

## Which Method Is Accurate When Using the Flexible Ruler to Measure the Lumbar Curvature Angle? Deep Pint or mid Point of Arch?

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**Abstract:** Flexible ruler (Flexicurve) is used to determine the degree of thoracic kyphosis and lumbar lordosis. This is done by the use of  $\theta = 4 \text{ Arctang } 2H/L$  equation to convert the collected data to degree. In the equation the L letter is the length of two obtained spinous process to the nearest millimeter. The length of a perpendicular line (H) drawn from the L to the curve called H. There are two methods when using the flexible ruler to measure the degree of lumbar lordosis. The first method uses the midpoint of L line to the curve as H value. The second method uses the deep point (deepest distance) between the curve and the L line as H value. It seems there is a difference between these two methods of measurement when we are dealing with the lumbar curvature angle. This study attempts to verify these differences if there is any. Hence this study is attempts to see which of these two methods is closed to X-ray method of lumbar lordosis measurement. Ten patients with low back pain (LBP) used as a subject. The subjects had to do an X-ray on their lumbar spine as it was requested by their physiotherapist. Then their lumbar lordosis was measured with the two methods of flexible ruler. Using the Repeated Measure ANOVA, the data was analyzed and the outcome revealed a meaningful difference between three methods of lordosis measurements. This study showed that the two methods of flexible ruler measurements (mid pint and deep point as H value) are statistically different from each other. Hence it revealed that the deep point method is closed to X-ray method of lordosis measurements.

**Key words:** Lordosis • Flexible ruler • Mid point • Deep point

### INTRODUCTION

The flexible ruler (flexicurve) was first described almost 50 years ago. Now this device is widely uses to measure the degree of spinal curvature in the sagittal plane such as kyphosis and lumbar lordosis in physiotherapy and sport medicine field [1].

This instrument is described as a 40, 50 or 60 cm strip of lead covered with plastic, which can be bent in one plane only and retains the shape into which it is bent [1-3]. Therefore, it is claimed that it can be used to copy any curved surface. For the spinal measurements, the flexible ruler is placed (molded) on the mid-line contour of the spine between two marked points, and then it is laid on a piece of paper and the spinal curvature copied by running a pencil along the flexible ruler.

To measure the degree of lordosis by this device, the tester carefully molds the flexible curve to the midline contour of the subject's lumbar spine. A marker indicates the location of spinous processes of the upper and lower vertebrae. The contour of the lumbar spine obtained from

the flexible curve was carefully traced by the tester onto paper. Then by using the equation of  $\theta = 4 \text{ Arctang } 2H/L$  the degree of lumbar lordosis calculated. In this equation L is a strait line from the first vertebrae to the last vertebrae which was marked by the tester and the H letter is the distance between the midpoint of L line and the lumbar curve. However the accuracy of the measurement by this way is questionable as the deep part of lumbar curvature may not be lay in the middle of the L line draw to the obtained curve. If this happens, the acquired degree of lordosis or lumbar curvature may not represent the real degree.

### METHODS

The purpose of this study was to find out while using the flexible ruler, which method of lumbar curvature measurement (H as a midpoint or H as a deepest part of the lumbar curve) is closer to the X-ray measurements on this area. The study is descriptive and based on quantitative data.

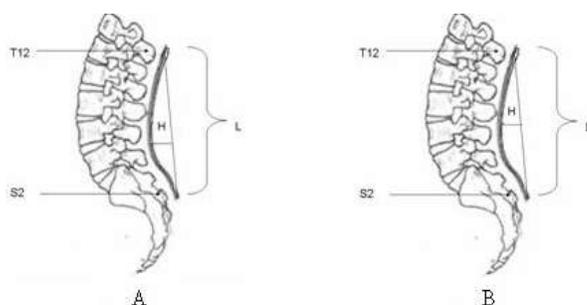


Fig. 1: The comparison of two methods of lumbar lordosis measurements using flexible ruler. (A) Using deepest part of the curvature as the H value and (B) using the midpoint of the curve

**Participants:** The study was carried out among male patients referred to a physiotherapy clinic as a result of lower back pain (LBP). Ten patients with LBP and with the mean age of  $22/4 \pm 1.8$ , mean height of  $167 \pm 6.3$  and the mean weight of  $70.1 \pm 6$  used as a subject. The subjects had to do an X-ray on their lumbar spine as it was requested by their physiotherapist. Then their lumbar lordosis was measured with the two methods of flexible ruler; 1- midpoint and 2- deep point of the arch and then by X-ray method of lumbar curvature measurement. All of the patients were agreed to tack part in the study.

**Research Instruments and Process:** A flexible ruler (flexicurve) was used to measure the degree of lordosis in the lumbar area. The flexible ruler is a flexible piece of lead covered in durable plastic that can be molded to the contour of the spine to measure curves in the sagittal plane. The flexible ruler provides a quick, inexpensive and noninvasive way to assess posture in clinical or community-based settings. Several investigators have established the validity of flexible ruler postural measures by correlating them with measures of kyphosis and vertebral wedging taken from spinal radiographs and other instruments, such as goniometers, kyphometers and inclinometers [4-8].

A 50 cm flexible ruler and a lateral X-ray of lumbar vertebrae to measure the lumbar curvature were used in this study. Using flexible ruler, lumbar curve was measured once by midpoint method and once with deepest part method on all 10 patients. The flexible ruler measurement protocol was based on the one described by Youdas et al 9 in which the spinous process of T12 to S2 was used to measure the degree of lumbar curvature. Then, lumbar curvature of all 10 patients was measured once again by X-ray method.

**Data Collection Procedures:** After signing a written consent form, subjects' posture was assessed using

flexible ruler. The measurement was performed with the subject standing in their usual relaxed posture.

The flexible ruler was then placed over the spinous processes of the lumbar spine and shaped to fit the contours of this spinal curve. The instrument was carefully removed and traced onto a piece of plain white paper. A vertical line was drawn to connect the T12 and S2 landmarks (total length of curvature/L line). First the maximum width (deepest part of curvature/ H line) and then the middle of the lumbar curvature length (midpoint of curvature/H line) was measured in centimeters and used to calculate the lumbar lordosis using the related equation in all 10 subjects (Fig. 1). To reduce examiner bias, all measurements from tracings were calculated randomly after all subjects were measured. An angle, theta ( $[\theta]$ ), was then determined by using these measurements in the equation:  $[\theta] = 4 \times [\arctan(2H/L)]$  where  $[\theta]$  represents the magnitude of the lordotic curve.

Then, all subjects were asked to have lateral lumbar vertebra radiographs by their physiotherapist. So, all the 10 subjects had their lateral pelvis radiographs taken. Study participants were made to stand up straight in a relaxed posture with their left sides toward the film cassette, knees extended as much as possible, hips straight, and hands placed on a height-adjustable bar so that the arms were flexed at  $30^\circ$  from the shoulder.

For lumbar lordosis measurement by X-ray, we used Nourbakhsh and Moussavi method<sup>10</sup>. By this way we connected the centre of the L1 to L5 vertebrae to each other (Fig. 2). Then we put the lumbar lateral radiography on Negatoscope and then a calk paper 30 by 40 centimeters in dimension up on each radiograph while it was holding by two clips. Next, we draw the limit and diameters of L1 to L5 on the paper (radiographs) and a curvature similar to flexible ruler measurements was obtained on the radiographs. In this way the two methods of flexible ruler and X-ray measurements could be comparable.

Table 1: Repeated measure ANOVA result on three methods of lordosis measurements

Lordosis	Mean difference (I-J)	Std. Error	Sig.	95% confidence interval for difference	
				Lower bound	Upper bound
X-ray vs Midpoint	7.038*	1.554	0.004	2.479	11.597
Midpoint vs Deepest point	-1.964*	0.579	0.024	-3.664	-0.264
X-ray vs Deepest point	-5.074*	1.475	0.022	-9.402	-0.746

\*The mean difference is significant at the 0.05 level. An adjustment for multiple comparisons: Bonferroni

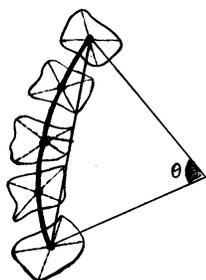


Fig. 2: The lumbar lordosis measurement by x-ray

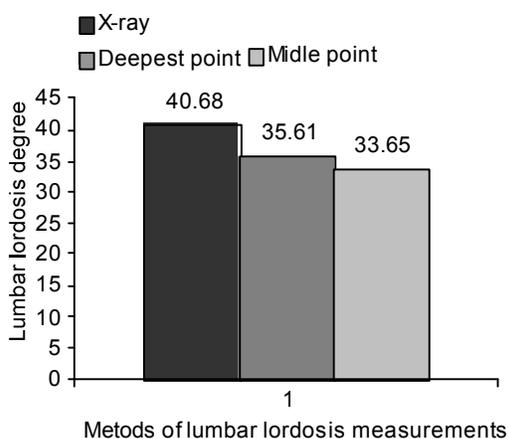


Fig. 3: The means of lordosis obtained by difference methods of flexible ruler and X-ray

**Data Analysis:** The data obtained from an X-ray and the two styles of flexible ruler methods were analyzed by using the repeated measure ANOVA to examine the differences between the three methods of lumbar curvature measurements. As the result of ANOVA was significant, Bonferroni follow up test was used to see where the difference is laid.

### RESULTS AND DISCUSSION

The results are presented in Table 1. The mean of lumbar curvature using three methods of measurements is presented in Fig. 3. These results show that the mean of lumbar curvature measurements performed by the deepest part method of flexible ruler (35.61 degree) was closest to

the X-ray method of lumbar curvature measurements (40.68 degree). The mean of lumbar curvature measurements performed by the midpoint of flexible ruler was 33.65 degree. Table 1, shows that there is a significant difference between three methods of measurements.

### CONCLUSION AND RECOMMENDATIONS

This study showed that there is a significant difference in the mean of lumbar curvatures obtained by the two methods of flexible ruler measurements, midpoint and deepest point of curve with each other and even with the X-ray method. This means that when we measure the lumbar curve of the subject with two methods of flexible ruler, it does not seem we obtain a similar degree. This study showed the measurements that calculated the deepest part of the curve as H value in the equation is close to the measurements obtained by the X-ray methods on the same subjects. From this study it can be concluded that if we use the midpoint of the L line as H value on the equation, then on average it might show 2 degree less than the real value of the lumbar curvature.

Hence this study showed that the correlation between the measurements performed by the deepest part of the curve in flexible ruler method with the X-ray method is high ( $r=98$ ). While this correlation for the midpoint method of the flexible ruler was less than the deepest part ( $r=88$ ).

From the findings of this study we recommend while using the flexible ruler to measure the degree of lumbar curvature, it is better to use the value of the deepest part of the curve as H value in the equation because the degree obtained by this way was indicated to be more accurate and more closed to the X-ray method of measurement [8-10].

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