



Original Article

Determining the correlation between Cobb angle severity and bone mineral density in women with adolescent idiopathic scoliosis



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الملخص

أهداف البحث: دراسة العلاقة بين مقدار معامل زاوية "كوب" ومختلف كثافات العظم لدى المرضى الإناث المصابات بجنف العمود الفقري لدى اليافعات في السعودية، وقياس مدى كثافة العظام في مختلف مناطق أجسامهن.

طرق البحث: استخدم البحث نموذج دراسة مقطعية كمية بعدد مناسب من المشاركات. شملت العينة المدخلة ٥٤ مريضة بجنف العمود الفقري لدى اليافعات تراوحت أعمارهن بين ١٠-٢٠ عامًا. تم تسجيل معامل زاوية كوب ودرجات "زد" في مقياس امتصاص الأشعة السينية ثنائي البواعث لكل من عظمة الفخذ وعظمة الفقرة القطنية، وتم جمعها بين الأعوام ٢٠٠٨-٢٠١٨.

النتائج: من بين ٥٤ مريضة، ٤١ منهن كان معامل زاوية كوب لديهن يتراوح بين ٤٠°-٧٠°، و١٣ بمعامل زاوية كوب < ٧٠°. متوسط كثافة العظام في الفقرات القطنية وعظمة الفخذ الأيمن والأيسر كان أعلى مقارنة بالمرضى اللاتي يكون حساب معامل زاوية كوب لديهن > ٧٠° مقارنة بالمرضى اللاتي معامل زاوية كوب < ٧٠°. من مجموعة المرضى اللاتي كانت زاوية كوب لديهن ≥ ٧٠° ستة (١٤.٦٪) وتسعة (٢٢٪) مرضى كن يعانين من نقص في كثافة عظام الفقرات القطنية وعظام الفخذ على التوالي. ومن المجموعة الثانية اللاتي معامل زاوية كوب < ٧٠° ثمانية (١١.١٪) وتسعة (٢٩.٢٪) مرضى كن يعانين من نقص في كثافة عظام الفقرات القطنية وعظام الفخذ على التوالي.

الاستنتاجات: مرضى جنف العمود الفقري اليافعات اللاتي يكون حساب معامل زاوية كوب لديهن عال تزيد نسبة إصابتهن بانخفاض مستوى الكثافة في العظام.

الكلمات المفتاحية: اليافعات؛ كثافة العظام؛ امتصاص الأشعة السينية ثنائي البواعث؛ جنف؛ عمود فقري

Abstract

Objectives: To determine the correlation between Cobb angle severity and varying bone mineral density (BMD) and measure the prevalence of low BMD in women with adolescent idiopathic scoliosis (AIS) in KSA.

Methods: The sample included 54 women with AIS between 10 and 20 years of age. Data regarding Cobb angles and femoral and lumbar Z-scores according to dual-energy X-ray absorptiometry (DXA) scans performed between 2008 and 2018 were reviewed.

Results: Of the 54 patients recruited, 41 exhibited Cobb angles of 40–70° and 13 had Cobb angles >70°. The mean lumbar bone, right femur, and left femur BMDs were markedly higher in those with Cobb angles ≤70° compared with BMDs in those with Cobb angles >70°. Of the group with Cobb angles ≤70°, six (14.6%) and nine (22.0%) exhibited low BMD according to their lumbar and femoral Z-scores, respectively. Of the group with Cobb angles >70°, eight (61.5%) and nine (69.2%) exhibited low BMD according to their lumbar and femoral Z-scores, respectively.

Conclusions: Female AIS patients with greater higher Cobb angles exhibited a significantly higher frequency of low BMDs.

Keywords: Adolescent; Bone mineral density; DXA scan; Scoliosis; Spine

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Introduction

Scoliosis is a type of spinal deformity defined as abnormal lateral curvature of the spine $> 10^\circ$ in individuals < 10 or $> 20^\circ$ in those > 10 years of age. The underlying pathophysiology of abnormal spine curvature includes congenital, neuromuscular, syndromic, idiopathic, and secondary causes, although most cases observed clinically fall under the idiopathic classification.¹

Adolescent idiopathic scoliosis (AIS) is a debilitating disease that affects the young population (Age range is from 10-20), with an estimated prevalence of 2%–3% among children worldwide.² The disease is common in KSA, with a prevalence of 2.5% among girls in the capital city of Riyadh.³ Disease severity is measured according to radiographic assessment(s) of spinal curve progression via the Cobb angle, the result of which often determines the treatment and management plan patients receive.

A prospective cohort study published in 2016 selected 513 newly diagnosed girls with AIS, of whom 32.9% were osteopenic. These patients experienced higher curve progression rates (Cobb angle up to 45°) (odds ratio 2.3) than those with normal bone mineral density (BMD), suggesting that low BMD was a significant prognostic factor for curve progression.⁴

The present study aimed to assess the correlation between BMD and Cobb angle(s) in a representative sample of young females with AIS in the Saudi population and to estimate the prevalence of low BMD.

Although the exact pathophysiology of AIS remains unclear, a correlation between AIS and low BMD has been established.⁵ However, to our knowledge, there have been no published studies that have explored the correlation between increasing Cobb angle and low BMD in patients with Cobb angles $\geq 40^\circ$. A study in 2019 used acid-etched scanning electron microscopy (SEM) at $1000\times$ magnification to visualise osteocytes in both AIS patients and controls. Microscopy results revealed that osteocytes in AIS patients were less uniform, with more variable shapes in transition from spindle-shape to more rounded appearances. This was in contrast to the more consistently spindle-shape osteocytes apparent in the controls. Moreover, SEM at $2000\times$ magnification revealed that osteocyte lacunae samples from AIS patients exhibited less connectivity with fewer canaliculi and were shorter in length. The same study compared serum bone markers between patients with Cobb angles $\geq 45^\circ$ and those with Cobb angles $< 45^\circ$ and found that the group with greater Cobb angles had 16% lower osteocalcin and 12% lower sclerostin levels.⁶

Materials and Methods

Study design

This quantitative cross-sectional study sampled individuals from a database of surgical AIS patients attending a paediatric orthopaedic clinic. Ultimately, 54 patients were included in the present study. Because all patients were considered to be surgical AIS cases, all exhibited Cobb angles $\geq 40^\circ$.

Study subjects and sampling method

Convenience sampling using E-SiHi Electronic Medical Record software was used to identify 186 patients with scoliosis, of whom males, those with pre-existing relative comorbidities predisposing to developing spinal deformity (e.g., metabolic disorders, history of spinal column surgery), and those > 20 or < 10 years of age were excluded.

Classification

To analyse patient BMD measurements and their correlation with Cobb angle, the sample was divided into two groups based on Cobb angle severity, as previously observed clinically according to respiratory complications, as follows: moderate ($40\text{--}70^\circ$); and severe ($> 70^\circ$).^{7,8} This was followed by measuring BMD using dual dual-energy X-ray absorptiometry (DXA) scans of the femoral neck and lumbar spine. According to DXA results, BMD was then classified as normal (Z-score > -2.0) and low (Z-score ≤ -2.0).

Procedures

Data from DXA scans, performed between 2008 and 2018, were collected and retrospectively reviewed. Centricity Radiological Information Software was used to exclude cases of congenital scoliosis, to calculate Cobb angles on radiographs, and to record preoperative DXA scan results.

Statistical analysis

Statistical analysis was performed using SPSS version 21.0 (IBM Corporation, Armonk, NY, USA) for Windows (Microsoft Corporation, Redmond, WA, USA). The chi-square test was used to compare data. Differences with $P < 0.05$ were considered to be statistically significant.

Results

The mean (\pm standard deviation) lumbar bone, right femur, and left femur Z scores for BMD in patients with Cobb angles $\leq 70^\circ$ were ($Z = -1.0 \pm 0.9$), ($Z = -1.1 \pm 0.9$) and ($Z = -1.0 \pm 1.0$), respectively. These results were markedly higher in the lumbar bone, right femur, and left femur BMD Z scores of patients with Cobb angles $> 70^\circ$ ($Z = -2.0 \pm 1.3$), ($Z = -2.2 \pm 1.3$), and ($Z = -2.2 \pm 1.1$), respectively. It can

Table 1: Demographics and Total Sample Mean Bone Mineral Density Measurements.

Age	13.1 ± 2.0
Total sample mean Cobb angle	61.4 ± 17.9
Cobb angle 40°–70°	53.0 ± 8.5
Cobb angle >70°	87.4 ± 15.0
Lumbar bone mineral density	–1.2 ± 1.1
Cobb angle 40°–70°	–1.0 ± 0.9
Cobb angle >70°	–2.0 ± 1.3
Right femur bone mineral density	–1.4 ± 1.0
Cobb angle 40°–70°	–1.1 ± 0.9
Cobb angle >70°	–2.2 ± 1.3
Left femur bone mineral density	–1.3 ± 1.1
Cobb angle 40°–70°	–1.0 ± 1.0
Cobb angle >70°	–2.2 ± 1.1

Table 2: Correlations Between Cobb Angle and Bone Mineral Density.

	Cobb angle 40–70° (n = 41)	Cobb angle >70° (n = 13)	Total (N = 54)	P value
Lumbar bone mineral density				
A. Normal*	35 (85.4%)	5 (38.5%)	40 (74.1%)	0.001
B. Low**	6 (14.6%)	8 (61.5%)	14 (25.9%)	
Femur bone mineral density				
A. Normal*	32 (78.0%)	4 (30.8%)	36 (66.7%)	0.002
B. Low**	9 (22.0%)	9 (69.2%)	18 (33.3%)	

* Normal: (Z-score > –2.0).

** Low: (Z-score ≤ –2.0).

be concluded that mean BMD at the three measurement sites was normal in patients with Cobb angles ≤70° and low in those with Cobb angles >70° (Table 1).

According to lumbar DXA results, 14 patients (of the entire sample [25.9%]) exhibited low BMD. Of the 13 patients with Cobb angles >70°, eight (61.5%) had low BMD; in comparison, six (14.6%) in the group with Cobb angles ≤70° exhibited low BMD (P = 0.001) (Table 2).

Similarly, one-third of all patients (n = 18; nine patients from either group) exhibited low BMD according to their femoral DXA results. This corresponds to 69.2% of patients with Cobb angles >70° having low BMD, and 22.0% of those with Cobb angles ≤70° with low BMD (P = 0.002) (Table 2).

Discussion

Results of the present study demonstrated a correlation between increasing Cobb angle and progressively lower BMD. These findings are consistent with those reported in a meta-analysis of three studies with a combined sample of 686 AIS patients.⁹ The study concluded that 51.1% of the patients were found to be osteopenic, which was comparable to the results of the present study. In contrast to the aforementioned study, however, the results of the

present study revealed a higher proportion of patients with low BMD (62.9% and 74.1% for lumbar and femoral BMD, respectively), possibly because the cohort only included AIS patients with Cobb angles ≥40°.

It is currently unknown whether low BMD in AIS patients is caused by physiological or genetic phenomena. Notwithstanding, a sex-linked predisposition is highly suggested because the female-to-male ratio of AIS patients has been reported to be approximately 3:1.¹⁰ Another study found no difference in BMD between AIS patients treated with a brace (n = 17) versus those without a brace (n = 29), suggesting that the treatment did not correct low BMD status.¹¹

The lumbar results for both groups were affected by vertebral rotation, which results in a lower BMD score if this rotation is not accounted for. The differences in BMD scores due to vertebral rotation can amount to a decrease of up to 1.1% in BMD results in an L3 vertebra rotated 7.5°, and a 19.0% decrease in an L3 vertebra rotated 45°.¹²

It would have been ideal to compare the BMD results from this study sample with a mirrored sample from another investigation; however, a suitable reference study that measured BMD within a similar age group using the same techniques could not be found. Nevertheless, the prevalence of low BMD among the normal Saudi female population aged 20–36 years has been reported to be approximately 9.0%.¹³

A Saudi-Arabian study sampled patients with AIS and siblings without the disease as controls and compared BMD results. The sample consisted of 32 female patients with AIS 14–26 years of age. DXA scans of their proximal left femurs revealed that 62.5% of the patients in the AIS group were osteoporotic and 28.1% were osteopenic, corresponding to a total of 90.6% of AIS-affected patients exhibiting a low BMD. Additionally, 65.5% of the patients with low BMD and AIS had Cobb angles ≥35°, while among the control group of 27 non-AIS female siblings of these patients, none had osteoporosis, and only three (11.1%) had osteopenia.¹⁴ These data suggest a strong correlation between low BMD and moderate to severe scoliosis in AIS patients.

To obtain more accurate lumbar DXA results, the BMD measurements should have been corrected by measuring vertebral rotation via calibrated computed tomography scans. This contrasts with femoral DXA scan measurements, in which correction for vertebral rotation is not necessary. As such, femoral DXA results are not subject to that limitation and are considered to be more accurate than the lumbar DXA results.

To fully appreciate the relationship between low BMD and AIS, and to determine whether low BMD is an independent factor, a cohort study would have been the superior design to use for the present investigation. However, it would have been unethical to withhold surgical intervention from patients who have developed severe Cobb angles simply for research purposes.

Conclusion

AIS patients with higher Cobb angles exhibited a statistically significant higher frequency of low BMD. The prevalence of low BMD in all patients included in the sample was

comparable with that of other studies that used the same testing methodology for the same parameters.

Recommendations

Expanding the study to include a larger sample would more accurately identify characteristic demographics and improve the quality of the results yielded in data analysis. Future studies may also aim to investigate the pathophysiology of the development of AIS to gain a deeper understanding of the disease process, answering questions, such as which of the two—low BMD or AIS—may predispose one to the other.

A relevant premise for a long-term cohort study would be to assess BMD in patients undergoing spinal fusion and compare their results with those from the general population to explore the possibility of an increased risk for low BMD-related consequences in patients with a history of AIS.

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Conflict of interest

The authors have no conflict of interest to declare.

Ethics approval

The study was approved by the Institutional Review Board at King Saudi University, with reference E-19-3867, dated 29th April 2019.

Authors contributions

FAM, AMA, and AMS conceived and designed the study, conducted research, provided research materials, and collected and organised the data. FAM and AMA analysed and interpreted the data. FAM, AMA, and AKA wrote the initial and final drafts of the article and provided logistic support. All authors have critically reviewed and approved the final draft, and are responsible for the content and similarity index of the manuscript.

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