Measurement of Spinal Curvature

A comparison of two manual methods

Blessing C Didia[1], Blessing NR Jaja[2], Esther I Abere[1], Chukuemeka E Agi[3]

Port Harcourt University Teaching Hospital, Departments of Human Anatomy[1] and Radiology[3], Rivers State, Nigeria

[2]Niger Delta University, Medical Faculty, Department of Human Anatomy, Bayelsa State, Nigeria

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ABSTRACT

Aim: *In correction of angular deformities of the spine, assessment of spinal curvature from radiographs is important. The methods used for such assessment vary from simple to sophisticated techniques depending on the facilities that are available. There is the need to use a simple, yet reliable method in a health care setting with limited resources. To ascertain the level of concordance between two manual methods of measuring the spinal curvature of spinal angular deformities.*

Method: *The traditional protractor method and the goniometer method were used to measure the angle of curvature in seventy standard erect anteroposterior and lateral spine radiographs of patients who had thoracic and thoracolumbar scoliosis or kyphosis and were managed in 4 tertiary hospitals in Nigeria. Correlation analysis was then applied to determine the association between both methods, with the level of significance set at $p<0.01$.*

Result: *A strong association between the two manual methods was obtained for both kyphosis and scoliosis ($r= 0.99$; $p> 0.01$). Measurement variability increased with magnitude of curvature.*

Conclusion: *The traditional protractor method as well as the goniometer method has clinical utility but for practical purposes, the goniometer should be preferred to the protractor method of measuring spinal curvature because of its simplicity and that it obviates intrinsic sources of error associated with the latter.*

Key words: *Spinal deformities, scoliosis, kyphosis, spinal curvature, cobb angle*

Correspondence: *Dr Blessing N. R Jaja Department of Human Anatomy, Faculty of Basic Medical Sciences, College of Health Sciences, Niger Delta University, Bayelsa State, Nigeria*

Omurga Eğriliğinin Ölçülmesi; İki manuel metodun karşılaştırılması

Amaç: *Omurganın açısal anormalliklerini düzeltmede radyografide spinal eğriliğini değerlendirmek çok önemlidir. Bu durumu değerlendirmek amacıyla basit ve karmaşık methodlar kullanılabilmektedir. Bu nedenle kısıtlı imkanları bulunan yerlerde basit ve güvenilir olan bir method kullanılmasına ihtiyaç vardır. Omurganın açısal deformitelerini değerlendirmek için 2 manuel methodu karşılaştırılması gerekmektedir.*

Metod: *Nijeryada 4 farklı hastanede torasik, torakolomber skolyozu veya kifozu bulunan 70 hastanın standart anteroposterior ve lateral filmi gonyometre ve geleneksel protraktor methodu ile değerlendirildi. Her iki method arasında istatistiksel olarak anlamlı bulunan değerler için korelasyon analizi yapıldı.*

Bulgular: *Kifoz ve skolyoz için her iki method arasında güçlü bir ilişki saptandı (r=0,99, p>0,01). Eğriliğin fazlalığı ile ölçüm değişkenliği artmaktaydı.*

Sonuç: *Goniometre yöntemi geleneksel protaktor yöntemi kadar klinik kullanımı olan bir methoddur ve basit olması nedeniyle omurga eğrilik ölçümünde tercih edilmelidir.*

Anahtar kelimeler: *Omurga deformitesi, skolyoz, kifoz, omurga eğriliği*

INTRODUCTION

Angular deformities of the spine could be debilitating conditions having both functional and social implications, especially in young persons who incidentally are mostly affected (1). For both scoliosis and kyphosis, radiological assessment of the extent of spinal curvature is the standard examination. It provides a means of evaluating the efficacy of treatment options as well as monitoring the progress of the disease process (1,2).

The most popular technique of assessing spinal curvature on radiographs has remained for more than five decades the Cobb method (3). In this technique, the angle of interception sustained by the most tilted upper and lower vertebrae of a spinal curvature is measured manually using a protractor; the so-called traditional method (3,4). This traditional method is relatively elaborate. Significant interobserver and intraobserver variations may exist in the value of Cobb angle measured by the traditional protractor method (4-7). The observed variability has been attributed to intrinsic error sources which can be obviated by even more elaborate measurement techniques. Dutton et al. (8) and Singer et al. (9) have shown improved measurement accuracy using computer-aided techniques; but these techniques are not universally available, cost ineffective and are used essentially for research purposes.

In the clinical setting, the goniometer is employed as a manual alternative to the protractor in estimating the angle of a spinal curvature. A few studies (4-7) in published literature have examined the reliability of manual measurement methods for spinal curvature.

We are unaware of any such studies which has examined the practical utility of spinal measurement techniques in our setting. Hence, our study was designed with the aim to determine the level of association between the goniometer method and traditional protractor method of measuring spinal curvatures among patients who had spinal angular deformities.

MATERIALS AND METHODS

For this study, seventy standard erect anteroposterior and lateral spine radiographs of thoracic and thoracolumbar spines of patients who had structural scoliosis or Kyphosis were used. The radiographs were obtained from the radiology departments of the University of Port Harcourt Teaching Hospital, Braithwaite Memorial Hospital, Port Harcourt, National Orthopaedic Hospital, Enugu and the Lagos State University Teaching Hospital, Lagos State. All hospitals are in Nigeria.

The radiographs which we used for the study were those of which the end plates were clearly visible. Anonymity and confidentiality of subjects whose radiographs were used were preserved. Thirty seven radiographs were of scoliotic spines while thirty three radiographs were of kyphotic spines. Each radiograph was labeled with a number for identification purposes and the angle of curvature then measured by an experienced observer, who is a consultant radiologist (Agi), using firstly the goniometer method and a week thereafter, the traditional protractor method. The upper and lower end vertebrae (end plates) were preselected for each radiograph. The end-vertebrae are the vertebra at the upper and lower limits of the curve which tilted most severely towards the concavity of the curve (Figure 1). In the goniometer method, one limb of the device was placed on the upper

Table 1*. Sex-related distribution of scoliotic and kyphotic angles as measured with the goniometer and protractor methods*

Variable			Scoliosis			Kyphosis	
Sex	Method	n	Mean (°)	CV(%)	n	Mean (°)	CV(%)
Male	Goniometer	20	21.9±16.2	73.9	17	19.2±10.7	53.1
	Protractor	20	22.5±15.8	70.2	17	19.8±10.7	62.9
Female	Goniometer	17	33.9±24.6	72.6	16	27.6±13.5	48.9
	Protractor	17	36.3±20.6	71.6	16	27.0±13.4	49.6

CV: Coefficient of variability

margin of the upper end-vertebra and the other limb on the lower margin of the lower end vertebra. The sustained angle was read off and recorded.

In the traditional method, according to Cobb (3), straight lines were drawn parallel to the upper margin of the upper end vertebra and the lower margin of the lower end vertebra using the same China graph pencil and ruler in all cases. Perpendicular lines were then drawn to these reference lines using a set square. The angle that was made by the intersection of the perpendiculars was read off with the aid of a protractor and recorded. The significance of variations observed between the two sets of data was assessed using the paired t-test while the measure of association was done using Pearson product moment correlation coefficient. Statistical analysis was undertaken separately for scoliotic curvatures and kyphotic curvatures. Test of significance was performed with the Student-Neumann- Keul's test. The level of significance was set at $p< 0.01$.

RESULTS

The results of the study are as summarized in Tables 1 and 2. Scoliotic angles derived by the traditional protractor method were highly associated with those derived by the goniometer method ($r= 0.98$; $n= 37$; $p> 0.01$).

Table 2*. Summary statistics of the relationship between the two measurement techniques*

Curvature	n	r	Intraobserver variability (95%CL)	p value
Scoliosis	37	0.98	±1.830	>0.01
Kyphosis	33	0.99	±0.520	>0.01

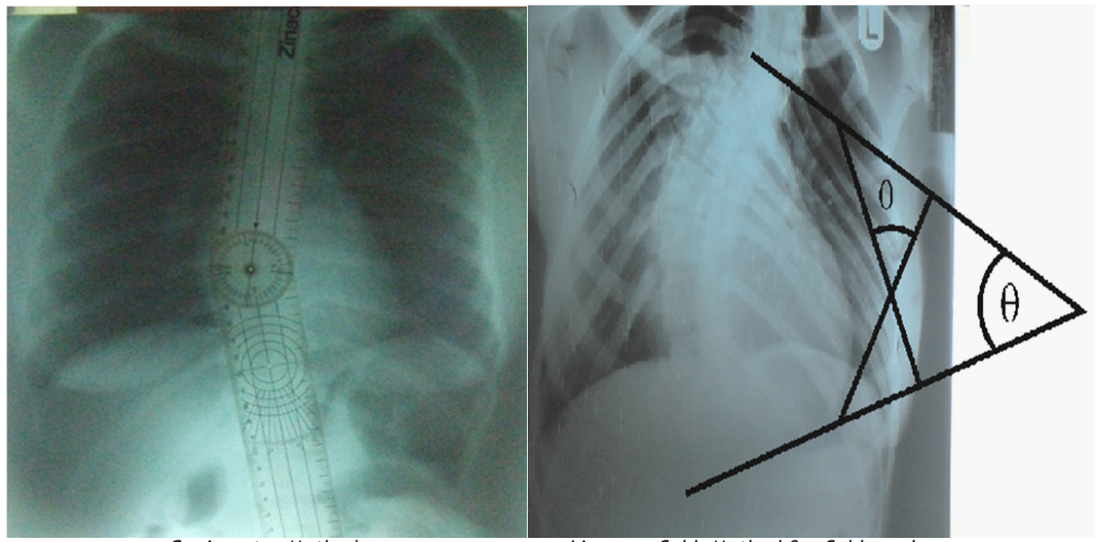
CL: Confidence Limit

This was also the case with Kyphotic angles ($r= 0.99$; $n:33$, $p> 0.01$). The mean of the differences in angles between the two methods was 5.7 degrees (Range: -8.0 to 29.0 degrees) for scoliotic curvatures. For kyphotic curvatures, it was 2.34 degrees (Range: -2.0 to 6.0 degrees). The overall 95% confidence limit for intraobserver variability was ±1.83 degrees for scoliotic curvatures and ±0.52 degrees for kyphotic curvatures. We noted a correlation between curve magnitude and measurement variability. The larger the curve the more variable was the value of the difference in Cobb angle as determined by the two methods.

DISCUSSION

Manual methods of estimating the angle of a spinal curvature following an angular deformity of the spine are dependent on end-vertebrae orientation. Computer aided techniques are measurement methods which are end-vertebrae independent. These take into consideration the radius of spinal curvature, unlike the manual methods which measure the tilt of end-vertebrae only. For purposes of quantification of thoracic kyphosis, the clinical utility of manual methods and computer-aided curve assessment techniques has been confirmed, with the indication that these are essentially equivalent (10). Although, it was also shown that the manual methods tend to over estimate kyphosis in the presence of end-plate deformation (10). In the present study, care was taken to exclude radiographs that may present measurement difficulties as a result of end-plate irregularity.

A high reproducibility between the two manual methods under evaluation, for both scoliosis and kyphosis, was observed in our study. The derived intraobserver variability of kyphotic curves (±0.520) is lower than the value of ±1.60 reported by Goh et al. who compared the



Goniometer Method Lippman-Cobb Method θ = Cobb angle

Figure 1. *Schematic diagrams of a scoliotic curve showing the Goniometer method and the Lippman-Cobb method of estimating the angle of spinal curvature.*

traditional protractor method to a computer technique of measuring thoracic kyphosis. The high degree of concordance between the two manual methods is, in part, the result of end plate preselection. The preselection of end-vertebrae, as was done in our study, is invariable to the study design which aims to assess the degree to which both manual methods can reliably reproduce a given angle without the confounding effect of end plate inconsistency. In a similar study on congenital scoliosis by Fernando et al., the end vertebrae were also preselected. These workers had reasoned that in the clinical setting, comparison of different radiographs of same patient with a spinal deformity is most likely to be undertaken with the end plates preselected in all cases as this will allow for effective assessment of curve progression.

It appears that the goniometer method has greater utility with kyphotic curves as compared to scoliotic curves given the relatively higher correlation and lower intraobserver variability of kyphotic curves relative to scoliotic curves in this study. In a previous study (2), it was shown that scoliotic curvatures may present measurement difficulties. This is related to the clarity of measurement points, the experience of the investigator and the magnitude of curvatures. In the present study, the first two variables were controlled by ensuring that only good quality radiographs with clearly visible end-plates were utilized and that a single experienced investigator carried out all measurements thus avoiding interobserver variations. The greater utility of the goniometer method with regard to kyphotic curves relative to scoliotic curves may, therefore, be due to the effect of curve magnitude. We had noted greater angle magnitude with scoliotic curves and angle variability with measurement accuracy.

Finally, for practical purposes of assessing spinal curvature following spinal angular deformity, the goniometer method should be the preferred manual method. It improves on the simplicity of the protractor method as well as obviates intrinsic error sources such as inaccurate placement of lines on radiographs, the use of improper diameter markers and non standard protractors. All of which have been previously shown (11) to reduce the accuracy and reliability of the traditional protractor method of estimating the Cobb angle.

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