis)		
Traditional thoracic mean	34.63 (30.07-39.18)	.004
Proposed thoracic mean	42.56 (39.97-45.15)	-
Traditional lumbar mean	34.38 (28.40-40.35)	.04
Proposed lumbar mean	41.44 (38.35-44.53)	-
Film 2 (severe scoliosis)		
Traditional thoracic mean	57.75 (50.59-64.91)	.01
Proposed thoracic mean	67.81 (64.53-71.10)	-
Traditional lumbar mean	69.50 (61.42-77.58)	.07
Proposed lumbar mean	77.94 (72.49-83.39)	-

addition to testing for differences in variance with the *F* test, we also used paired *t* test to test for difference in mean angle between the 2 methods. We also calculated simple percent agreement among the raters for each method. Finally, we used a χ^2 test, using actual frequency counts and ensuring that no cell contained fewer than 5 observations, to determine whether there were differences in satisfaction between the 2 methods.

Our sample was nonrandom because it included everyone in the class. The Central Limit Theorem holds that for nonrandom samples, once you obtain a large enough sample size, you can assume a Gaussian distribution and use parametric, inferential statistics. In general, the rule of thumb to delineate non-Gaussian from Gaussian distributions is approximately 30. Although some researchers and statisticians might disagree with this, we decided to use this as our arbitrary cutoff. We had 32 participants each making 8 observations of tilted vertebrae (256 measurements with 128 in each group) and 4 angle measurements (64 measurements with 32 in each group).

Results

Cobb angle measurements for moderate scoliosis (Table 1) included all measurements from participants who rated the first radiograph, which depicted a moderate scoliosis. Using method A, raters agreed to within 3 vertebral levels (T3 to T6 with a maximum of 31.3% of participants agreeing on T5 or T6) on the most tilted thoracic superior vertebra and to within 6 levels (T7 to L2 with a maximum of 18.8% of participants agreeing on T9, T11, and T12) on the most tilted thoracic inferior vertebra. Regarding the lumbar curve, raters agreed to within 5 levels (T9 to L2 with 25.0% agreement on T11) on the superior vertebra and 3 levels (L2 to L5 with 37.5% agreement on L5) on the inferior vertebra.

On the first film (Table 1), raters using method B agreed to within 1 vertebral level (T4 to T5 with 81.3% agreement on T5) on the most tilted thoracic superior vertebra and to within 3 levels (T10 to L1 with 50.0% agreement on T10) on the most tilted thoracic inferior vertebra. Regarding the lumbar curve, raters agreed to within 4 levels (T10 to L2 with 43.8% agreement on T11) on the superior vertebra and 2 levels (L3 to L5 with 50.0% agreement on L4) on the inferior vertebra. Although the percent of raters agreeing on most tilted vertebra for the moderate scoliosis film increased from method A to method B, percent agreement did not significantly differ for either method, with the exception of the difference between the rating of thoracic superior vertebrae for the methods A and B (31.3 % vs 81.3%, respectively; $P < .05$).

On the second film (Table 2), raters using method A agreed to within 3 vertebral levels (T2 to T5 with 37.5% agreement on T3 and T5) on the most tilted thoracic superior vertebra and to within 4 levels (T7 to T12 with 43.8% agreement on T12) on the most tilted thoracic inferior vertebra. Regarding the lumbar curve, raters agreed to within 5 levels (T8 to L1 with 37.5% agreement on T12) on the superior vertebra and 2 levels (L3 to L5 with 87.5% agreement on L4) on the inferior vertebra.

On the second film (Table 2), raters using method B agreed to within 2 vertebral levels (T3 to T5 with 68.8% agreement on T4) on the most tilted thoracic superior vertebra and to within 2 levels (T10 to T12 with 68.8% agreement on T10) on the most tilted thoracic inferior vertebra. Regarding the lumbar curve, raters agreed to within 2 levels (T11 to L1 with 56.3% agreement on T11) on the superior vertebra and 2 levels (L3 to L5 with 81.3% agreement on L4) on the inferior vertebra. Again, although the percent agreement of most tilted vertebra increased between methods (except for the inferior lumbar vertebra), there was no difference in percent agreement on most tilted vertebra using either method for the severe scoliosis film.

To test the hypothesis that there would be a significant difference in variance between the 2 methods, we ran a 2 -tailed F test for equality of variances (Table 3). The variance of measurements decreased when using method B from thoracic to lumbar measurements and for the moderate and severe scoliosis films. All decreases were statistically significant, except for the lumbar measurement variance for the severe scoliosis film (film 2). Similar results were evident for changes in mean angle between the 2 methods (Table 4). That is, mean angles were different for each pair of measurements apart from the lumbar measurement mean angle for the severe scoliosis film (film 2).

After completing all measurements, each participant was asked, "If both methods yield the same results, which do you find easier to learn, understand, and apply?" Of the 32 participants, seven (21.9%) chose method A, whereas 25 (78.1%) chose method B ($\chi^2 = 20.25$; $P < .001$), a statistically significant difference, suggesting greater satisfaction with the proposed novel method.

Discussion

The findings of this study demonstrate statistical differences in means and variances between method A (traditional) and method B (proposed). Percent agreement for the most tilted vertebrae increased for every category, except one, from the traditional method to the proposed method. In other words, the data seem to suggest improved percent agreement on which vertebrae represent the superior and inferior delineations of the spinal deformity and less variance in the reported Cobb angle. Thus, the method proposed in this study appears to offer potential improvements for interexaminer reliability in the determination of the Cobb angle.

A majority of participants (78.1%) found the proposed method easier to learn, understand, and apply. Although additional study might be needed, the authors contend that this aspect of the method could prove extremely valuable. First, a method that could be grasped more readily by physicians-in-training might streamline the teaching process and lessen the learning curve. Second, in determining appropriate care for a patient, a physician would typically have the radiographs read by a radiologist or ideally, in the case of juvenile scoliosis, a pediatric radiologist. Yet, a subspecialist might not always be readily available, particularly to physicians in rural and underserved settings. A method that is easier to learn, understand, and apply could offer promise for general practitioners, pediatricians, and other health care personnel who wish to assess patients and monitor them with greater confidence, especially in uncomplicated cases.

Although we cannot generalize these results outside this class of students, this study suggests that the method is feasible and that additional study may be warranted with physicians-in-training, residents, practicing physicians, and allied health care professionals who care for patients with scoliosis.

Limitations

This study does not reflect realistic conditions of radiograph interpretation because paper-to-paper comparison was used. In future studies, experienced practitioners with digital conditions would better reflect a clinical environment. Our sample was nonrandom, but because it included everyone in the class, it was clearly representative of that class. In this case, our parametric, inferential tests and results can be applied to this setting. We are careful not to draw any conclusions that state that our results can be generalized to all learners in all settings. Generalization to samples and populations outside this classroom would take other studies with larger random samples.

Future Studies

Future studies with more experienced participants or other possible variations should be considered. Given the numerous digital level apps that exist, we are operating under the assumption that adding an application tailored to radiographic use would not pose any technical challenges. If such a digital level could be integrated, this novel method of Cobb angle evaluation appears to offer a viable alternative to the current method. Although additional study will be needed, such a preliminary conclusion might be justified because the data suggest improved interexaminer reliability and relative ease of learning and application.

Conclusion

In this group of naive students, there was improved interrater reliability and greater satisfaction with a method using a digital level to measure the Cobb angle. The results also suggest that variance between measurements methods is also reduced in some cases.

Acknowledgments

The authors thank the California State University Sacramento for their collaborative efforts.

Funding Sources and Conflicts of Interest

Funding was provided by the Summer Scholars Program for medical students at Central Michigan University. The lead author, a medical student, received a $3,000 stipend to complete this research in the summer of 2017. No conflicts of interest were reported for this study.

Contributorship Information

Concept development (provided idea for the research): M.L.C.

Design (planned the methods to generate the results): M.L.C., J.M.C.

Supervision (provided oversight, responsible for organization and implementation, writing of the manuscript): M.L.C., J.M.C.

Data collection/processing (responsible for experiments, patient management, organization, or reporting data): M.L.C.

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

Literature search (performed the literature search): M.L.C.

Writing (responsible for writing a substantive part of the manuscript): M.L.C., J.M.C.

Critical review (revised manuscript for intellectual content, this does not relate to spelling and grammar checking): M.L.C., J.M.C.

Practical Applications

- This study evaluates the interexaminer reliability of this method and the participants' impressions of how easily it can be learned, understood, and applied when compared with the traditional method.
- It may become a viable alternative to current methods, particularly with less experienced clinicians.

References

1. *Dorland's Illustrated Medical Dictionary*. 32nd ed. Philadelphia, PA: Elsevier Saunders; 2012.
2. Yochum TR, Rowe LJ. *Essentials of Skeletal Radiology*. Philadelphia, PA: Lippincott Williams & Wilkins; 1987.
3. Hefti F. *Pediatric Orthopedics in Practice*. New York, NY: Springer; 2010.
4. Korbel K, Kozinoga M, Stoliński Ł, Kotwicki T. Scoliosis Research Society (SRS) Criteria and Society of Scoliosis Orthopaedic and Rehabilitation Treatment (SOSORT) 2008 Guidelines in Non-Operative Treatment of Idiopathic Scoliosis. *Pol Orthop Traumatol.* 2014;79:118-122.
5. Gstoettner M, Sekyra K, Walochnik N, Winter P, Wachter R, Bach CM. Inter- and intraobserver reliability assessment of the Cobb angle: manual versus digital measurement tools. *Eur Spine J.* 2007;16(10):1587-1592.
6. Kim H, Kim HS, Moon ES, et al. Scoliosis imaging: what radiologists should know. *Radiographics.* 2010;30(7):1823-1842.
7. Bess S, Schwab F, Lafage V, Shaffrey CI, Ames CP. Classifications for adult spinal deformity and use of the Scoliosis Research Society-Schwab Adult Spinal Deformity Classification. *Neurosurg Clin N Am.* 2013;24(2):185-193.
8. Ovadia D. Classification of adolescent idiopathic scoliosis (AIS). *J Child Orthop.* 2013;7(1):25-28.
9. Bloch KE, Brack T, Simonds AK. *ERS Handbook: Self-Assessment in Respiratory Medicine*. Amsterdam, Netherlands: European Respiratory Society; 2015.