(International Print/Online Journal)
SJIF IMPACT FACTOR: 5.565
PUBMED-National Library of Medicine ID-101739732
ISSN (Print): 2209-2870
ISSN (Online): 2209-2862
IJMSCR
International Journal of Medical Science and Current Research (IJMSCR)
Available online at: www.ijmscr.com
Volume 7, Issue 1 , Page No: 465-473
January-February 2024

From Curves to Angles: Comparison of Different Techniques for Assessing Thoracic kyphosis in Indian postmenopausal Women

[1]Dr Vijendra Jangid, [2]Dr Rambir Singh, [3]Dr Madhumita Choudhary, [4]Dr Manvi Shehrawat, [5]Dr Aayush Richhariya
[1]Resident (Radiodiagnosis), **[2]Professor-, [3]Resident(Radiation Oncology), [4]Resident **Radiodiagnosis, [5]Assistant Proffessor
[1,2,4]American International Institute Of Medical Sciences, Udaipur
[3]RNT Medical college – Udaipur, [5]Geetanjali Medical College, Udaipur

***Corresponding Author:**
Dr Vijendra Jangid
Resident- RADIODIAGNOSIS- American international institute of medical sciences. Udaipur

Type of Publication: Original Research Paper
Conflicts of Interest: Nil

Abstract

Keywords: Cobbs angle, Vertebral centroid angle, Flexicurve

Introduction

The Cobb angle is a widely used technique for radiographic measurement of thoracic kyphosis [1,2].

While it is considered as a gold standard method [3], there are several concerns regarding its validity. The angle primarily reflects the endplate tilt of vertebrae within selected curve limits, potentially missing regional changes and true intervertebral curvature. [4]. This limitation becomes particularly troublesome in the presence of osteoporosis, where vertebral deformities are prevalent.

The Cobb method's reliability can be compromised by difficulties in accurately identifying the endplate, particularly in individuals with a high risk of osteoporosis [5]. Alternative radiographic measurement techniques, such as the vertebral centroid method, posterior tangent method, and various computer-aided methods have been proposed [6,7].

The method of assessing the sagittal curvature of the spine, known as the vertebral centroid angle technique, demonstrates superior reliability and reduced measurement error as compared to the Cobb angle method [8, 9] .

In our study, we place a particular emphasis on evaluating the concurrent validity of the Flexicurve method in measuring thoracic kyphosis. By comparing the results obtained through the Flexicurve method, we can determine the accuracy and reliability of this innovative approach.

Our objective was to determine the level of concurrence between these measurements and to evaluate the factors contributing to disparities between these two methods.. We presumed that the Flexicurve angles would exhibit stronger alignment with vertebral centroid angles as opposed to Cobb angles [4] and further speculated that age and BMI might contribute to some of the differences observed between the methods.

Methods

Our research encompassed a group of 50 postmenopausal women. (mean age: 62.4 years) with a moderate body mass index (mean BMI: 26.23). These women came with complain of chronic back pain and radiating neuropathic discomfort. Their visits spanned various outpatient departments at our institute. Subsequently they were referred to the department of radiology for imaging of the whole spine using a 16-channel, 1.5 Tesla Philips Achieva MRI system.

Each patient who fulfilled the inclusion and exclusion criteria as described in Table 1 and provided written informed consent was included in our study.

Table 1 : Table showing inclusion & exclusion criteria for the research

Inclusion Criteria	Exclusion Criteria
Postmenopausal	Menstruation within last 12 months
Independent with ambulation & activities of daily living (ADLs)	Previous thoracic spine surgery
Provided informed consent.	Reported systemic inflammatory condition or neurodegenerative disorders
	Known pathology of thoracic spine
	Known malignancy involving spine
	BMI > 30 & <18

Radiological evaluation of thoracic kyphosis

Cobb angle:

To calculate the Cobb angle, a technique was employed by drawing a line from the upper endplate of T1 and lower endplate of T12 as depicted in Figure 1. This line was subsequently extended to determine the angle formed at their point of intersection, utilizing the aid of a protractor [10].

Figure 1 : Thoracic kyphosis assessment from MRI saggital view using global cobb angle.

Volume 7, Issue 1; January-February 2024; Page No 465-473

Vertebral Centroid Angle:

To calculate the centroid angles, a technique was employed, which involved measuring the angle formed by the intersection of two lines. Each line passed through a pair of adjacent vertebral centroid points at specific segments of the thoracic curvature as depicted in Figure 2. The vertebral centroid positions were identified at T1/T2 and T11/T12 for comprehensive kyphosis assessments [11]. To locate the vertebral centroid, reference points were marked at selected vertebrae, excluding any obvious osteophytes. Diagonal lines were then drawn between the designated reference points, and their point of intersection was defined as the vertebral centroid [12].

Figure 2: Thoracic kyphosis assessment from MRI saggital view using global centroid angle.

Non- Radiological evaluation of thoracic Kyphosis :

Flexicurve Method:

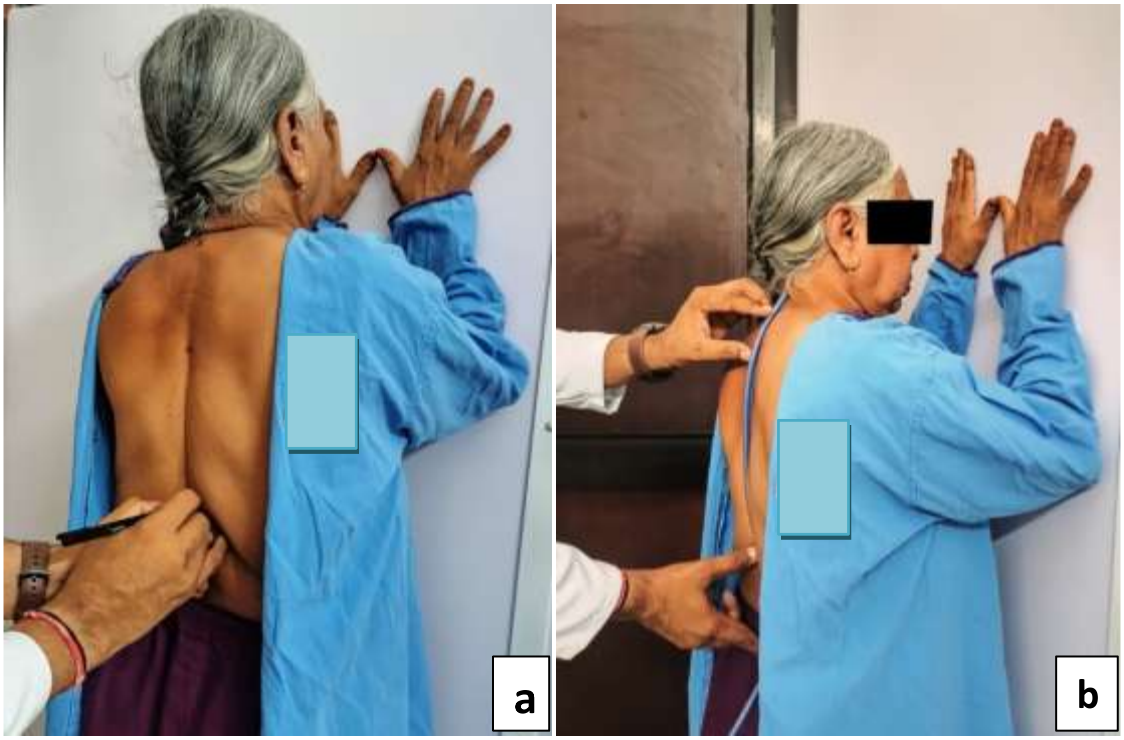
The assessment of spinal curvature was done using the flexicurve scale. The flexicurve is an 80 cm long ruler made of flexible plastic-covered metal. It features markings at 1 mm intervals and can be molded around rounded structures. This instrument is useful in accurately assessing spinal curvature.

The assessment procedure involved carefully molding the flexicurve to match the shape of the spine, after localization and marking the C-7 and T-12 spinous process (Figures 3a & 3b). This ensured a comprehensive evaluation of the spinal curvature using the flexicurve method [3, 13].

Volume 7, Issue 1; January-February 2024; Page No 465-473

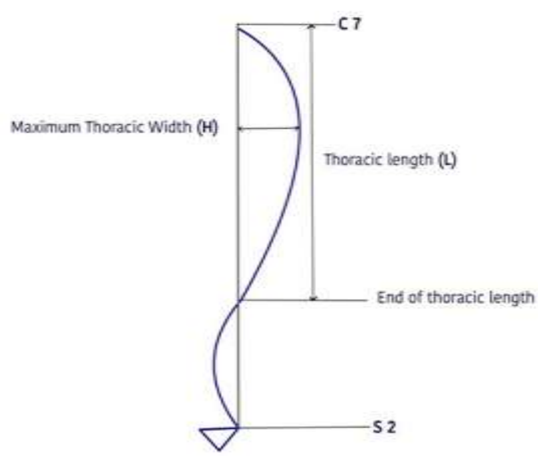
Figure 3(a) Skin marking of C7 and T12 vertebrae

Figure 3(b) Flexicurve scale molding.



To determine the kyphosis angle (degree°) using the flexicurve method, we utilized the thoracic length (L) and deepest point of the thoracic curve (H) dimensions as illustrated in Figure 4. The angle was calculated using the mathematical equation: [theta] = 4 X [arctan(2H/L)] [14, 15].

Figure 4: The method of thoracic kyphosis measurement with flexicurve scale using deepest part of curvature as H value.



Data Analysis:

A Bland and Altman approach was used to compare the thoracic kyphosis angles obtained from each method [16]. The flexicurve kyphosis angles were paired with the radiographic Cobb angles and vertebral centroid angles. A graphical representation of the differences between the measurements of each method for each participant (y-axis) plotted against their mean (x-axis) was used to assess the agreement [17]. Additionally, a Bland and Altman plot was created to compare the vertebral centroid angles scaled to Cobb angles.

In the Bland and Altman plot, a solid labelled line depicted the mean difference between the measurements of each method, highlighting any bias [18]. Before calculating the 95% confidence intervals and incorporating them as the 95% limits of agreement in each plot, the differences were assessed for normality [19]. The scatter of differences was examined to determine if there was proportional bias and homoscedasticity of differences between measures, ensuring uniformity around the mean and within the limits of agreement [20].

Descriptive data for each measure are detailed in Table 2.

Bland-Altman limits of agreement analysis were employed to compare the level of agreement between measurements obtained from the flexicurve method with radiological Cobb and Vertebral centroid angle. In the Bland-Altman plot, the mean difference between the measurements obtained from each method was illustrated using a solid labelled line. This line represents the average or mean difference between the two sets of measurements. The Bland-Altman plot is a graphical representation that allows visual assessment of the level of agreement between the methods by plotting the differences on the y-axis and the average of the measurements on the x-axis.

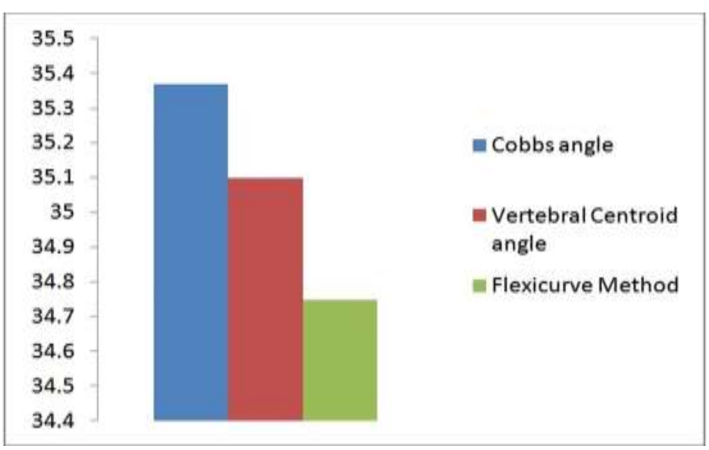
Results:

Table 2: participant's characteristics and descriptive data

	n	Mean	SD	Minimum	Maximum
Age (years)	50	62.4	7.26	50	76
Height (meters)	50	1.54	0.07	1.41	1.7
Weight (kg)	50	61.9	4.3	54	74.3
BMI	50	26.15	2.51	20.8	30
Cobbs angle	50	35.37	2.41	31	40.4
Vertebral centroid angle	50	35.1	2.8	32	43.5
Flexicurve angle	50	34.74	2.4	29.6	40.7

The mean difference between thoracic kyphosis angles obtained from all three methods is represented in the bar graph (Figure 5).

Figure 5: Comparison of the thoracic kyphosis between Cobb, Vertebral centroid, Flexicurve

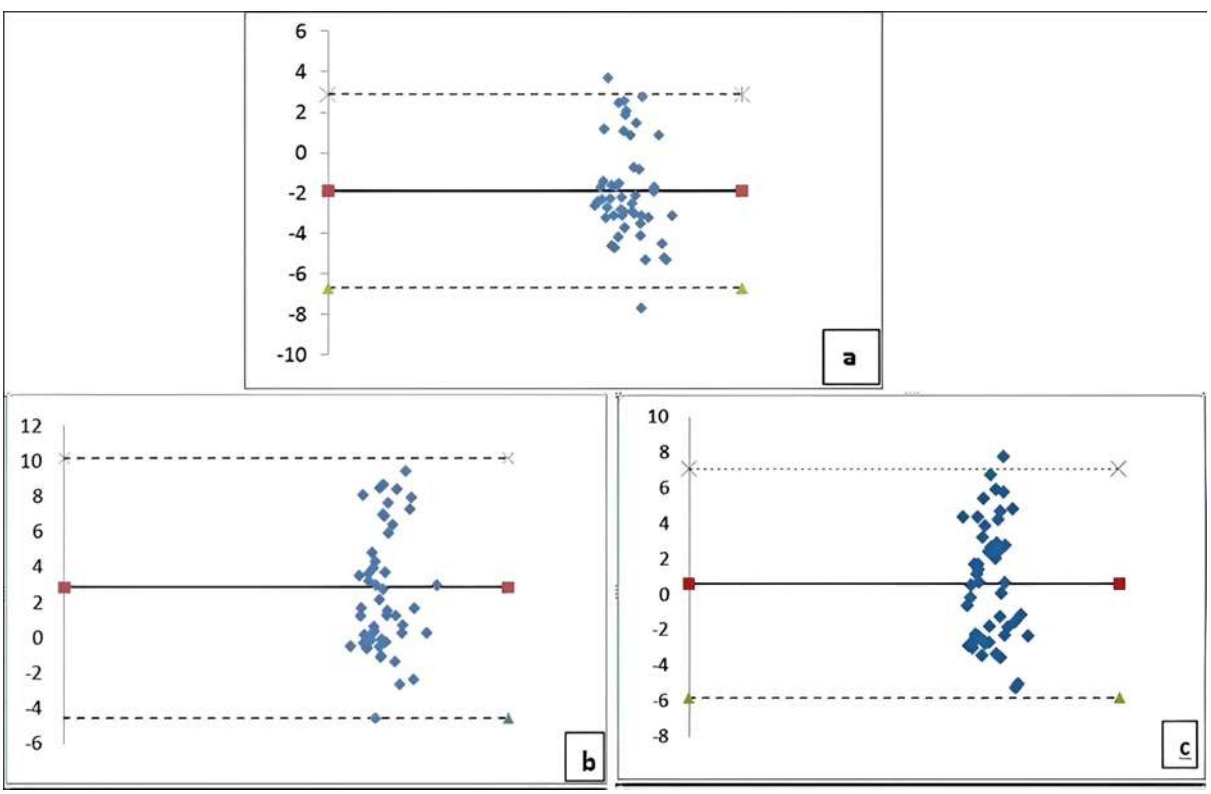


The correlation between the measurements of thoracic kyphosis using the Cobb angle and Vertebral centroid shows a significant connection (r=0.57, p-value = 1.2138e-06). Furthermore, it can be observed that a majority of the data points, with a standard deviation of 2.24 degrees, lie within the limits of agreement (-6.70, +2.88). This range represents the disparity between the values of the Cobb angle and vertebral centroid and falls within boundaries of agreement (md ±2 SDd) in a Bland Altman plot (Figure 6a).

The correlation between the vertebral centroid and Flexicurve angle also demonstrates a notable association (r=0.16, p-value = 4.42e-06). A Bland Altman graphic representation with a standard deviation of 3.47 and limits of agreements (-4.2, +9.3) shows that most of the points representing the deference are within the limits of agreement (md ±2 SDd), with random dispersion and average deference approximate to bias (Figure 6b).

While there was no association found between correlating data obtained from Cobb and Flexicurve angle (r= 0.08, p values = 0.19). A standard deviation of 3.32 and limits of agreements (-5.8, +7.14) Bland Altman plot was plotted (Figure 6c).

Figure 6 (a-c) The Bland Altman plot displays the difference between two measurements plotted against their average for (a) Cobb angle and Vertebral centroid measurements. (b) Vertebral centroid and Flexicurve measurements. (c) Cobb angle and Flexicurve measurements. In the plot, the mean difference is represented by a solid line, while the upper limit of agreement (+1.96 standard deviations) and the lower limit of agreement (-1.96 standard deviations) are depicted as dotted lines.



Discussion

Based on our data analysis, it appears that the prediction of vertebral centroid angles from Flexicurve values yields higher accuracy. However, it is important to note that this accuracy becomes more variable as the degree of thoracic kyphosis increases. Consequently, caution should be exercised when interpreting and utilizing Flexicurve kyphosis angles in postmenopausal women with elevated thoracic kyphosis levels. Furthermore, it is important to acknowledge the potential challenges associated with using radiographic Cobb angles as a means to assess the reliability of Flexicurve in older demographics. While the Cobb angle is widely recognized as the gold standard, it may not be the most suitable radiographic reference point for comparing Flexicurve accurately [21].

In previous research, the flexicurve has been recognized as a viable tool for assessing spinal curvature. Various studies have highlighted its reproducibility and validity in measuring thoracic kyphosis [22]. This study introduces an approach by comparing various methods for assessing thoracic curvatures, which distinguishes it from previous investigations. Given the existing literature on the flexicurve, the objective of this study is to identify the instrument's advantages and limitations, aiming to enhance its widespread utilization in clinical practice with a reasonable level of confidence.

There are several potential explanations for the differences observed in thoracic kyphosis measurements between the Flexicurve and radiological methods. Firstly, the flexicurve may be capturing angles that are fundamentally distinct from those measured by Cobb and vertebral centroid angle. Consequently, the disparities observed could indeed indicate a genuine flaw in using the Flexicurve instrument. However, it is crucial to note that palpation plays a vital role in determining the accurate positioning of anatomical landmarks, which is an indispensable requirement to ensure the reliability and reproducibility of postural analysis. Also, there may be inherent challenges in using Cobb angles as a standard for assessing the reliability of the Flexicurve in older postmenopausal women. While the Cobb angle is consistently regarded as the gold standard, it may not be the most suitable radiographic benchmark for comparing with the Flexicurve. Lastly, the mathematical calculation employed to determine Flexicurve kyphosis angles is of significant importance. The choice of scaling metrics, along with the geometric formula may vary depending on factors such as angle type and the specific age group of the population being studied. Individual characteristics of the study population, including age, weight, postmenopausal history, and body mass index, may have distinct influences on thoracic kyphosis measurements [23]. These factors can potentially confound comparisons between different assessment methods.

The vertebral endplate destruction in postmenopausal women in the form of marginal and bridging osteophytes can lead to errors in measurements of thoracic kyphosis by Cobb angle and thus vertebral centroid angle estimation could give a better correlation with the Flexicurve scale method [21, 24]. Flexicurve constantly underestimates the angle obtained from Cobb in extremes of ages in few of our study subjects with discrepancies of about 2-8 degrees, while on the other hand; vertebral centroid angle shows a better correlation with the flexicurve angle in advanced age also. As individuals grow older, the disparities between Flexicurve and radiographic angles exhibit a progressive escalation. This implies that the precision of Flexicurve diminishes as age advances when employing these two methodologies [14]. As an essential aspect, the limitations of our study are that we employed the Flexicurve method but during measurement, we did not formally identify T12 on the Flexicurve. Instead, we made an inference based on the tracing after the measurement, considering it as the end of the thoracic length. We must diligently address this potential source of error to ensure the accuracy and reliability of our findings concerning thoracic length dimensions and the Flexicurve kyphosis angle.

In our study there was no statistically significant difference between the vertebral centroid and Flexicurve angle, it shows 99% confidence and 1% level of significance. Therefore we accept the null hypothesis and reject the alternate hypothesis. The association between Cobb and vertebral centroid measures was moderate to strong with a correlation coefficient (r=0.57). Pearson correlation analyses were repeated when the sample was dichotomized.

Among the methods evaluated, the Flexicurve stands out as a promising choice. It is affordable, ease of use, and high levels of both reliability and validity. Considering this review, future research should focus on investigating methods that currently possess limited and inconsistent levels of evidence. By doing so, we can further enhance our understanding of thoracic kyphosis measurement techniques.

Conclusions

The Flexicurve method has proven to be a valuable and practical tool for evaluating thoracic kyphosis in postmenopausal women. It offers a non-invasive, cost-effective, and user-friendly solution in a clinical setting. According to our research, the measurement of Thoracic Kyphosis in healthy postmenopausal women using the Flexicurve method exhibits stronger agreement with vertebral centroid angles as compared to Cobb angles. However, it is important to note that as age increases, the Flexicurve method's inaccuracies tend to amplify and become more variable.

References

1. Barrett E, McCreesh K, Lewis J. Reliability and validity of non-radiographic methods of thoracic kyphosis measurement: A systematic review. Man Ther [Internet]. 2014;19(1):10–7. Available from: http://dx.doi.org/10.1016/j.math.2013.09.003
2. Teixeira FA, Carvalho GA. Reliability and validity of thoracic kyphosis measurements using flexicurve method. Braz J Phys Ther [Internet]. 2007;11(3). Available from: http://dx.doi.org/10.1590/s1413-35552007000300005
3. Spencer L, Fary R, McKenna L, Ho R, Briffa K. Thoracic kyphosis assessment in postmenopausal women: an examination of the Flexicurve method in comparison to radiological methods. Osteoporos Int [Internet]. 2019;30(10):2009–18. Available from: http://dx.doi.org/10.1007/s00198-019-05023-5
4. Been E, Kalichman L. Lumbar lordosis. Spine J [Internet]. 2014;14(1):87–97. Available from: http://dx.doi.org/10.1016/j.spinee.2013.07.464
5. Greendale GA, Nili NS, Huang M-H, Seeger L, Karlamangla AS. The reliability and validity of three non-radiological measures of thoracic kyphosis and their relations to the standing radiological Cobb angle. Osteoporos Int [Internet]. 2011;22(6):1897–905. Available from: http://dx.doi.org/10.1007/s00198-010-1422-z
6. Jung S-H, Hwang U-J, Kim J-H, Ha S-M, Kwon O-Y. Correlation among non-radiological measurements for thoracic kyphosis. J Musculoskelet Sci Technol [Internet]. 2020;4(1):1–5. Available from: http://dx.doi.org/10.29273/jmst.2020.4.1.1
7. Vrtovec T, Pernus F, Likar B. A review of methods for quantitative evaluation of spinal curvature. Eur Spine J [Internet]. 2009;18(5):593–607. Available from: http://dx.doi.org/10.1007/s00586-009-0913-0
8. Goh S, Price RI, Leedman PJ, Singer KP. A comparison of three methods for measuring thoracic kyphosis: implications for clinical studies. Rheumatology (Oxford) [Internet]. 2000;39(3):310–5. Available from: http://dx.doi.org/10.1093/rheumatology/39.3.310
9. Harrison DE, Harrison DD, Cailliet R, Janik TJ, Holland B. Radiographic analysis of lumbar lordosis: Centroid, Cobb, TRALL, and Harrison posterior tangent methods. Spine (Phila Pa 1976) [Internet]. 2001;26(11):e235–42. Available from: http://dx.doi.org/10.1097/00007632-200106010-00003
10. Briggs AM, Wrigley TV, Tully EA, Adams PE, Greig AM, Bennell KL. Radiographic measures of thoracic kyphosis in osteoporosis: Cobb and vertebral centroid angles. Skeletal Radiol [Internet]. 2007;36(8):761–7. Available from: http://dx.doi.org/10.1007/s00256-007-0284-8
11. Lundon KMA, Li AMWY, Bibershtein S. Interrater and intrarater reliability in the measurement of kyphosis in postmenopausal women with osteoporosis. Spine (Phila Pa 1976) [Internet]. 1998;23(18):1978–85. Available from: http://dx.doi.org/10.1097/00007632-199809150-00013
12. Kado DM, Christianson L, Palermo L, Smith-Bindman R, Cummings SR, Greendale GA. Comparing a supine radiologic versus standing clinical measurement of kyphosis in older women: The fracture intervention trial. Spine (Phila Pa 1976) [Internet]. 2006;31(4):463–7. Available from: http://dx.doi.org/10.1097/01.brs.0000200131.01313.a9
13. Yanagawa TL, Maitland ME, Burgess K, Young L, Hanley D. Assessment of thoracic kyphosis using the flexicurve for individuals with osteoporosis. Hong Kong Physiother J [Internet]. 2000;18(2):53–7. Available from: http://dx.doi.org/10.1016/s1013-7025(00)18004-2
14. Fon GT, Pitt MJ, Thies AC Jr. Thoracic kyphosis: range in normal subjects. AJR Am J Roentgenol

[Internet]. 1980;134(5):979–83. Available from: http://dx.doi.org/10.2214/ajr.134.5.979

15. Rajabi R, Mohamadi F. Which Method Is Accurate When Using the Flexible Ruler to Measure the Lumbar Curvature Angle? Deep Pint or mid Point of Arch? World Appl Sci J. 2007;4.
16. de Oliveira TS, Candotti CT, La Torre M, Pelinson PPT, Furlanetto TS, Kutchak FM, et al. Validity and reproducibility of the measurements obtained using the flexicurve instrument to evaluate the angles of thoracic and lumbar curvatures of the spine in the sagittal plane. Rehabil Res Pract [Internet]. 2012;2012:1–9. Available from: http://dx.doi.org/10.1155/2012/186156
17. Chen Y-L. Vertebral centroid measurement of lumbar lordosis compared with the Cobb technique. Spine (Phila Pa 1976) [Internet]. 1999;24(17):1786. Available from: http://dx.doi.org/10.1097/00007632-199909010-00007
18. Elpeze G, Usgu G, Yiğit S. Reliability of the smartphone application inclinometer and flexicurve in measuring thoracic kyphosis. Cureus [Internet]. 2023; Available from: http://dx.doi.org/10.7759/cureus.35886
19. Ludbrook J. Special article comparing methods of measurement. Clin Exp Pharmacol Physiol [Internet]. 1997;24(2):193–203. Available from: http://dx.doi.org/10.1111/j.1440-1681.1997.tb01807.x
20. Ludbrook J. Confidence in Altman-Bland plots: A critical review of the method of differences. Clin Exp Pharmacol Physiol [Internet]. 2010;37(2):143–9. Available from: http://dx.doi.org/10.1111/j.1440-1681.2009.05288.x
21. Alanay A, Pekmezci M, Karaeminogulları O, Acaroglu E, Yazıcı M, Cil A, et al. Radiographic measurement of the sagittal plane deformity in patients with osteoporotic spinal fractures evaluation of intrinsic error. Eur Spine J [Internet]. 2007;16(12):2126–32. Available from: http://dx.doi.org/10.1007/s00586-007-0474-z
22. Grindle DM, Mousavi SJ, Allaire BT, White AP, Anderson DE. Validity of flexicurve and motion capture for measurements of thoracic kyphosis vs standing radiographic measurements. JOR Spine [Internet]. 2020;3(3). Available from: http://dx.doi.org/10.1002/jsp2.1120
23. Kado DM, Huang M-H, Karlamangla AS, Cawthon P, Katzman W, Hillier TA, et al. Factors associated with kyphosis progression in older women: 15 years' experience in the study of osteoporotic fractures. J Bone Miner Res [Internet]. 2013;28(1):179–87. Available from: http://dx.doi.org/10.1002/jbmr.1728
24. Villemure I, Aubin CE, Grimard G, Dansereau J, Labelle H. Progression of vertebral and spinal three-dimensional deformities in adolescent idiopathic scoliosis: a longitudinal study. Spine (Phila Pa 1976). 2001;26(20):2244–50.