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DIAGNOSTIC METHODS: LITERATURE REVIEW

Procedures of assessment on the quantification of thoracic kyphosis and lumbar lordosis by radiography and photogrammetry: A literature review

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ABSTRACT

The quantification of thoracic kyphosis and lumbar lordosis can be assessed in different ways; among them radiography and photogrammetry. However, the assessment procedures are not consistent in the literature for either method. The objective of this study was to conduct a literature review about postural assessment through radiography and photogrammetry, for delineating the procedures for both methods. In total 38 studies were selected by an online search in the *MEDLINE* and *LILACS* databases with the keywords: radiograph and posture, postural alignment, photogrammetry or photometry or biophotogrammetry. For the radiographic method, the results showed divergences in arm positioning and in the calculation of thoracic and lumbar angles. The photogrammetry demonstrated differences in relation to the camera, tripod, plumb line and feet positioning, angle calculation, software utilization, and the use of footwear. Standardization is proposed for both methods to help establish normative values and comparisons between diagnoses.

1. Introduction

Radiography and photogrammetry are methods of postural evaluation used to assess thoracic kyphosis and lumbar lordosis angles in the sagittal plane (De Oliveira Pezzan et al., 2011; Leroux et al., 2000; Ran et al., 2014; Iunes et al., 2005). However, both methods present nonconformity in their analysis procedures that may interfere in the measures. Radiography, considered as the gold standard method of postural assessment, allows the quantification of the spine's angles from calculations performed from the vertebrae visible through the x-ray (De Carvalho et al., 2010; Vacari et al., 2013). Normally, the calculations are obtained using the Cobb method (Kado et al., 2006; Harrison et al., 2001) by the intersection of a straight line drawn from the endplate of one vertebra of reference to a straight line drawn from the endplate of another vertebrae of reference (Findikcioglu et al., 2013; Kado et al., 2006; Harrison et al., 2001). However, the vertebrae of reference seem to vary between studies, which may lead to different measures, and make comparisons and establishment of normative values difficult.

Arm positioning is another discrepancy in the radiologic assessment that may impair the assessment. Studies have described the arms forward with shoulders in different angles (Jang et al., 2007; Karaaslan et al., 2013; Ploumis et al., 2009), hanging onto a support (Boulay et al., 2006; Roussouly et al., 2005), crossed on the chest (Lee et al., 2014; Park et al., 2013) or relaxed in a free position (Mac-Thiong et al., 2004). Faro et al. (2004) showed differences up to $\overline{X} = 5°$ (DP = 9) in thoracic kyphosis in radiographies with arms flexed in front with elbows totally extended compared to elbows flexed with fists on the clavicles. As arm position may cause differences in angle measures, it is necessary to define which is more appropriate in radiography analysis, to avoid compromising the results.

Photogrammetry, on the other hand, is a reliable manner of obtaining information about an object and the environment through the measurement and interpretation of photography images, allowing quantification of the human body measurements (Tommaselli et al., 1999). However, in photogrammetry, the assessment is not only divergent regarding the vertebrae of reference as occurs in radiography, but also in the method used to assess the kyphosis and lordosis angles. For example, in the study of Iunes et al. (2005) the angles were obtained from the extension of three straight lines formed from markers attached to three vertebrae in

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relation to the plumb line. However, Saad et al. (2009) and Rodrigues et al. (2009) calculated the angles following the Cobb method. Therefore, to assess the posture through photogrammetry, some methodological issues need to be clarified, such as equipment assembly, calibration, and photograph quality.

According to Watson (1998), photographs can give a good support on the postural assessment. However, the photos must be of high quality and free from distortions, the equipment must be precisely set and remain in the same position during the assessment, and the ambient must be calibrated, appropriately illuminated, and provide privacy to the subject who is being photographed (Watson, 1998). As seen in radiography studies, discrepancies have also been noticed in photogrammetry studies. Therefore, it is necessary to identify the differences between the studies and set a suitable procedure that enables photogrammetry to be used as a good method of postural analysis.

Within this scope, both methods present divergences in their procedures that may make the analysis and diagnosis of postural deviation and the comparison between the measurements difficult. It is important to identify the divergences and establish an adequate procedure to avoid errors and measurement distortions. Indeed, no study was found analyzing radiography and photogrammetry procedures in order to standardize the procedures of these methods. Therefore, the present study aimed to perform a review of the literature regarding the studies that assessed thoracic kyphosis and lumbar lordosis measurements through radiography and photogrammetry, in order to standardize an adequate procedure for each method that reduces errors, providing more reliability to the measures.

2. Method

Studies from January 2000 to February 2015 were selected from the PubMed and Lilacs databases using the following keywords: a) radiograph and posture, b) postural alignment and c) photogrammetry or photometry or biophotogrammetry. The authors choose to select articles from 2000 in order to get recent information about how the postural evaluation have advanced in both method, once the postural assessment has been updating over the years with the equipment improvement and medical progress.

The inclusion criteria established that the studies included the analysis of the thoracic kyphosis and lumbar lordosis through radiography or photogrammetry, in the sagittal plane and standing position. The exclusion criteria were; articles related to other parts of the body than the spine; samples including patients with: a) metabolic illness, b) cancer disease, c) any kind of prosthesis; studies of dentistry, postural control, range of motion; and literature reviews, meta-analysis and case studies.

3. Results

Fig. 1 shows the flowchart of the selection of the articles. Our search in the databases resulted in 38 studies. Among them, 22 were related to radiography and 16 to photogrammetry. Tables 1 and 2 detail the procedures described in all studies found for radiography (Table 1) and photogrammetry (Table 2). All selected studies reported that the radiograph and photos were taken in a standing position and a lateral view. However, studies with breast reduction surgical interventions, participants with idiopathic scoliosis, and pregnancy found in the search were also selected. The authors decided to keep these articles because they described the procedures of assessment of the thoracic kyphosis and lumbar lordosis.

The radiography presented discrepancies in arm positioning during the x-ray exam and in reference vertebrae used for angle

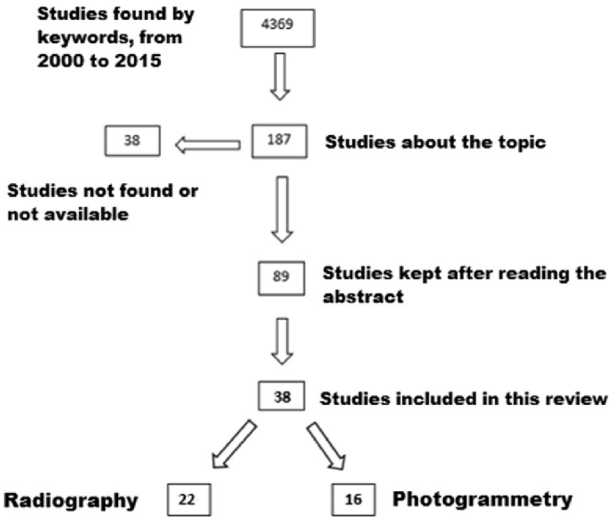

Fig. 1. Flowchart of the article selection.

calculations. Among all the studies selected, nine did not mention the arm positioning. However, different arm positions were described in 13 studies, such as hands on a support in front at different heights, arms flexed forward at different degrees, fists on clavicles or arms crossed on the chest. The vertebrae of reference varied among the studies. For the thoracic kyphosis angle calculation, the majority of studies used the T1 superior endplate and T12 inferior endplate vertebrae as references and for the lumbar lordosis, the L1 superior endplate and S1 superior endplate were most frequently used as references (see Table 1).

The photogrammetry, on the other hand, demonstrated nonconformity in; positioning the participant/patient for the photo, setting calibrations, feet positioning and footwear, equipment assembly, photo resolution, analysis software, reference vertebrae, and method used for angle calculations. Among all the photogrammetry studies selected, seven reported the use of a device between the feet, two positioned the patient on a wooden support base, and five studies used a mat to demarcate the feet positioning. The plumb line for the calibration was present in 10 studies, although it was placed in different positions.

The camera distance varied between 1.95 m and 3 m and tripod height varied from 0.63 to 1.20 m, but in two studies the tripod was set as half the patient's height. The photo resolutions were reported in five studies and varied from 1600 × 1200 pixels to 3072 × 2304 pixels. The most commonly used software was SAPO. Different vertebrae of reference and methods were used to calculate the angle. In six studies, the authors calculated the thoracic kyphosis angle by the intersection of a straight line linking the C7 spinous process to a horizontal extension of the T7 spinous process to the plumb line and a straight line linking the T12 spinous process to a horizontal extension of the T7 spinous process to the plumb line. However, in seven studies the lumbar lordosis angle was calculated by the intersection of a straight line linking the T12 spinous process to the horizontal extension of the L3 spinous process to the plumb line and a straight line linking the L5 spinous process to a horizontal extension of the L3 spinous process to the plumb line (see Table 2).

4. Discussion

The present study aimed to perform a literature review of studies that assessed the thoracic kyphosis and lumbar lordosis measurements through radiography and photogrammetry, in order to standardize an adequate procedure for each method that reduces