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Using EOS Imaging Technique to Provide Reference Values for Proximal, Distal, and Total Thoracic Kyphosis in the Iranian Population

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Abstract

Background & Objectives: EOS, as a new imaging technique, has several benefits over conventional radiography in measuring spinal curvatures. In this study, we aimed to use EOS to determine the normal values of thoracic kyphosis besides its association with the participants' age and gender.

Materials & Methods: In this retrospective cross-sectional study, 100 individuals with no history of spinal abnormality were included. Spinal curvatures, comprising proximal thoracic segment, distal thoracic segment, and total thoracic kyphosis, were measured on EOS images using a Cob method. The demographic characteristics of the participants, such as age and gender were also extracted from medical profiles.

Results: The study population included 31 males and 69 females with a mean age of 27.2 ± 17.4 years (range 6-66). The mean curvatures of proximal and distal thoracic segments were 14.5 ± 6.5º and 32.7 ± 7.5º, respectively. The mean total thoracic kyphosis was 47.2 ± 7.2º. Besides, distal and total thoracic kyphosis, but not proximal thoracic segment, were significantly more in participants aged over 40 years (p=0.03, p=0.04, and p=0.07, respectively). No significant association was found between the thoracic curvatures and participants' sex.

Conclusion: It seems that there is a direct relationship between distal and total thoracic kyphosis and aging; however, more studies are required in order to approve our results.

Keywords: Spinal curvature, thoracic kyphosis, EOS

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Introduction

In a normal human, the thoracic spine contains some degree of kyphosis. This kyphosis can be divided into two segments, including proximal thoracic kyphosis (from T1 to T5) and distal thoracic kyphosis (from T5 to T12). Each segment has a specific effect on the total thoracic curvature of the spine (1).

Thoracic kyphosis is affected by several physiologic conditions such as aging, and pathologic conditions such as fracture, osteoarthritis, and congenital anomalies (2).

While the angle of kyphosis is more than normal ranges, hyperkyphosis occurs, which is generally assumed as a Cobb angle

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of 50° or more in the standing position and has several detrimental effects through changing vertebral loading during daily activities (3, 4). Therefore, reliable evaluation of thoracic kyphosis has critical importance.

To date, a standing lateral spine X-ray is the gold standard for the objective assessment of kyphosis (5). However, the reliability of kyphosis measurement on lateral spine radiographs is small (6). Therefore, there are strong attempts to find a safe and reliable method for kyphosis measurement. EOS is a 3D imaging system with low-dose radiation capable of capturing full-body 3D images of patients in a natural and standing position (6). It is shown that patients with adolescent idiopathic scoliosis will receive approximately 16–34 times lesser organ dose from EOS as compared with the standard digital radiography (6). Moreover, it produces images with higher contrast and sharpness; thereby, it can provide more reliable and accurate measurement of spinal curvatures (7). For these advantages, there is a growing trend towards the implication of EOS for measuring spinal curvatures (8, 9).

Recently, several studies have investigated the implication of EOS imaging for the evaluation of thoracic kyphosis (8, 10, 11). However, according to our knowledge, no study has been performed to define the normal value of the proximal thoracic segment using EOS. Hence, in this work, we aimed to harness the EOS imaging technique for the assessment of the normal values for thoracic kyphotic parameters, such as spinal curvatures of proximal and distal segments, in the asymptomatic Iranian population. We also assessed the association of the measured angle with the participants' age and gender.

Materials & Methods

This retrospective cross-sectional study was approved by the Ethics Committee of Iran University of Medical Sciences (ethical code: IR.IUMS.FMD.REC.1398.255). Medical profiles of the individuals who underwent EOS imaging in the Shafa Orthopedic hospital between January 2019 and January 2020 were reviewed. Individuals with a history of spinal abnormality were excluded from the study. The remaining patients were included in the study (n=100).

The demographic characteristics of the participants, including age and gender, were extracted from the participants' medical records. Spinal curvatures were extracted from the EOS images and included proximal thoracic segment, distal thoracic segment, total thoracic kyphosis, and lumbar lordosis (Figure 1). The Cobb method was used to measure the proximal (sagittal angle between T1 and T5), distal (sagittal angle between T5 and T12), and total thoracic kyphosis angle (angle between T1 and T12). Lumbar lordosis was assessed through the Cobb method between the line along with the superior L1end plate and the line along with the S1 endplate.



Figure 1. Evaluation of total kyphosis and lumbar lordosis on the EOS image

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Statistical Analysis

SPSS software, version 16, was used for the statistical analysis. Descriptive statistics were provided with mean ± standard deviation or number & percentage. A comparison of mean values between different groups was made by an independent t-test or its non-parametric counterpart (Mann-Whitney U test). P values less than 0.05 were considered statistically significant.

Results

A total of 100 participants with no history of spinal abnormality were included in this study. The study population included 31 males and 69 females with a mean age of 27.2 ± 17.4 years (range 6-66). The most common age group was 10-20 years (n=44).

The mean proximal thoracic segment was 14.5 ± 6.5º. The mean distal thoracic segment was 32.7 ± 7.5º. The mean total thoracic kyphosis was 47.2 ± 7.2º. The mean lumbar lordosis was 57.6 ± 11.1º. Spinal curvatures were not significantly different between males and females (Table 1). Distal and total thoracic kyphosis was significantly more in participants aged over 40 years. Proximal thoracic kyphosis was not significantly different between the participants aged <40 years and participants aged >40 years. Lumbar lordosis was significantly smaller in participants older than 40 years of age in comparison with those younger than 40 years of age (Table 2).

Table 1. Comparison of spinal curvatures between males and females

Variable	Males (n=31)	Females (n=69)	P-value
Proximal thoracic segment (º)	14.6±6.5	14.4±6.5	0.88
Distal thoracic segment (º)	33.3±8.1	32.3±7.3	0.53
Total thoracic kyphosis (º)	48±8.5	46.8±6.6	0.44
Lumbar lordosis (º)	56.8±11.2	58±11	0.61

Data are presented as mean ± standard deviation. P-value <0.05 is considered significant

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Table 2. Comparison of spinal curvatures between males and females

Variable	Aged <40 y (n=73)	Aged >40 y (n=27)	P-value
Proximal thoracic segment (º)	14.2±6.4	14.8±6.7	0.07
Distal thoracic segment (º)	32.2±8.6	34.5±8	0.03
Total thoracic kyphosis (º)	46.1±8.3	48.8±6.9	0.04
Lumbar lordosis (º)	58.6±11	56.2±10.8	0.03

Data are presented as mean ± standard deviation. P-value <0.05 is considered significant

Discussion

Hyperkyphosis is described as abnormal thoracic spine curvature, and the Cobb method is a gold test for its diagnosis (12, 13). If this condition is not rapidly recognized and stopped, serious problems may occur, like osteoporosis. To detect this abnormal condition, we must have enough information about the normal range of these angles (14). On the other hand, EOS is a modern imaging technique based on a slot-scanning X-ray system to diminish radiation exposure in orthopedic-related images and has barely been used for the measurement of spinal curvatures (15).

Hence, in this study, we assessed the normal values of proximal, distal, and total thoracic kyphosis in an Iranian population with no history of spinal abnormality by this imaging method. Our results indicated that the evaluated variables were not associated with the participants' gender. However, distal and total thoracic kyphosis was significantly more in participants older than 40 years of age.

In another attempt, Gleb et al. determined the indices of sagittal spinal alignment on standing radiographs of 100 adults older than 40 and without a history of significant spinal abnormality (16). In this work, the mean angle of proximal and distal thoracic segments were 14 ± 8 and 34 ± 11, and unlike our findings (the mean angle of proximal and distal thoracic segments were14.8±6.7and 34.5±8, respectively). No significant association was found between the thoracic kyphosis and the age of the patients (16). This difference may be associated with the exerted inclusion criteria

for selecting subjects.In the study of Gleb et al. only adults aged >40 years were included whereas we had no age limitation. Also, Abrisham and co-workers assessed the normal range of thoracic kyphosis and lumbar lordosis angles in the Iranian population using EOS imaging method. The average angles of thoracic kyphosis and lumbar lordosis were 43.55±6.44 and 32.42±6.29, respectively, and dissimilar to our reports, the mean lumbar lordosis and thoracic kyphosis were significantly associated with sex but not with age (8). This difference could be attributed to the higher number of participants aged over 40 in the study of Abrisham et al.

In another research by Bassani et al., EOS imaging technique was used to describe the normative parameter of sagittal spine alignment in 160 asymptomatic elderly subjects (age>60, Caucasian). In the mentioned research, the mean angles of thoracic kyphosis and lumbar lordosis were 55±14º and 57±12º, and finally, they concluded that the reference values in the elderly are considerably different compared to younger adults (11). Similarly, the total mean thoracic kyphosis and lumbar lordosis was 48.8±6.9º and 56.2±10.8º in participants aged > 40 years. In the current study that was significantly different from what was observed in adults aged <40 years. It has been declared that the aging occurrence changes postural alignment in light of morphostructural alteration of the elements involved in the stability of posture (17).

The main limitations were retrospective design, lack of a control group assessed by conventional radiography, a small number of patients in some age subgroups, and inability to perform multivariate analysis. Therefore, future complementary studies are required to confirm the results of this study.

Conclusions

Our study showed that there is a direct relationship between distal and total thoracic kyphosis and aging. Also, thoracic kyphosis angle could be assessed by the EOS imaging method, allowing a lesser organ irradiation dose and sharpen images. However, more projects are needed in order to validate our results.

Data Availability Statement

All data related to this research have been included in the manuscript.

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Conflict of Interest

The authors have no conflicts of interest to declare.

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