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DOES THE USE OF BRACE TREATMENT HAVE AN EFFECT ON BONE MINERAL DENSITY IN ADOLESCENT IDIOPATHIC SCOLIOSIS (AIS) PATIENTS?

KORSE KULLANIMININ ADÖLESAN İDİOPATİK SKOLYOZLU (AIS) HASTALARDA KEMİK MİNERAL YOĞUNLUĞU ÜZERİNE ETKİSİ VARMI?

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SUMMARY

Purpose: The objective of this study is to investigate the relationship between Cobb angle and bone density, as well as the effect of brace treatment, on bone mineral density (BMD) in adolescent idiopathic scoliosis (AIS) patients.

Method: Bone density in the lumbar spines of AIS patients was measured using the DEXA method. Patients aged from 8 to 18 with a Cobb angle of >10° were included in the study. The relationships between the Cobb angle and age, gender, height and weight, BMI, BMD, and Z-score were determined. Patients who had used a brace and those who had not were evaluated.

Results: Significant correlations were observed when the BMD values of the entire lumbar region were compared to BMI, age, and weight. There was no correlation between the Cobb angle degrees and these parameters. When the Z-scores were compared with the Cobb angles, no correlation was observed in the values obtained from the spinal axis except for those obtained from the proximal thoracic and lumbar/thoracolumbar regions. There was no significant difference between the two genders. A meaningful difference was found in terms of age and BMD between the group of 15 patients that had used a brace and the group who did not, but no meaningful differences related to BMI, height, weight, Z-score, or Cobb angle were obtained.

Conclusion: No apparent relationship was detected between BMD and Cobb angle. Bracing reduced bone density significantly in AIS patients. We are of the opinion that more comprehensive studies are needed on the bone mineral metabolisms of patients with AIS.

Keywords: Adolescent idiopathic scoliosis; bone mineral density; brace; Cobb angle.

Level of evidence: Retrospective clinical study, Level III

ÖZET

Amaç: AİS'lu hastalarda korse kullanımının kemik mineral yoğunluğu üzerine etkisi ve Cobb açısı ile ilişkisi araştırıldı. Materyal ve Metot: AİS'lu hastaların lomber omurgasında kemik yoğunluğu DEXA metodu kullanılarak ölçüldü. Cobb açısı >10° olan 8 yaşından 18 yaşına kadar hastalar çalışmaya dahil edildi. Cobb açısı ile yaş, cinsiyet, boy, ağırlık, kemik mineral indeksi (BMI), kemik mineral yoğunluğu (BMD) ve Z-skoru arasındaki ilişki araştırıldı. Korse kullananlar ile kullanmayanlar karşılaştırıldı.

Sonuçlar: Lomber bölgenin BMD değerleri ile BMI, yaş ve ağırlık arasında anlamlı korelasyon gözlendi. Ancak Cobb açısı derecesi ile bu parametreler arasında herhangi bir korelasyon görülmedi. Z-skoru ile Cobb açısı karşılaştırıldığında proksimal torasik ve lomber/torakolomber bölgeler hariç herhangi bir korelasyon gözlenmedi. Her iki cinsiyet arasında anlamlı fark yoktu. Breys kullanan 15 hasta ile kullanmayanlar arasında yaş ve BMD değerleri açısından anlamlı bir farklılık bulundu, ancak BMI, boy, ağırlık, Z-skoru ve Cobb açısı arasında fark bulunmadı.

Tartışma: BMD ve Cobb açısı arasında açık bir ilişki saptanmadı. Buna karşılık AİS da breys kullanımının Kemik yoğunluğunu anlamlı olarak azalttığı görüldü. Sonuçlarımıza göre AİS'lu hastaların kemik mineral metabolizması üzerine breys kullanımının etkisi ile ilgili daha kapsamlı çalışmalara ihtiyaç vardır.

Anahtar Kelimeler: Adölesan idiopatik skolyoz; kemik mineral yoğunluğu; korse; Cobb açısı.

Kanıt Düzeyi: Retrospektif klinik çalışma, Düzey III

INTRODUCTION:

Adolescent idiopathic scoliosis (AIS) is one of the most common spinal deformities, predominantly seen in females. Previous studies have shown that there is a significant relationship between osteopenia and AIS (4-7). Burner et al.[4] were the first investigators to report AIS patients who suffered from lower bone mass, and Cheng et al. (5-6) showed generalized osteopenia in both axial and peripheral skeletons of AIS girls. A lower bone mineral mass is always associated with lower bone strength. The weakening of the spinal architecture by osteopenia might exacerbate spinal deformity. However, based on histomorphometric studies, no correlation has been found between the severity of the lateral curve and bone density[8]. Some authors have proposed that poor bone quality can be regarded as a unique prognostic factor in curve progression[14].

Brace treatment for scoliosis is used to prevent spinal curve progression. Bracing has been widely accepted as a standard non-surgical treatment for AIS patients with a mild or moderate curve; however, it has always been blamed for causing permanent loss of bone mineral mass and a predisposition to adult osteoporosis. Furthermore, in a study conducted by Snyder et al.[23], dual-energy X-ray absorptiometry (DEXA) showed a significant increase in spinal bone mineral density (BMD) over one year of brace wear. BMD correlated with measures of growth and pubertal status, but not average daily brace wear or severity of scoliosis. In their study, the annual rate of change of volumetric bone density was found to have increased only slightly during the study period. They postulated that this fact suggested that most of the change occurred in BMD with time-related growth in the dimension of the spine. They proposed that brace treatment does not inhibit bone density accumulation in patients with AIS. Szalay et al.[24] also concluded that adolescents with idiopathic scoliosis are not osteoporotic. In their study, 49 AIS patients were compared with 40 normal controls using DEXA. They suggested that the primary etiology of relative osteopenia in scoliosis was related to a tendency towards low BMD. In low BMI individuals, scoliosis contributes to the individual having a low bone density for age, whereas in an overweight person, the scoliosis produces asmall decrease in BMD that is clinically insignificant.

The objective of our study is to determine the relationship between Cobb angles and bone density in AIS patients, and to shed light on the disputes over osteoporosis in AIS patients, and the effects of brace use.

MATERIALS AND METHODS:

In our study, we measured the bone density in the lumbar spine of patients with AIS using the DEXA method. In patients with scoliosis, by means of the Cobb method, the scoliotic curve was measured. Patients with a curve of >10° between 8 and 18 years of age were included in our study, while those with a curve due to congenital, neuromuscular, syndromic and other known reasons were excluded (Table-1).

Table-1. The mean age of patients according to gender.

	N	Age (months) Mean ± SD
Male	16	190.19 ± 36.45
Female	124	169.78 ± 28.77
Total	**140**	**172.11 ± 30.3**

We evaluated the relationship between age, gender, weight, height, BMI, BMD, Z-score and Cobb angle, as well as the BMD values, between patients using a brace and those who were not. All analyses were performed using NCSS (NCSS 2007, Kaysville, UT). Moreover, statistical analyses utilized the independent T square (Pearson Q square) and Mann-Whitney U test (Table-2).

Table-2. The mean age, BMI, height, and weight of patients.

	Mean ± SD
Age (months)	172.11 ± 30.3
BMI (kg/m²)	19.03 ± 3.27
Height (BH1) (cm)	159.81 ± 10.19
Weight (BW1) (kg)	**49.43 ± 10.75**

RESULTS:

From 2000–2011, 140 patients (124 females, 16 males) with a curve of >10° were evaluated. The mean age and standard deviation of the patients were found to be 172.11 ± 30.3 months, and their BMI was 19.03 ± 3.27 kg/m2, height was 159.81 ± 10.19 cm, and weight was 49.43 ± 10.75 kg. The total value of BMD in the lumbar region was found to be 0.83 ± 0.17 and the Z-score was –0.28 ± 1.23 (Table-3).

Table-3. The distribution of BMD and Z-score values in lumbar vertebrae of the patients.

	BMD (Mean ± SD)	Z-Score (Mean ± SD)
L1	0.81 ± 0.18	-0.85 ± 1.16
L2	0.87 ± 0.18	-0.19 ± 1.26
L3	0.9 ± 0.18	0.07 ± 1.35
L4	0.85 ± 0.16	-0.3 ± 1.4
Total	**0.83 ± 0.17**	**-0.28 ± 1.23**

The Cobb angle was 22.58° ± 12.04° in the proximal thoracic, 31.99° ± 17.82° in the main thoracic and 29.91° ± 12.1° in the lumbar/thoracolumbar area (Table-4).

Table-4. The distribution of the Cobb angles according to proximal, main thoracic and lumbar vertebrae.

Cobb Angle	Mean ± SD
Proximal Thoracic	22.58 ± 12.04
Main Thoracic	31.99 ± 17.82
Lumbar/Thoracolumbar	29.91 ± 12.1

A significantly important positive correlation was observed between the BMD values, all lumbar vertebrae and the age, BMI, height, and weight (Table-5). However, no difference was observed with the Cobb angles (Table-6).

Table-5. The comparison of BMD and Z-scores values with age, BMI, height and weight in all patients.

			Age (months)	BMI kg/ m2)	Height (cm)	Weight (kg)
BMD	**L1**	**r**	**0.396**	**0.273**	**0.389**	**0.433**
		p	**0.0001**	**0.002**	**0.0001**	**0.0001**
	L2	**r**	**0.48**	**0.353**	**0.447**	**0.524**
		p	**0.0001**	**0.0001**	**0.0001**	**0.0001**
	L3	**r**	**0.487**	**0.35**	**0.464**	**0.53**
		p	**0.0001**	**0.0001**	**0.0001**	**0.0001**
	L4	**r**	**0.521**	**0.393**	**0.504**	**0.572**
		p	**0.0001**	**0.0001**	**0.0001**	**0.0001**
	Total	**r**	**0.459**	**0.288**	**0.374**	**0.418**
		p	**0.0001**	**0.002**	**0.0001**	**0.0001**
Z-Score	**L1**	r	**-0.287**	0.063	-0.128	-0.038
		p	**0.002**	0.504	0.168	0.688
	L2	r	**-0.254**	0.124	-0.133	-0.002
		p	**0.006**	0.193	0.157	0.986
	L3	r	**-0.282**	0.071	-0.141	-0.052
		p	**0.002**	0.454	0.132	0.583
	L4	r	**-0.261**	0.111	-0.129	-0.016
		p	**0.004**	0.239	0.165	0.862
	Total	r	**-0.321**	0.091	-0.174	-0.054
		p	**0.0001**	0.335	0.062	0.569

Table-6. Comparison of BMD and Z-scores with Cobb angles.

			Proximal Thoracic	Main Thoracic	Lumbar / Thoracolumbar
BMD	**L1**	**r**	-0.119	0.009	0.02
		p	0.385	0.921	0.834
	L2	**r**	-0.157	0.022	0.082
		p	0.254	0.804	0.388
	L3	**r**	-0.223	-0.025	0.151
		p	0.102	0.780	0.109
	L4	**r**	-0.159	0.012	**0.197**
		p	0.246	0.894	**0.037**
	Total	**r**	-0.169	0.041	0.029
		p	0.240	0.680	0.781
Z-score	**L1**	**r**	-0.219	-0.096	0.108
		p	0.131	0.326	0.293
	L2	**r**	**-0.296**	-0.056	0.153
		p	**0.041**	0.572	0.143
	L3	**r**	-0.327	-0.087	**0.224**
		p	0.022	0.378	**0.029**
	L4	**r**	-0.221	0.01	**0.261**
		p	0.127	0.915	**0.01**
	Total	**r**	**-0.307**	-0.073	0.187
		p	**0.032**	0.463	0.07

A significantly important negative correlation was observed between the Z-scores of the lumbar vertebrae and age, whereas there were no observed differences between the BMI, height, and weight (Table-5). A positive correlation was observed in the lumbar/thoracolumbar region, while there was a negative correlation at the L2–3 region in the proximal thoracic between the Z-scores. We also found a negative correlation between the Z-scores and the proximal Cobb angle (Table-6). No significantly important differences were found between the two genders (Table-7).

Table-7. Comparison of BMD, Z-score, and Cobb angles with both genders (p>0.05)

		Male	Female	p
BMD	**L1**	0.84±0.19	0.8±0.18	0.319
	L2	0.88±0.19	0.87±0.18	0.564
	L3	0.89±0.19	0.9±0.18	0.781
	L4	0.83±0.17	0.86±0.16	0.527
	Total	0.86±0.18	0.82±0.17	0.912
Z-score	**L1**	-0.96±1.47	-0.83±1.11	0.631
	L2	-0.29±1.64	-0.17±1.21	0.911
	L3	-0.28±1.53	0.12±1.31	0.444
	L4	-0.82±1.57	-0.22±1.36	0.119
	Total	-0.58±1.48	-0.23±1.19	0.412
Cobb Angle	**Proximal Thoracic**	22.6±16.33	22.58±11.74	0.849
	Main Thoracic	27±16.67	32.67±17.93	0.210
	Lumbar/Thoracolumbar	25.2±9.41	30.63±12.34	0.143

There was a significant difference between the BMD and age values of the patients who had used a brace and those who had not. However, no difference was found between the BMI, height, weight, Z-scores, or Cobb angle (Table-8).

Table-8. Comparison of those who had used a brace and those who had not

		AIS	AIS + Brace	p
Age (months)		174.54±29.08	151.87±33.75	**0.011**
BMI (kg/m²)		19.18±3.15	17.65±4.03	0.375
Body Height (cm)		160.34±10.33	155.07±7.59	0.055
Body Weight (kg)		50.01±10.55	44.29±11.6	0.211
BMD	L1	0.82±0.18	0.72±0.17	**0.046**
	L2	0.89±0.17	0.78±0.18	**0.029**
	L3	0.91±0.17	0.8±0.18	**0.029**
	L4	0.86±0.15	0.76±0.17	**0.032**
	Total	0.87±0.16	0.76±0.17	**0.027**
Z-score	L1	-0.78±1.15	-1.43±1.1	0.058
	L2	-0.11±1.24	-0.86±1.27	0.077
	L3	0.16±1.31	-0.66±1.46	0.068
	L4	-0.22±1.36	-0.99±1.59	0.108
	Total	-0.19±1.2	-0.94±1.36	0.078
Cobb Angle	**Proximal Thoracic**	22.61±12.78	22.45±8.94	0.628
	Main Thoracic	31.25±17.92	37.4±16.64	0.144
	Lumbar/Thoracolumbar	29.18±11.89	35.07±12.73	0.111

DISCUSSION:

The relationship between idiopathic scoliosis and osteopenia was first defined by Burner et al. in 1982. In AIS, low bone density and osteopenia were shown in both the axial and peripheral skeleton[10,21]. Abnormal histomorphometric bone cell activity was found on biopsy of AIS[1]. In addition, they found that when the bone density of AIS patients was low in adolescence, it was also low in adulthood[15]. A decrease in bone density in adolescents with idiopathic scoliosis may increase the risk of osteoporosis and related complications[1,2,10,15,26]. However, the underlying mechanisms and the

reasons leading to a decrease in bone density in AIS have not yet been clearly defined[3,12,13,20,27].

There have been many studies showing that the balance between the receptor activator of the nuclear factor-kappa B ligand (RANKL/RANK) and osteoprotegerin (OPG) plays a central role in bone modulation in diseases such as osteoporosis, glucocorticoid induced osteoporosis, chronic inflammatory arthritis, hypogonadism, lack of estrogen, bone marrow transplantation and osteolytic bone metastasis of malignancies. Nevertheless, there have been no studies regarding RANKL, OPG and AIS. The purpose of a study by Chiru was to compare the serum concentration of soluble RANK, the serum level of OPG and the bone mass of an AIS group and a non-AIS group. In this study, 15 AIS patients and eight healthy adolescents were evaluated[18].

Studies in the literature have shown a significant relationship between osteopenia and AIS[5-7,9]. Cook showed for the first time that AIS is responsible for low bone mass[9]. Cheng observed widespread osteopenia in both the axial and peripheral skeleton in girls with AIS[5,7]. Moreover, Cheng, after a follow-up of more than three years in 14 girls with initial osteopenia, also showed that osteopenia in AIS is permanent up to maturity[6]. In recent studies by Lee, it has been shown that a low level of physical activity may play a role in the decreased bone mass in AIS[16]. As stated by Lostein, in immature scoliosis with a moderate curve, the use of a brace is suggested[17]. While Lonstein and Wiley suggest the use of a brace on a daily basis for a satisfactory result, Lee advises a certain amount of physical activity[16,17,25].

Morris and Fuchs, on the other hand, have expressed concerns regarding brace use with AIS, due to its unfavorable effect on BMD and bone mineral content (BMC)[11,19]. Thus, owing to insufficient increase of the bone mass, the risk might be higher and osteopenia or osteoporosis may be prolonged, and brace treatment of patients with AIS could increase the risk of osteoporosis as an adult. For this reason, studies concerning the effects of a brace in the building up of bone density are necessary[22]. According to Snyder, even though brace use has no effect on the build-up of BMD, the initial bone mineral amount of patients with AIS was not taken into account. It was also not clear whether there were different initial build-up parameters of BMD between the osteopenic and non-osteopenic AIS patients[23]. Qui, in a prospective study investigating any differences in the increase of bone minerals in 49 osteopenic and non-osteopenic AIS patients during the brace treatment period (1.1 years) and the effect of brace usage on BMD build-up, showed that there was a positive bone mineral increase in the lumbar vertebrae and femoral neck during a period of over a year in nearly all AIS girls (94%). The brace treatment and the initial bone mineral level may not have an important role in BMD build-up. However, it was shown that the growth potential of AIS patients during brace treatment is the most important factor affecting the increase of the bone mineral level[22].

In our study, we found that the BMD levels were significantly lower in patients with AIS using braces than those who were not. However, the significantly lower ages of the patients using braces than those who were not may be a factor causing the low BMD levels ($p=0.011$). When all the patients with AIS were evaluated, no relationship was found statistically between the BMD and Cobb angle, whereas a positive correlation was found between the age, BMI, height and weight. There was a negative correlation between the Z-score and the age, while between the BMI, height and weight there were no such significant relationships. We observed a negative correlation between the Cobb angle and Z-score at L2–3 and in the total proximal thoracic curve, whereas there was a positive correlation between L3–4 and the lumbar/thoracolumbar curve. When both genders were compared, there was no significant difference between all the parameters. We experienced difficulties in comparing the bone density levels in patients using braces, and so the effect of using braces could not be evaluated thoroughly.

Our study found that the use of a brace significantly reduced bone density levels for AIS patients.

Although there was no apparent relationship between the BMD and Cobb angles, all other parameters showed a positive correlation. When all the parameters were compared for both genders, no meaningful differences were observed.

We are of the opinion that more comprehensive studies are needed on the bone mineral metabolisms of patients with idiopathic scoliosis. It is also advisable to measure the effects of braces on scoliotic patients and to include parameters regarding bone mineral metabolism, such as 25-hydroxy vitamin D and others.

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