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SPINAL PANTOGRAPH – A NON-INVASIVE TECHNIQUE FOR DESCRIBING KYPHOSIS AND LORDOSIS IN THE THORACO-LUMBAR SPINE

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A spinal pantograph – a non-invasive method for describing and documenting the posture of the back in the standing position – is described. Thoracic kyphosis and lumbar lordosis can be recorded by a simple technique. A comparative study of the range of kyphosis and lordosis measured by X-ray and this mechanical device shows a statistically significant correlation. As regards the thoracic kyphosis, the spinal pantograph seems to be as accurate as the X-ray. In lumbar lordosis an underestimation is seen with the clinical device.

Compared with non-scoliotic cases, a significantly decreased kyphosis is observed in structural scoliosis, even in cases with a scoliotic angle of less than 30° according to Cobb.

The advantage of this spinal pantograph is that it reduces the radiation dosage. It can be used for screening and follow-up examination of the posture especially during the growing stage.

Key words: kyphosis; lordosis; posture; scoliosis; spinal pantograph

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Determination of the range of a thoracic kyphosis and lumbar lordosis has mainly been performed roentgenographically. However, there has been less interest in the evaluation of spinal curves in the sagittal plane, than there has been concerning lateral deviation as seen in scoliosis. Not very much has been reported about these physiological curves in the standing position. For example, no detailed reports concerning kyphosis and lordosis in growing children or adults have been made. One reason for this deficiency in our knowledge of the posture of the back is the lack of simple, non-invasive methods for describing and documenting these spinal curves. Lateral X-ray of the spine cannot be used in screening; it would not be ethical or economical.

In looking for a non-complicated device for this purpose, a spinal pantograph has been developed at the Department of Orthopaedic Surgery, Malmö General Hospital. This apparatus will be described briefly together with a study comparing the results of this measurement technique and X-rays.

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MATERIAL AND METHODS

The spinal pantograph (Figure 1) consists of a pantograph with an arm, at the end of which a low-frictioned wheel is mounted. The decreasing scale can vary between 1:2 and 1:20. In the present study, 1:4 has been chosen as the most suitable for this purpose. A drawing table has been fixed below the pantograph for recording the decreased contour line of the trunk. The pantograph and the drawing table are mounted on a tripod, which can be raised or lowered. The tripod also allows the pantograph to work in both the sagittal plane for recording kyphosis/lordosis and the transversal plane for describing the hump deformity seen in structural scoliosis.

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Figure 1. Spinal pantograph, when measuring kyphosis/lordosis.

The patients stand in front of the spinal pantograph, in an erect, relaxed position supporting their weight equally on both legs. The spinal processes of C_7 and L_5 are marked with a dermograph. By letting the wheel of the pantograph lightly follow the spinal processes between these two landmarks, the kyphosis and the lordosis are recorded on a paper roll on the drawing table. By indicating C_7 and L_5 on the contour line on the paper, even the height of the thoraco-lumbar spine can be evaluated. When recording the asymmetry of the rib hump in structural scoliosis the pantograph is placed horizontally (Figure 2). Here the rotational deformity can be estimated in a standing position.

Evaluation of the range of the kyphosis and lordosis

On the *X-ray* (Figure 3) the kyphosis and lordosis angles were measured according to Cobb (1948), i.e. the range of the kyphosis is the angle determined between the upper and the lower end vertebra of the curve. The range of the lordosis is the angle between the upper end vertebra (= the lower end vertebra of the thoracic curve) and the lower end vertebra of L_5.

On the *pantograph*, a similar technique is used. Using a ruler the contour line of the image of the curves is followed, and those tangents which deviate maximally from the vertical line are registered (Figure 3). Thus by drawing three lines, both the thoracic kyphosis and lumbar lordosis can be calculated.

The present material consists of 71 cases. There were 15 cases with a structural scoliosis of less than 30°, 41 cases without any visible spinal disorder on X-ray who served as "controls" and 15 cases with Scheuermann's disease. All patients were teenagers.

All cases were X-rayed and pantographed. The X-ray examination – lateral exposure – was performed in a standing, relaxed position – an identical posture to the one used while being pantographed.

Reliability of the spinal pantograph

1. Reproducibility: Repeated examinations were made at varying intervals in 30 patients. Each time they were told to stand in the same comfortable position. The mean differences between the different observations were $2.7 \pm 1.8°$ (range 0–7°) and $3.0 \pm 1.8°$ (range 0–7°) in thoracic kyphosis and lumbar lordosis, respectively. There was no significant difference between the thoracic and lumbar curve.

2. The inter-investigator error for repeated measurements of the same curves was also evaluated. Ten medical and paramedical persons were briefly informed as to how to measure the degree of the curves and asked

Figure 2. Spinal pantograph, when registering the rotational deformity of the trunk seen in scoliosis.

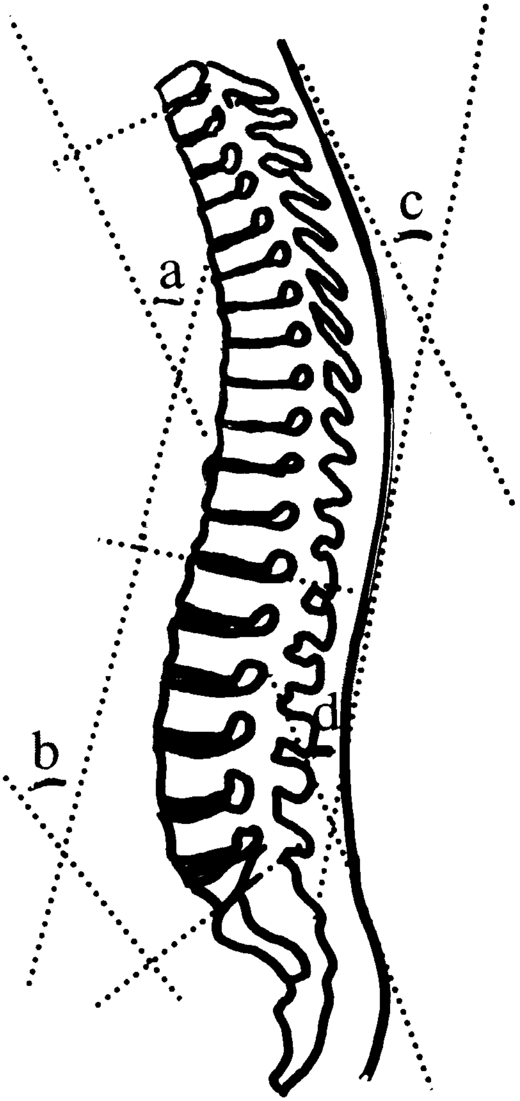

Figure 3. Determination of the range of thoracic kyphosis and lumbar lordosis with X-ray (a and b angles) and with spinal pantograph (c and d angles).

to determine the thoracic kyphosis and lumbar lordosis in 38 spines. The coefficient of variation (c/v $= \frac{SD}{M} \times 100$) was 6.5 per cent and 7.0 per cent in kyphosis and lordosis, respectively.

RESULTS

Thoracic kyphosis was studied in 71 cases. A statistically significant positive correlation was seen between the range of the thoracic kyphosis estimated on an X-ray and that measured with the spinal pantograph in standing patients (Figure 4). The correlation coefficient was 0.97.

When dividing the material into scoliosis, "controls" and Scheuermann's disease, a statisti-

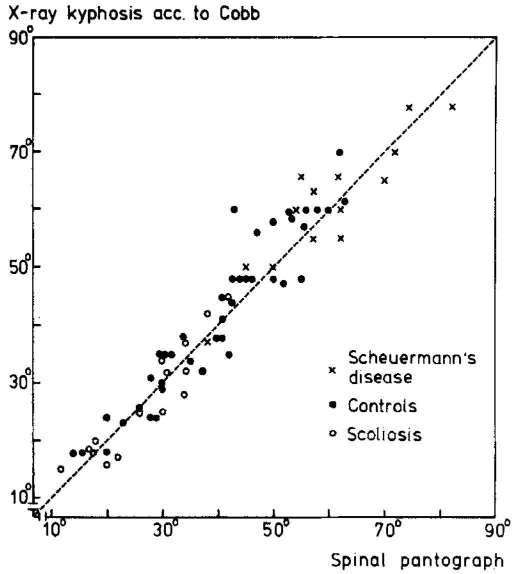

Figure 4. Comparison of the range of thoracic kyphosis in X-ray and spinal pantograph studies.

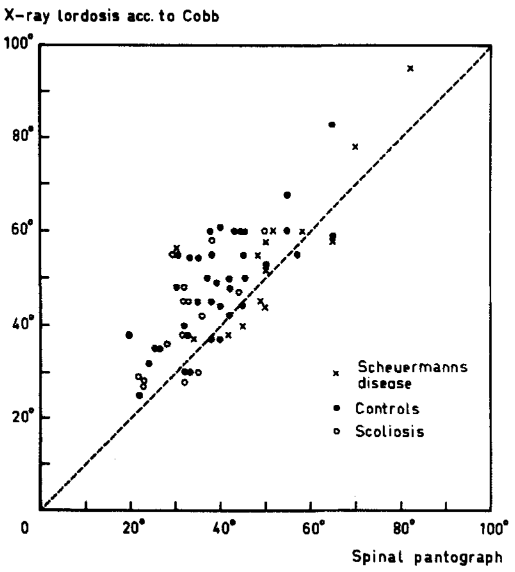

Figure 5. Comparison of the range of lumbar lordosis in X-ray and spinal pantograph studies.

Table 1. Mean and standard deviation of thoracic kyphosis examined with X-ray and spinal pantograph (Pant).

	Scoliosis (n = 15)		"Controls" (n = 40)		Scheuermann's disease (n = 16)	
	X-ray	Pant	X-ray	Pant	X-ray	Pant
Mean (degrees)	25.9	25.9	40.9	39.7	62.8	61.8
± SD	10.1	9.3	13.6	12.2	12.6	12.5

Table 2. Mean and standard deviation of lumbar lordosis examined with X-ray and spinal pantograph (Pant).

	Scoliosis (n = 15)		"Controls" (n = 38)		Scheuermann's disease (n = 14)	
	X-ray	Pant	X-ray	Pant	X-ray	Pant
Mean (degrees)	41.9	33.7	48.0	38.9	55.6	51.3
± SD	10.5	7.4	12.6	11.0	15.5	13.9

cally significant difference was seen between these three groups (scoliosis – controls P<0.001, controls – Scheuermann's disease P <0.001 (Table 1). In scoliosis, the mean range of kyphosis was 25°, in controls 40° and in Scheuermann's disease 62°. On the other hand, in all groups there were significant correlations between the X-ray and pantograph findings.

Lumbar lordosis was estimated in 68 cases. Even in these curves, a statistically significant positive correlation was seen between the X-ray and pantograph findings (Figure 5). The correlation coefficient was 0.80. Here, however, there is a tendency to underestimate the range of the lordosis investigated with the pantograph technique. These differences were statistically significant in the scoliosis group ($0.05 > P > 0.02$) and in the "control" group ($0.01 > P > 0.001$). Even in the Scheuermann group a similar trend was seen but it was not significant.

When comparing the mean range of the lumbar lordosis between the scoliotic group and "controls" (Table 2), no significant difference was seen in either X-ray or pantograph findings. In the lordosis registered with the pantograph, the cases with Scheuermann's disease were more pronounced than in the controls. This latter difference could, however, not be seen when using the X-ray.

DISCUSSION

Not very much has been published about the mean degree and range of thoracic kyphosis and lumbar lordosis in either children or adults. However, we know that the posture varies during the growth period. There seems to be a tendency for an increase in kyphosis and lordosis, with the maximum occurring during adolescence. This increase of the sagittal curves has been suspected as being pathological by many observers, and different forms of treatment have been suggested.

Actually we do not know whether these more pronounced curves in teenagers should be regarded as abnormal (Moe et al. 1978). Perhaps a wider range of variation of posture in this age group should be regarded as physiological. One of the most important reasons for this lack of knowledge is the lack of non-invasive methods for measuring kyphosis and lordosis. Roentgenographical methods are available but cannot be used for screening, especially not in childhood. Various clinical, mechanical devices have been tested: e.g. the kyphometer described by Debrunner (1972). Thulbourne & Gillespie (1976) have developed another measuring device, especially intended for registering the rib hump in structural scoliosis. Other mechanical devices were launched by Rippstein (1967), Neugebauer (1970) and Timm (1971).

The purpose of this study was to present and evaluate a simple mechanical device for describing and documenting the shape of the thoraco-lumbar spine in the sagittal plane by means of a known decreasing scale. In this manner, the total length between C_7 and L_5 can be recorded. Even the clinical range of the thoracic kyphosis and lumbar lordosis can be estimated. These angles can be evaluated by letting a ruler follow the imaged contour line of the spine. The reliability of this technique was shown to be acceptable. By comparing the kyphosis and lordosis angles registered in the same case but at different observations, the mean difference was $2.7 \pm 1.8°$ and $3.0 \pm 1.8°$ in thoracic kyphosis and lumbar lordosis, respectively. This shows that it is apparently easy to reproduce a relaxed, standing position, which of course is necessary, independent of the measuring device.

The inter-investigator error for repeated measurements of the same curves was also studied by determining the coefficient of variation (6.5 per cent and 7 per cent in kyphosis and lordosis, respectively). This means that this technique can be easily learnt. However, as in all clinical measuring methods, it is preferable that the follow-up is performed by the same examiner.

When comparing the kyphosis angle of the thoracic spine recorded with X-ray and spinal pantograph a significant correlation was observed. There was even a significant correlation between these two techniques for the lumbar lordosis, but it was less than that seen in the thoracic region. The pantograph method has a tendency to underestimate the lordosis.

The present material of teenagers consisted of thoracic structural scoliosis, Scheuermann's disease and spines without any obvious pathological signs on X-ray. But when looking at the thoracic kyphosis, the mean value differs significantly; in scoliosis 25°, controls 40° and Scheuermann's disease 62°. There is thus an evident flattening of the kyphosis, which is well known as one component of structural scoliosis. The "control" group, however, can not be compared with a representative group of the normal population as their ages vary between 10 and 19 years. Furthermore, they were all admitted as patients suffering from pains in the back.

No statistically significant difference could be seen in the lumbar lordosis between scoliosis and "controls". On the other hand, the lordosis was increased in cases with Scheuermann's disease located in the thoracic region.

One important reason for evaluating a mechanical non-invasive device is to replace or decrease the number of radiographs for screening or follow-up examinations of children with so-called "bad" posture. Even if Scheuermann's disease requires a roentgenographic diagnosis, the progress of the kyphosis can, after the diagnosing X-ray, be performed by non-invasive techniques.

This spinal pantograph seems to describe the range of, at any rate, the thoracic kyphosis, with the same exactness as X-ray. As regards the lumbar lordosis, there was less agreement between the X-ray and spinal pantograph findings. On the other hand, X-ray examination for the range of the lordosis seems to be inaccurate since the lower border of the lordotic angle is not well defined. The sensitivity of this method as regards registering changes of the kyphosis and/or lordosis has not yet been studied and needs further long-term observations.

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