Accuracy of a Radiological Evaluation Method for Thoracic and Lumbar Spinal Curvatures Using Spinous Processes

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Abstract

Objective: The purpose of this study was to assess a radiographic method for spinal curvature evaluation in children, based on spinous processes, and identify its normality limits.

Methods: The sample consisted of 90 radiographic examinations of the spines of children in the sagittal plane. Thoracic and lumbar curvatures were evaluated using angular (apex angle [AA]) and linear (sagittal arrow [SA]) measurements based on the spinous processes. The same curvatures were also evaluated using the Cobb angle (CA) method, which is considered the gold standard. For concurrent validity (AA vs CA), Pearson's product-moment correlation coefficient, root-mean-square error, Pitman- Morgan test, and Bland-Altman analysis were used. For reproducibility (AA, SA, and CA), the intraclass correlation coefficient, standard error of measurement, and minimal detectable change measurements were used.

Results: A significant correlation was found between CA and AA measurements, as was a low root-mean-square error. The mean difference between the measurements was 0° for thoracic and lumbar curvatures, and the mean standard deviations of the differences were ±5.9° and 6.9°, respectively. The intraclass correlation coefficients of AA and SA were similar to or higher than the gold standard (CA). The standard error of measurement and minimal detectable change of the AA were always lower than the CA.

Conclusion: This study determined the concurrent validity, as well as intra- and interrater reproducibility, of the radiographic measurements of kyphosis and lordosis in children. (J Manipulative Physiol Ther 2017;40:700-707)

Key Indexing Terms: *Kyphosis; Lordosis; Radiographic Image Interpretation, Computer-Assisted*

Introduction

The early detection of spinal alterations, especially in children and adolescents, is important because during those phases such alterations are unconsolidated and thus can be delayed or even reversed.[1] Traditionally, spinal alterations are quantified by means of radiographic examination.[2] However, this clinical practice exposes the individual to ionizing radiation, which increases the risk of leukemia and breast and thyroid cancer.[3] The need for early identification of spinal alterations, without exposing the individual to ionizing radiation, has encouraged the development of alternative noninvasive instruments designed to objectively measure spinal curvature.[4]

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Several of these instruments present good reliability indices. However, a recent systematic review revealed that of 28 included studies that evaluated thoracic curvature, only 11 presented results for validity, with correlation coefficients varying from 0.98 to 0.38.[4] One of the difficulties highlighted in the validation of alternative instruments lies in the anatomical structure used in the evaluation, because with alternative instruments, the measurements are based on the spinous processes, whereas radiographic methods are based on the vertebral bodies.

There are several radiographic methods for evaluating the spine in the sagittal plane using the innermost structures of the vertebrae, including the Cobb method,[5] the gold standard method, centroids,[5] tangent circles,[6] radius of curvature,[7] non-constricted Cobb technique,[8] and pelvic radius-L1 technique.[9] As far as we know, there are no studies on radiographic methods based on the spinous processes.

We believe that, although this is one more radiographic method, its recognition would facilitate the validation of noninvasive evaluation methods of the spine such as photogrammetry,[2] flexicurve,[10] and arcometer,[1] among others, because skin-surface results could be compared with angles of curvature calculated using radiographic examinations based on spinous processes.

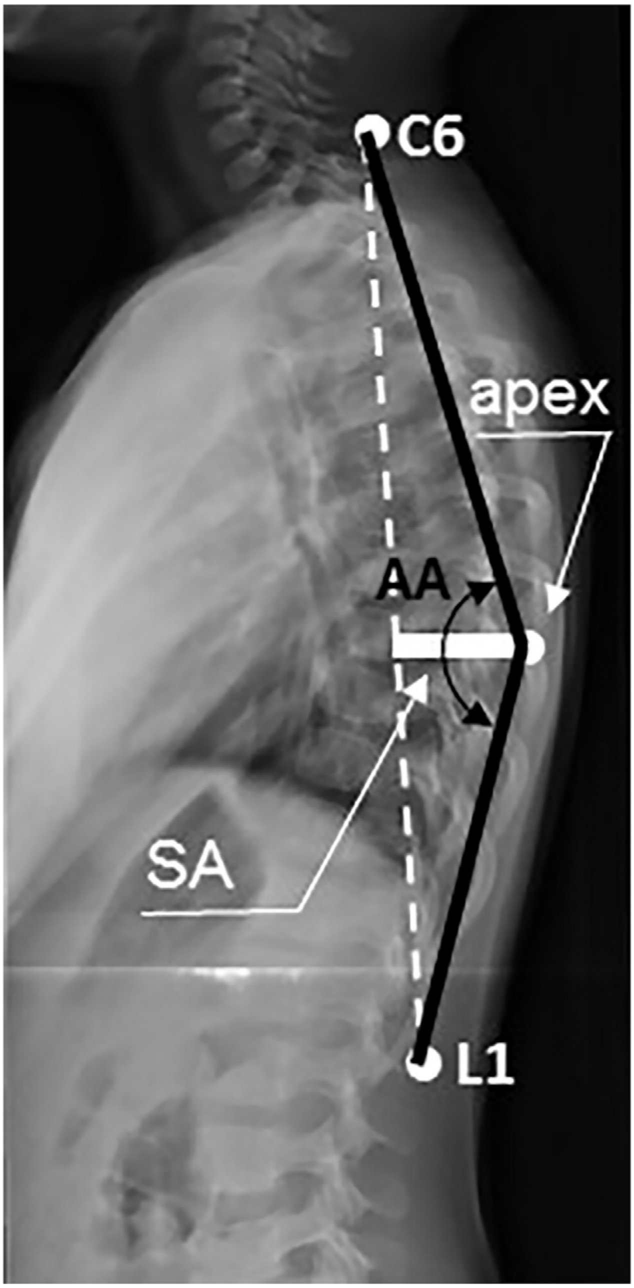

Fig 1. *Linear and angular measurements of thoracic curvature. The dotted line is a vertical straight line connecting upper (C6) and lower (L1) vertebral levels. The black lines are lines used for angular measurement: from the C6 spinous process to the apex of the curvature and from L1 to the spinous process to the aforementioned apex.* AA, *apex angle;* SA, *sagittal arrow.*

Thus, this study was aimed at (1) proposing a radiographic method for angular assessment of sagittal curvatures based on spinous processes of the vertebrae; (2) evaluating the concurrent validity as well as intra- and interrater reproducibility of the radiographic method; and (3) identifying reference values for the normality of sagittal curvatures found with this method.

Methods

Participants

Included in this study were participants of both sexes, ranging in age from 5 to 18 years, who had undergone radiographic examination in a hospital in Porto Alegre. Participants who had previous surgery or congenital deformity in spinal structures were excluded. This study was approved by the research ethics committee of University (CAAE: 31062314.5.0000.5347), and the children's guardians signed the informed consent form.

Sampling

The sample size was calculated[11,12] assuming the null hypothesis value of the intraclass correlation coefficient (ICC) to be 0.40 (eg, on the basis that any value lower than 0.40 might be considered clinically "unacceptable"), 80% of power, and a significance level of 95% to detect an ICC value of 0.60; a minimum of 87 participants needed was calculated in 2 replicated measurements (twice by the same evaluator), and a minimum of 52 participants needed was calculated in 3 replicated measurements (1 for each evaluator). Assuming the worst case (n = 87), and allowing for losses, 90 participants (48 girls and 42 boys), average age 12.1 ± 4.9 years, body mass 42.5 ± 14.5 kg, height 143 ± 15 cm, and body mass index 20.2 ± 4.0 kg/m^2, were invited to participate in the study.

Designing an Alternative Radiological Measurement

Each sagittal curvature of the spine (thoracic and lumbar) was evaluated based on linear and angular measurements. The curvature of the thoracic spine was defined using spinous processes from vertebrae C6 to L1. To obtain the linear measurement, a straight line was drawn joining the spinous processes from vertebrae C6 to L1 (Fig 1). A second line was drawn perpendicularly from the apex of the curvature to the first line. This second line was labeled the sagittal arrow (SA), and its length defined as the linear extent of the curvature (Fig 1). The angular measurement was acquired by drawing 2 lines: the first joining the spinous process from C6 to the apex of the curvature, and the second, from the spinous process from L1 to the aforementioned apex (Fig 1). The internal angle between these 2 lines was labeled the apex angle (AA) and defined as the angular extent of the curvature. This same procedure was performed for the lumbar region, the curvature of which was defined using spinous processes from vertebrae T11 to S2.

Three experts (raters 1-3 [R1-R3]) used MATLAB software Version 7.9 (The MathWorks, Natick, Massachusetts) to calculate the sagittal arrow and apex angle of radiographic examinations independently (n = 90 in the thoracic region, n = 89 in the lumbar region) by using an algorithm specifically developed for this study. The evaluation order of the radiographic examinations was randomized, and the raters