Comparison of Parameters Characterizing Lumbar Lordosis in Radiograph and Photogrammetric Examination of Adults

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Abstract

Objective: The purpose of this study was to test validity of photogrammetry compared with radiography as a method of measuring the Cobb angle and the size of anterior-posterior spine curvatures in adults.

Methods: The study included 50 volunteers, 23 men and 27 women whose mean age was 52.6 years. The average weight of the subjects was 81.3 kg, average body height was 172.0 cm, and the average body mass index was 27.4. Based on radiologic examination, the length and depth of lumbar lordosis were determined and the size of the Cobb angle of lumbar scoliosis. After the radiologic examination, a photogrammetric test was performed for each subject with the projection moire phenomenon.

Results: The Pearson correlation found statistically significant associations concerning the length of lordosis ($P < .001$) and the Cobb angle ($P < .001$). Correlation of the depth of lordosis indicated a strong trend ($P = .063$).

Conclusions: This study found that the moire method of photogrammetric measurement produced similar findings to radiographic measurements in determining size of the Cobb angle and the length of lumbar lordosis. (J Manipulative Physiol Ther 2015;38:225-231)

Key Indexing Terms: *Photogrammetry; Radiography; Spine; Lumbar Vertebrae*

A variety of subjective and objective measuring methods are used in evaluating parameters characterizing the shape of the spine. The individual methods, in addition to differences in their methods of imaging—using radiographs and other measurements—are different in their accuracy, repeatability, and reliability.[1,2] To date, determining the angle of curvature by means of the Cobb method on a radiograph in the anteroposterior projection has been the criterion standard, for instance, in evaluations of the occurrence and severity of scoliosis.[3-5] Many studies indicated, however, that overexposure of children to x-ray radiation in radiographic tests is harmful to their health.[6-12] According to the research of Doody et al[6], more than 17% of respondents on whom radiologic examinations were performed due to medical indications, have received a higher dose of x-ray radiation than that permissible. Researchers are therefore still looking for more accurate, repeatable, and appropriate methods of assessing the shape of the spine free from the risk of the side effects of radiation.[5,13-17] This is important when monitoring the processes concerning scoliosis progression in children. Assessment of spine anterior-posterior curvature is important for patients with lower back pain syndromes to determine any predisposition arising from the formation of the spine, which could be prevented and treated.

Knowing if photogrammetric measurement could produce similar results to radiographic findings would validate predictive measurement of the external shape of the spine. This would allow the photogrammetric method to evaluate the shape of the spine in patients with lumbar pain syndromes and in monitoring the rehabilitation process in cases of scoliosis but without the risks of radiation. Therefore, the purpose of this study was to test the validity of photogrammetry compared with radiography as a

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method of measuring the Cobb angle and the size of anterior-posterior spine curvatures in adults.

Methods

After obtaining the consent of the subjects, the study included 50 volunteers, 23 men and 27 women, aged 35 to 65 years (mean, 52.67 ± 10.66); average weight of the subjects was 81.33 kg (±13.65); average body height, 172.07 cm (±10.91). The mean body mass index (BMI) was 27.4 ± 1.7. Each of those tested had a radiograph of the lumbar spine performed as per medical indications. Patients were recruited from the Department of Orthopedics at the Medical Centre of Postgraduate Education. All patients who met the inclusion criteria gave their consent to participating in the study. The study was conducted between January and April 2013. The study design was approved by the Bioethics Committee of the Medical Faculty of the University of Rzeszów.

Inclusion criteria were indication for radiograph, age 35 to 65 years, the ability to independently maintain a standing position, and lack of comorbidities affecting the posture of the body (in the interview and orthopedic examination).

Exclusion criteria included patients who had no indications for radiographic examination, lack of ability to maintain an erect posture, age younger than 35 or older than 65 years, and other diseases influencing the parameters characterizing the posture.

Based on radiologic examination, the length and depth of lumbar lordosis were determined and the size of the Cobb angle of lumbar scoliosis, using the Carestream Health Solution System, version 11.0-pacs01. This was completed by 2 experienced researchers: a professor in orthopedics with 50 years of experience and a physiotherapist with 15 years of experience after training in measurements in radiographs. With differences in findings, arithmetic means of the results were calculated.

The examinations were performed on the same day. After the radiologic examination, a photogrammetric test was performed for each subject, with the use of the projection moire phenomenon and the application of MORA 4 Generation produced by CQ Elektronik System. This equipment combines the advantages of a system of spatial analysis MORA/ISIS and gait analysis laboratories based on markers. The moire method is based on the principle of light beam refraction between the grid screen and its generated shadow, which is projected onto the patient who is positioned behind the screen. Light interference occurs after the propagation of light waves through the raster. A contour graph, commonly referred to as a *moire pattern*, is obtained. The shape of the topographic lines depends on the shape of the projected area (usually the patient's back) and the distance between the grid screen and the patient. The height of each contour line can be determined by determining the distance between the light source, patient, and recording camera. The moire method enables the generation of a 3-dimensional image of the subject's back. The generated image can be used for the calculation and analysis of 93 postural parameters. Such a methodology is noninvasive in nature and offers a relatively efficient and accurate option for assessing body posture in 3 dimensions. In addition, the computer-aided technique allows for the storage and analysis of large volumes of recorded data.[18]

Testing Operating Procedure

Initially, specific anthropometric points were marked on the subject's back. Such points included the scapular lower angles, spinous processes, and the posterior superior iliac spines. Patient-related demographic and medical data were entered into a central database. Other data relating to the study subject were recorded, including information relating to knees and heels, thorax, history of trauma, surgery and locomotor abnormalities, and gait observed during clinical observations.

The patient was then positioned at the appropriate distance with their back toward the camera. The lights in the room were switched off. The alignment of the patient was corrected to ensure that the pelvic rotation angle was 0°. The generated digital image of the back was then recorded and saved within a designated central database. From the series of images generated, an optimal image was selected with minimal pelvic rotation and corresponded with a model patient posture.

After image selection and recording, the examiner marked the necessary anthropometric points using specially designated software. A 3-dimensional image was then created. Based on the photograms generated, it was possible to determine several dozen postural parameters. After the photogram (Fig 1), the length of lumbar lordosis was established (the length of lordosis calculated between first vertebra of the sacrum and the point of thoracolumbar junction and the depth of lumbar lordosis [depth peak of lumbar lordosis–transition point between kyphosis and lordosis]) and the size of the Cobb angle (Fig 2). Photograms and radiographs were analyzed independently by 2 experienced investigators. Photogrammetric measurements were analyzed by 2 specialists in the field with 10 years of experiences. During the analysis, they were not aware about results of radiographic examination, to avoid bias. In case of differences in the outcomes, the final result was determined by consensus. A sample radiograph image is shown in Figure 3. The comparison included the length of lumbar lordosis, the depth of lordosis, and the Cobb angle.

Statistical Analysis

The results of 3 quantitative parameters were compared, evaluated with 2 techniques. We applied the Student *t* test for dependent samples to determine whether there were systematic differences between the measurements and the