Original Article

PREVALENCE OF OSTEOPENIA AND OSTEOPOROSIS IN ADULT SCOLIOTIC WOMEN ASSESSED WITH DUAL-ENERGY X-RAY ABSORPTIOMETRY (DXA)

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Summary

DXA is a gold-standard method for assessing bone mineral density (BMD) to diagnose osteopenia and osteoporosis. Osteoporosis and degenerative lumbar scoliosis are well-known diseases in adults, which are most often coexistent. This study aimed to assess the prevalence of osteopenia and osteoporosis in 1019 women aged ≥40 years divided into different groups according to the Cobb angle measured from DXA scan images with DICOM software. We found that the incidence of osteoporosis of the lumbar spine and total hip, as well as the incidence of osteopenia of the total hip, increased in the groups according to the Cobb angle. The group with a Cobb angle >10° showed the highest prevalence of osteoporosis. According to the Cobb angle, the incidence of osteopenia of the lumbar spine remained similar in the different groups. The results of the current study show that scoliosis has an essential impact on the interpretation of DXA scans. The BMD's false elevation, respectively, of the T-score of some vertebrae, could lead to an incorrect final diagnosis. In this case, additional assessment of the hip BMD could be useful for a more accurate interpretation of the results based on the lumbar spine BMD.

Keywords: DXA, interpretation, scoliosis, osteopenia, osteoporosis

Introduction

Osteoporosis is the most common bone disorder among women aged ≥65 years regardless of the risk factors and women under 65 with at least one risk factor [1]. Several tools are available to assess osteoporosis risks, such as OST (Osteoporosis self-assessment tool) [2], OSIRIS score (Osteoporosis index of risk) [3], and ORAI score (Osteoporosis risk assessment index) [4]. Osteoporosis and osteoporotic fractures are associated with lower health-related quality of life and increased mortality risk [5,6]. Taking measures such as early osteoporosis therapy and prevention of falls in the elderly may be the best strategy to avoid these consequences [7]. After assessing the risk of osteoporosis, it could be better decided if Dual-energy X-ray absorptiometry (DXA) should be recommended. DXA is a gold-standard method for the assessment of bone mineral density (BMD) to diagnose osteopenia and osteoporosis [8]. According to the World Health

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Organization criteria, osteoporosis is defined as BMD value corresponding to T-score less than -2.5 SDs. Patients with T-score between -1 SD and -2.5 SDs are considered as osteopenic. Osteoporosis and degenerative lumbar scoliosis are well-known diseases in adults, which are often coexistent [9,10,11,12].

Scoliosis is defined as a coronal plane spinal curvature. Several published studies have used DXA images to detect lumbar scoliosis by measuring the Cobb angle [13,14,15,16,17]. The definitions of scoliosis differed among the studies due to the Cobb angle values. Some of them defined lumbar scoliosis as Cobb angle >5° [16], Cobb angle >7° [14], and other studies defined it as Cobb angle ≥11° [17] and Cobb angle ≥10° [15]. Extensive retrospective studies have been conducted to identify the incidence of lumbar scoliosis, using Cobb angle measurements from DXA scan images [13,17] due to the strong correlation between the Cobb angle measured from DXA scan image and Cobb angle assessed from lumbar radiography [14].

This study aims to identify the prevalence of osteopenia and osteoporosis in adult scoliotic women using DXA scan images.

Materials/Patients and Methods

We assessed lumbar scoliosis from DXA images by measuring Cobb angle using DICOM software in 1019 women aged ≥40 years who underwent DXA scans in the Dr. Georgi Stranski University Hospital in Pleven. Chaklin's classification of scoliosis was used to define lumbar scoliosis. Women with Cobb angle <5° have been attributed to the group without lumbar scoliosis. The group of women with scoliosis consisted of two subgroups - with Cobb angle between 5° and 10° and with Cobb angle above 10°.

BMD values of L_1-L_4 in g/cm^2 and total T-score in standard deviations (SDs) of L_1-L_4, BMD values, and T-score values of the total hip were collected from DXA scans. The prevalence of osteopenia and osteoporosis among scoliotic and non-scoliotic women was assessed using spinal and hip T – score values.

Statistical analysis was performed using SPSS version 19. Descriptive statistics were used to calculate mean values, standard deviations, standard errors, minimum and maximum values. We used the ANOVA test to investigate the relationship between a quantitative variable and a qualitative variable with more than two expressions. Statistically significant difference was defined as p-value <0.05.

Results

The cases of lumbar scoliosis in the 1019 women studied amounted to 125 of (12.3%). The mean age was 60.84 ± 9.5 years (range 40 – 89), and most of them were 60 years old. (Figure 1).

The mean age was significantly higher in the groups with increased Cobb angle (p=0.000):

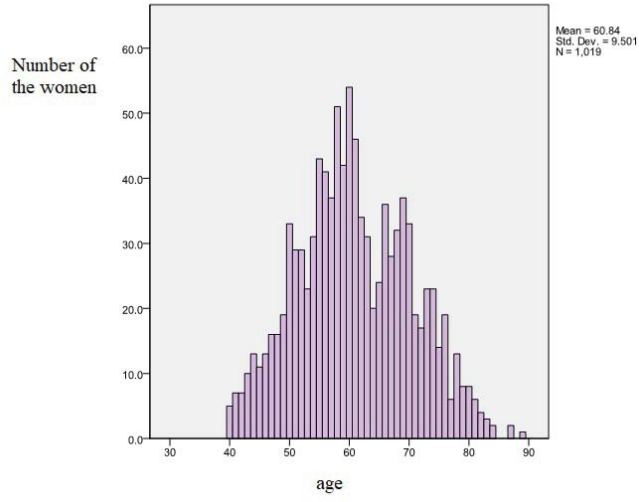

Figure 1. Distribution of the women by age

894 women in the group with a Cobb angle <5° were 60 ± 9 years of age, ranging from 40 to 87 years. Hundred and six women were in the group with Cobb angles of 5° - 10°, with a mean age of 65 ± 10 years (range 41-87). The group with Cobb angles > 10 included 19 women, aged 66 ± 10, age range 43-89 years.

We used the ANOVA test to find out if there was a significant difference between scoliotic and non-scoliotic women in the BMD values and in the T-scores of the lumbar spine and the hip. According to the Cobb angle, we compared the differences in the mean values between the three groups (Table 1).

We found a significant difference in the total T-score of L_1-L_4 (p = 0.016), as well as in the total T- score of the hip (p = 0.002) among the groups according to the Cobb angle. The women with Cobb angles >10° had a significantly lower T-score of L_1-L_4 (-2.5 SDs), and a hip T-score (-2.2 SDs), as compared to those with Cobb angles of 5°-10° (T-score of L_1- L_4 = -1.3 SDs and T-score of the hip = -1.2 SDs) and those with Cobb angles <5° (T-score of L_1-L_4 = -1.6 SDs and T-score of the total hip = -1.2 SDs). The BMD of L_1-L_4 and the total hip BMD in the women with Cobb angles >10° were also significantly lower (0.777 g/cm^2 for L_1-L_4 and 0.660/cm^2 for the total hip, respectively), as compared to the BMD values of the women with Cobb angles between 5°-10° (0.903 g/cm^2 for L_1-L_4 and 0.785 g/cm^2 for the total hip) and Cobb angles <5° (0.862 g/cm^2, respectively 0.789 g/cm^2), (p = 0.016 for L_1- L_4 and p = 0.004 for the total hip).

The patients with Cobb angles >10° showed the highest incidence of osteoporosis of the lumbar spine – 10 out of 19 women (52.6%). The incidence of osteoporosis of the lumbar spine decreased by about 20% in the group of women with Cobb angles between 5°-10° - 31 of 106 women (29.2%), and in the group with Cobb angles <5° in 287 of 889 patients (32.3%). The incidence of osteopenia was similar in all the three groups according to the Cobb angle – 341 of 889 (38.4%) in the group with Cobb angles <5 °, 31 of 106 (29.3%) in the group with Cobb angles between 5°-10°, and 7 of 19 (36.8%) in the group with Cobb angles >10°, respectively (Figure 2).

The BMD of the total hip was assessed in1009 of 1019 women. The incidence of osteopenia and osteoporosis of the total hip increased in the groups according to the Cobb angle: a Cobb angle <5° corresponded to osteopenia in 444

Table 1. ANOVA test for comparison of the total BMD and total T-score of the lumbar spine and hip between the groups according to the Cobb angle; SD-standard deviation; N-number; CI-confidential interval

ANOVA тест		(N)	mean	SD	Standard error	95% CI		P-value
						lower	upper	
BMD/T-score	Cobb angle							
Total T-score of L_1-L_4 (SD)	< 5°	894	-1.6775	1.74046	.05837	-1.7921	-1.5629	0.016
	5 - 10°	106	-1.3057	1.87966	.18257	-1.6677	-.9437	
	>10°	19	-2.4526	1.10824	.25425	-2.9868	-1.9185	
	All	1019	-1.6532	1.75174	.05501	-1.7611	-1.5452	
Total BMD of L_1-L_4 (g/cm^2)	< 5°	894	.8618	.19320	.00648	.8491	.8745	0.016
	5 - 10°	106	.9031	.20803	.02021	.8630	.9431	
	>10°	19	.7769	.12257	.02812	.7178	.8360	
	All	1019	.8645	.19437	.00610	.8526	.8765	
T-score of the total hip (SD)	< 5°	882	-1.1662	1.20358	.04053	-1.2458	-1.0867	0.002
	5 - 10°	105	-1.2248	1.23559	.12058	-1.4639	-.9856	
	>10°	16	-2.2375	.80156	.20039	-2.6646	-1.8104	
	All	1003	-1.1894	1.20826	.03815	-1.2643	-1.1146	
BMD of the total hip (g/cm^2)	< 5°	882	.7891	.15226	.00513	.7790	.7991	0.004
	5 - 10°	105	.7845	.15011	.01465	.7555	.8136	
	>10°	16	.6604	.09885	.02471	.6078	.7131	
	All	1009	.7865	.15208	.00480	.7771	.7960	

of 889 women (49.9%), and osteoporosis in 70 of 889 women (8.9%); a Cobb angle of 5°-10° corresponded to osteopenia in 55of 105 women (52.4%) and osteoporosis - 9.5% (10/105 women). A Cobb angle >10° correlated with osteopenia in 12of 16 women (75%) and with osteoporosis in 3 of 16 women (18.8%). (Figure 3).

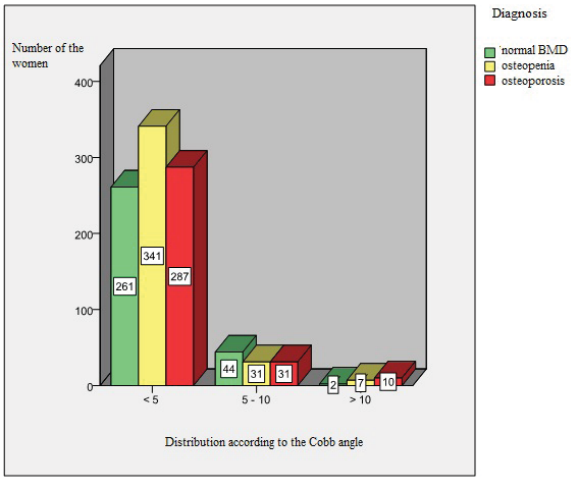

Figure 2. Distribution of the women with normal BMD, osteopenia and osteoporosis of the lumbar spine in the different groups according to the Cobb angle

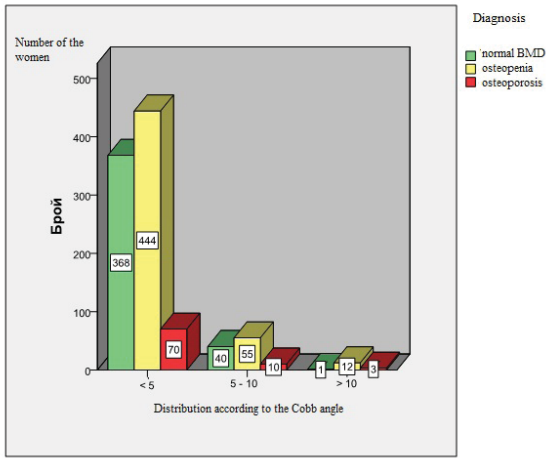

Figure 3. Distribution of the women with normal BMD, osteopenia and osteoporosis of the total hip in the different groups according to the Cobb angle

Discussion

Several published studies have shown a relationship between age and scoliosis [12,17,18]. In the retrospective study of Kebaish et al., scoliosis was defined as Cobb angle ≥11°, and its prevalence was examined in 2 973 patients aged ≥40 yrs. The authors investigated the link between the incidence of scoliosis and the following three parameters: age, race, and gender. They showed that the incidence of degenerative spinal changes increased with age. The overall prevalence of lumbar scoliosis in their study was 8.8% (263/2973 patients). Older subjects had a higher incidence of scoliosis, which was 3.14% in subjects between 40 and 50, and 50% in subjects aged ≥90 years, respectively.

In their study, Jung et al. found a statistically significant association between age and prevalence of scoliosis, with a p-value <0.001. This result was similar to the result of our study. The incidence of scoliosis increased in the groups as follows: in group 1 (age up to 49) it was 0%; in group 2 (age range 50-59) -1.8%: group 3 (age range 60-69) - 4.1%; group 4 (age ≥70 years) - 9.4%. The odds ratio was 1.11, so each one year increased the risk of lumbar scoliosis by 11%. [12]. In the study of Xu et al., the correlation between age and scoliosis was also statistically significant (p <0.001). Scoliosis incidence increased with age and reached 27.5% in patients older than 80 [18].

The association between age and scoliosis was confirmed by several other studies. A cross-sectional study carried out by Urrutia et al. demonstrated the correlation between age and degenerative lumbar scoliosis in post-menopausal females. In a retrospective study of Kebaish et al. analyzed the relationship between adult scoliosis and age, race, and gender [15,17,19]. These studies support the results of our research, which showed a significant difference between the age and the incidence of scoliosis in the groups according to the Cobb angle.

We found that the incidence of osteoporosis of the lumbar spine and total hip, as well as the incidence of osteopenia of the total hip, increased in the groups with the increase in the Cobb angle. The group with a Cobb angle >10° showed the highest prevalence of osteoporosis. The incidence of osteopenia of the lumbar spine remained similar in the groups. Previous studies have shown controversial results about the relationship between osteoporosis and lumbar scoliosis. Unfortunately, there is a difference in the published theories concerning this relation. Some authors have suggested that patients with osteoporosis are predisposed

to scoliosis [11], while others think scoliosis predisposes to osteoporosis [15]. There are also some publications, which could not show any relationship between osteoporosis and scoliosis in adults. The most common causes for lumbar scoliosis in subjects after 40 years are spondyloarthrosis, pathological fractures, and *congenital* spinal *anomalies*. Regarding the effect of scoliosis on the BMD of the lumbar spine, it has been established that degenerative lumbar scoliosis could lead to false elevated BMD values [20]. It is most often associated with degeneration and osteophyte formation, subchondral sclerosis, spinal rotations, and aortic calcification. On the one hand, degenerative lumbar scoliosis has been associated with increased spinal BMD values from DXA scans [21]. On the other hand, idiopathic adolescent scoliosis (IAS) in adults was mostly linked to lower spinal BMD values. Degenerative spine conditions are usually age-related and involve loss of normal structure and function of the spine. They have been characterized by disc space narrowing (DSN) and the presence of vertebral osteophytes. Most of the studies that examined the association between osteophytes and bone mass and DSN and bone mass at the spine suggested that they were linked to an increased bone mass. It has also been assumed that osteoarthritis of the spine, through disc space narrowing, has a protective effect against bone loss, mediated by a lower rate of bone resorption [21,22,23]. The causes of osteoporosis or osteopenia in patients with IAS remain unknown. It has been proposed that poor bone quality and low calcium intake in patients with IAS may be contributing factors. Low bone mass in patients with IAS may also result from abnormal bone mineralization and abnormal bone turnover rate during pubertal growth [24].

Osteoporosis is a major consideration in the management of adult degenerative scoliosis. Degenerative curves become progressive as a result of the asymmetric load on weakened vertebrae, which become progressively more wedged and deformed. With the progression of the deformity, the patient may become more symptomatic [10,25].

Despite the complex impact of scoliosis on the lumbar spine BMD values and, therefore, on the final DXA results, we found that women with scoliosis showed a higher incidence of osteoporosis than those without scoliosis. Falsely elevated spinal BMD values may have had an effect in the group with osteopenia in our study. This effect could be attributed to the absence of a statistical difference in the incidence of osteopenia of the lumbar spine between scoliotic and non-scoliotic women. Regardless of the authors' different conclusions in previous studies concerning the relation between scoliosis and osteoporosis, these two conditions were found to be most often coexistent and age-dependent. This fact could explain the absence of a strong correlation between the lumbar spine T-score and Cobb angle.

Conclusions

Based on the results of the current study, we can draw the following conclusions:

1. The incidence of osteoporosis of the lumbar spine increased in the groups with the increase of the Cobb angle.
2. Women with Cobb angles >10° showed the highest prevalence of osteoporosis.
3. The larger the Cobb angle was, the more frequent osteopenia of the total hip was.
4. The incidence of osteopenia of the lumbar spine remained similar in the groups corresponded to the Cobb angle.
5. Scoliosis has an important impact on the interpretation of DXA scans, so falsely elevation of the BMD, respectively, of the T-score of some vertebrae could lead to an incorrect final diagnosis.
6. Additional assessment of the hip BMD could be useful for a more accurate interpretation of the results based on the lumbar spine BMD.

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