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Osteoporosis, Spinal Mobility and Chest Expansion Index in Patients With Ankylosing Spondylitis

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A B S T R A C T

To determine the correlation between the bone mineral density (BMD) and spinal mobility and chest expansion index in patients with ankylosing spondylitis. Eighty patients with confirmed diagnosis of ankylosing spondylitis were included in this study. In all of them physical examination was performed including assessment of spinal mobility and chest expansion index. Bone mineral density of the lumbar spine (L1–L4, anteroposterior view) and at the left hip was measured by dual X-ray absorptiometry (DXA) in standard manner. According to the WHO classification of osteoporosis, patients were classified in three groups (normal, osteopenic or osteoporotic) depending on the osteoporotic status in lumbar spine, hip and femoral neck region. Eighty patients (46 men and 34 women; age 25–73 years) were included. Mean BMD for lumbar spine was 1.104±1.043 (T score: 0.67±2.15) and for total hip was 1.057±0.899 (T score: –0.28±2.34). Significant difference in the mobility of thoracic spine was observed in patients in regard to the WHO classification of osteoporosis in lumbar and femoral region (p=0.031, Oneway Anova for osteoporosis of lumbar region; p=0.022, Oneway Anova for osteoporosis of total hip region). Mean value for the chest expansion index was 3.07±1.66 cm. Chest expansion index was significantly reduced in patients having osteoporosis in lumbar and total hip region (p=0.015, Oneway Anova for osteoporosis of lumbar region; p=0.038, Oneway Anova for osteoporosis of total hip region). The observation that reduced mobility of thoracic and lumbar spine and chest expansion index occured in patients with low BMD in lumbar and total hip region suggest that osteoporosis should be monitored more frequently in patients with AS.

Key words: *osteoporosis, ankylosing spondylitis, spinal mobility, chest expansion index*

Introduction

Ankylosing spondylitis (AS) is a chronic inflammatory disease characterized by predominant affection of both sacroiliac joints and spine, but peripheral joints, entheses or extraarticular structures may also be involved. It has been established that patients with severe radiological changes have decreased spinal mobility[1–4]. Reduced spinal mobility may decrease patient's ability to perform the acitivities of daily life in great manner.

Osteoporosis and its consequences, primarily vertebral fractures, have been recognized as a severe complication of ankylosing spondylitis[5,6]. Incidence of the osteoporosis in ankylosing spondylitis is estimated in a wide range between 18.7–62%[7].

The prevalence of osteoporosis is greater in male patients and increases with patient's age and disease duration[8,9]. Although the osteoporosis may be diagnosed in high percentage of patients with AS, distribution, clinical significance and the occurence of the osteoporosis is not completely clear.

To our knowledge no study has been published that looked into the association between range of motion measures and bone mineral density in patients with spondyloarthropathies. Therefore, the aim of our study was to determine the correlation between the bone mineral density (BMD), spinal mobility and chest expansion index in patients with AS.

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Patients and Methods

Study design and settings

This cross-sectional study was performed in the Department of Rheumatology, Physical Medicine and Rehabilitation, University Hospital Center »Sestre Milosrdnice« in Zagreb from September 2004 till September 2005. Study has been reviewed by the Hospital's ethic committee and has been performed according to the ethical standards laid down in the Declaration of Helsinki[10].

Participants

Eighty patients (46 men and 34 women; age 25–73 years) with confirmed diagnosis of ankylosing spondylitis (according to the modified New York criteria) who consecutively came to our Department were enrolled in the study[11]. Prior to the participation in the study, patients signed the informed consent.

Data collection, measurement

A questionnaire was filled in by two investigators experienced in clinical studies, prior to the physical examination. Among others it consisted of the following: demographic data, physical examination which included assessment of spinal mobility and chest expansion index and data on bone mineral density of lumbar spine and left region. During the physical examination, spinal mobility expressed as index of movement in sagittal plane of cervical, thoracic and lumbar spine and chest expansion index (in centimetres) were measured. All of the measurements for each patients were performed on the same day from 11 a.m. to 1 p.m.

Index of sagittal movement of cervical, thoracic and lumbar spine represents the difference of flexion and extension of each spinal segment using tape measures[12,13]. Spinal mobility was examined in patient while standing. When measuring lumbar inclination two horizontal lines are drawn on patient's skin on two levels: at the level of spinous process of L5 vertebrum and another 10 cm above. Method of measuring thoracic inclination consists of drawing a horizontal line at the level of spinous process Th 1 and another 30 cm below. Referral value of the distance between two lines, when measuring lumbar inclination, in healthy person is 4.5 cm and for the thoracic inclination is 3 cm. For the sagittal flexibility of the cervical spine, two horizontal lines are also drawn: one at the level of protuberantia occipitalis externa and another at the level of vertebra prominens. The amount of inclination and reclination is presented numerically as the index of inclination and index of reclination (greater index means better mobility). Their total represents the total index of sagittal flexibility and normal values in our population are following: for cervical spine 9–10 cm, for thoracic spine 3.5–5 cm, for lumbar spine 4.5–6 cm. Chest expansion index is measured in standing position, too. Patient was asked to breath in deeply, hold the breath and then to breath out. Tape measure is placed over the 4^{th} intercostal region during breathing in/out and is expressed as the difference of these two values[13,14].

Bone mineral density was measured at the lumbar spine (L1–L4, anteroposterior view) and at the left hip by dual-energy x-ray absorptiometry (DEXA, Hologic, QDR 4500, USA) in standard manner. Patients were classified according to the WHO criteria: osteoporosis if T score was less than –2.5 SD, osteopenia as T score between –1.0 to –2.5 SD and normal T score if values were better than –1.0 SD[15].

They were also classified due to pathological T score (osteoporosis and osteopenia) or the value within the normal range because many people experience osteoporotic fracture while not having BMD below a threshold for osteoporosis. BMD was used as the referent value according to WHO classification as it reflects the fracture risk as the most important consequence of osteoporosis.

We analyzed the correlation of spinal mobility with T score of femoral neck region despite the fact that the most often measured area of densitometry is total hip, but bone mineral density of femoral neck region is recognized as very important in predicting risk for osteoporotic fractures because the results of DXA measurement are rarely influenced by osteophytes and other degenerative changes.

Statistical methods

Data were analyzed using the methods of descriptive statistics, Student T-test and one-way ANOVA test for the difference between means of continuous variables (spinal mobility and chest expansion index) in osteoporosis groups (SPSS ver.13). Regression analysis was performed in order to establish the correlation between BMD, T score and WHO classification of osteoporosis (normal, osteopenia, osteoporosis) of total hip and lumbar spine and measures of spinal mobility and chest expansion index.

Results were considered to be significant when p values were less than 0.05.

Results

Forty six men and thirty-four women were included in this study. Mean age of subjects was 52.3±10.4 years (range 25–73 years). Mean duration of the disease was 21.8±10.3 years. Sixty-seven patients (85.9%) were B 27 antigen positive. Mean values of the indices of the sagittal movements were as follows: cervical spine 5.46±2.52 cm, thoracic spine 1.92±1.33 cm and lumbar spine 3.54±1.96 cm. Mean value for the chest expansion index was 3.07± 1.66 cm. Clinical and demographic data are shown in Table 1.

Spinal mobility

Mean BMD for lumbar spine was 1.104±1.043 and T score was –0.67±2.15. Table 2 shows the distribution of patients according to spinal mobility and osteoporosis in lumbar region. The significant difference in mobility of thoracic spine (p=0.031, Oneway Anova) was observed in patients in regard to the WHO classificiation of osteoporo-

TABLE 1
DEMOGRAPHIC AND CLINICAL FEATURES OF PATIENTS WITH ANKYLOSING SPONDYLITIS

Patients characteristics		Median±SD
Age (years)		52.30±0.38
Disease duration (years)		21.87±10.32
Sagittal movement indices:		
	Cervical (cm)	5.46±2.51
	Thoracic (cm)	1.92±1.33
	Lumbar (cm)	3.53±1.86
Chest expansion index (cm)		3.07±1.66
		N (%)
Gender	Male	46 (57.5)
	Female	34 (42.5)
B27	Positive	67 (85.9)
	Negative	11 (14.1)
Peripheral arthritis	Yes	52 (65.8)
	No	27 (34.2)
Enthesis	Yes	55 (68.8)
	No	25 (31.2)

sis in lumbar region. No significant difference was observed for cervical and lumbar spine (cervical spine p=0.304, Oneway Anova; lumbar spine p=0.091, Oneway Anova, respectively).

Table 3 show the distribution of patients according to spinal mobility and osteoporosis status in hip region. Mean BMD for total hip was 1.057±0.899 (T score –0.28±2.34). The same significance of association, regarding spinal segments, was observed comparing spinal mobility and distribution of patients according to the osteoporosis status measured in hip region (cervical spine p=0.724, Oneway Anova; thoracic spine p=0.022, Oneway Anova; lumbar spine p=0.064, Oneway Anova). When patients were classified in two categories (T score pathological or normal) spinal mobility of thoracic, but also of lumbar spine were significantly decreased (p=0.039, t-test; p=0.044, t-test, respectively) in patients with pathological values of T score in hip region compared to those with normal values.

Table 4 shows the distribution of patients according to spinal mobility and osteoporosis status in femoral neck region. According to the WHO classification of osteoporosis in femoral neck region, significant difference in the mobility of thoracic (p=0.013, Oneway Anova) and lumbar spine (p=0.010, Oneway Anova) was

TABLE 2
DISTRIBUTION OF PATIENTS WITH ANKYLOSING SPONDYLITIS ACCORDING TO OSTEOPOROSIS STATUS IN LUMBAR REGION (WHO DEFINITION) AND MEASURES OF SPINAL MOBILITY IN SAGITTAL PLANE

		Spinal mobility					
		Cervical spine*		Thoracic spine**		Lumbar spine***	
		N (%)	Mobility (cm, $\overline{X}$±SD)	N (%)	Mobility (cm, $\overline{X}$±SD)	N (%)	Mobility (cm, $\overline{X}$±SD)
Osteoporosis status of lumbar region	Normal	44 (57.14)	5.057±2.288	44 (57.14)	2.034±1.282	43 (56.58)	3.593±2.119
	Osteopoenia	19 (24.67)	6.116±3.279	19 (24.67)	2.211±1.493	19 (25)	4.158±1.7164
	Osteoporosis	14 (18.18)	5.607±2.067	14 (18.18)	1.071±0.997	14 (18.42)	2.643±1.598
Total		77		77		76	

TABLE 3
DISTRIBUTION OF PATIENTS WITH ANKYLOSING SPONDYLITIS ACCORDING TO OSTEOPOROSIS STATUS IN HIP REGION (WHO DEFINITION) AND MEASURES OF SPINAL MOBILITY IN SAGITTAL PLANE

		Spinal mobility					
		Cervical spine*		Thoracic spine**		Lumbar spine***	
	N (%)	mobility (cm, $\overline{X}$±SD)	N (%)	mobility (cm, $\overline{X}$±SD)	N (%)	mobility (cm, $\overline{X}$±SD)	
Osteoporosis status of hip region	Normal	52 (68.42)	5.629±2.510	52 (68.42)	2135±1.302	51 (68)	3.853±2.117
	Osteopoenia	20 (26.31)	5.125±2.689	20 (26.31)	1.65±1.3485	20 (26.66)	3.225±1.446
	Osteoporosis	4 (5.26)	5.125±1.931	4 (5.26)	0.375±0.478	4 (5.33)	1.625±1.600
Total		76		76		75	

*p=0.724 (One way ANOVA), **p=0.022 (One way ANOVA), ***p=0.064 (One way ANOVA)

TABLE 4
DISTRIBUTION OF PATIENTS WITH A ANKYLOSING SPONDYLITIS ACCORDING TO OSTEOPOROSIS STATUS IN FEMORAL NECK REGION (WHO DEFINITION) AND MEASURES OF SPINAL MOBILITY IN SAGGITAL PLANE

		Spinal mobility					
		Cervical spine*		Thoracic spine**		Lumbar spine***	
		N (%)	mobility (cm, $\overline{X}$±SD)	N (%)	mobility (cm, $\overline{X}$±SD)	N (%)	mobility (cm, $\overline{X}$±SD)
Osteoporosis status of femoral neck region	Normal	23 (30.26)	5.348±2.569	23 (30.26)	2.391±1.413	23 (30.66)	4.457±2.225
	Osteopoenia	37 (48.68)	5.668±2.460	37 (48.68)	1.946±1.240	36 (48)	3.458±1.653
	Osteoporosis	16 (21.05)	4.969±2.837	16 (21.05)	1.125±1.190	16 (21.33)	2.563±1.878
Total		76		76		75	

TABLE 5
DISTRIBUTION OF PATIENTS WITH ANKYLOSING SPONDYLITIS ACCORDING TO OSTEOPOROSIS STATUS IN LUMBAR, HIP AND FEMORAL NECK REGION (WHO DEFINITION) AND MEASURES OF CHEST EXPANSION INDEX

		Chest expansion index					
		Lumbar region*		Hip region**		Femoral neck region***	
		N (%)	mobility (cm, $\overline{X}$±SD)	N (%)	mobility (cm, $\overline{X}$±SD)	N (%)	mobility (cm, $\overline{X}$±SD)
Osteoporosis status	Normal	41 (55.4)	3.012±1.610	49 (67.12)	3.455±1.8036	22 (30.13)	4.00±1.611
	Osteopoenia	19 (25.67)	3.911±1.787	20 (27.4)	2.50±1.147	35 (47.95)	2.966±1.604
	Osteoporosis	14 (18.91)	2.25±1.297	4 (5.48)	2.00±1.354	16 (21.95)	2.094±1.381
Total		74		73		73	

found. Classifying patients in two groups, spinal mobility of thoracic and lumbar spine were decreased in patients having pathological values of T score in femoral neck compared to those with normal values (p=0.05, t-test; p=0.02, t-test, respectively). Regression analysis showed no correlation between BMD, T score and WHO classification (normal, osteopenia, osteoporosis) of total hip and lumbar spine and measures of spinal mobility: for cervical spine mobility (range from –0.12 to 0.175), for thoracic spine mobility (range from –0.251 to 0.197) and for lumbar spine mobility (–0.224 to 0.051). Table 6. shows p values of one-way ANOVA for spinal mobility in relation to normal or pathologic value of T-score which was found to be significant for osteoporosis status in hip and femoral neck region, but not in lumbar region in regard to spinal mobility of thoracic and lumbar spine.

Chest expansion index

Table 5 shows distribution of patients according to the osteoporosis status in lumbar, hip and femoral neck region (WHO classification) and chest expansion index.

Lower average chest expansion index were observed in patients having osteoporosis in lumbar region (p=0.015, Oneway Anova) and in total hip region (p=0.038, Oneway Anova) compared to those having osteopenic or normal values. Patients with pathological values of T score in hip and femoral neck region had also decreased chest expansion index (p=0.004, t-test; p=0.002, One-way Anova, respectively), but not in lumbar region (p=0.629, t-test).

Table 6 shows p values of one-way ANOVA for chest expansion index in relation to normal or pathologic value of T-score. This relation is found to be significant for osteoporosis status in hip and femoral neck region, but not in lumbar region in regard to chest expansion index. As with spinal mobility, regression analysis showed no correlation between BMD, T score and WHO osteoporosis

TABLE 6
SIGNIFICANCE (EXPRESSED AS P VALUE) OF SPINAL MOBILITY AND CHEST EXPANSION INDEX IN RELATION TO NORMAL OR PATHOLOGIC VALUE OF T-SCORE IN HIP, FEMORAL NECK AND LUMBAR REGION (One way ANOVA) IN PATIENTS WITH ANKYLOSING SPONDYLITIS

T score	Spinal mobility			Chest expansion index
	Cervical spine	Thoracic spine	Lumbar spine	
Hip region	0.398	0.039	0.044	0.004
Femoral neck region	0.866	0.050	0.020	0.003
Lumbar region	0.163	0.330	0.863	0.629

classification (normal, osteopenia, osteoporosis) of the total hip and lumbar spine and chest expansion index: –0,015 and 0.042 for BMD of lumbar and total hip region, 0.057 and –0.293 for WHO osteoporosis classification of lumbar and total hip region, –0.070 and 0.051 for T score of lumbar region and total hip region.

No significant correlation was found between chest expansion index and spinal mobility indices and total hip and lumbar BMD and osteoporosis status in lumbar and hip region when adjusted to age, gender and disease duration (all p values >0.05).

Discussion

This study shows that patients with ankylosing spondylitis who have low T-scores in lumbar and hip region also have decreased thoracic and lumbar mobility as well as chest expansion index compared to those with normal BMD.

Inflammatory process may lead to the ossification and ankylosis of bony structures which is the pathologic basis of the disease. On the other hand, several factors may contribute to the development of the osteoporosis: inflammatory process itself, hormone disorders, decreased spinal mobility and low level of physical activity in general[16–18].

Low BMD in patients with ankylosing spondylitis has been well observed in the early stage of the disease as well as later in its course independent of spine mobility and exercise[19–21]. Osteopenia and osteoporosis, as defined by the WHO standards, occur at lumbar spine in 18.7–31.2% and at the femoral neck in 13.7–41.2% of AS patients[7].

Although the main anatomical, clinical and radiological features of ankylosing spondylitis have been described, the correlation between BMD and vertebral mobility has not been thoroughly studied and reported in literature. Upper and middle portion of lumbar spine are responsible for lateral bending, while flexion and extension are greatest in the lumbosacral level. Rib cage stabilizes thoracic region and there is little motion at all. Chest expansion index serves in patients with AS as the thoracic measurement only, although being relatively unreliable[22,23]. Although there are several methods which may be used to assess the mobility of thoracic and lumbar spine, only lumbar spinal flexion and extension, lateral bending and chest expansion index are mobility criteria for AS[11]. Tape methods which measure spinal range of motion are easily available tools which could be reliable and valid test in AS[24]. Values of observed indices in healthy subjects may not be the same and several factors can contribute to variability of the results like body height of subjects (with consequent length of spinal segments), their age, gender, profession, training programmes. Therefore, the normal value of particular index cannot be most precise, but rather informative in group of healthy subjects and are as follows: for lumbar spine 4.5–6 cm, for thoracic spine 3–3.5 cm, for cervical spine 9–10 cm14. Inflammatory process primarily affects sacroiliac joints, following lumbar and thoracic spine, therefore showing its tendency to spread ascendently. Syndesmophytes, recognized as radiological changes, are early observed in thoraco-lumbar junction. These can be followed by the appearance of ligamentous ossification and other tissue changes which also contribute to the restriction of spinal mobility. Ossification of the ligaments is a late change and spinal mobility may be reduced long before the radiological alterations are present.

Our findings indicate more consistently reduced spinal mobility in the thoracic than in the lumbar spine. Possible explanation is that lower parts of thoracic spine contribute by decreasing mobility of that segment much more than the upper part of lumbar spine affects it. Gratacos' study showed no significant difference in Schober's measure in patients with active vs. patients with inactive disease, although patients with active disease tended to have a slightly lower degree of spinal mobility[16]. BMD in thoracic spine was not measured since the method is not standardized and it has not been validated regarding the values for osteoporosis, osteopenia and normal finding. At the same time, the ribs themselves or inflammatory changes of the rib cage could influence the BMD measurement. Studies by Devogelaer and Mullaji showed that cortical bone is spared from the osteoporotic events in the early course of the disease[25,26]. Therefore, low BMD in hip region may be a consequence of higher rate of the metabolic activity of trabecular bone and its susceptibility to cytokines and hormonal changes seen in the active form of disease[27]. Absence of consistent significant correlation between bone density of lumbar spine with spinal mobility is probably due to falsely increased BMD in patients with long lasting disease due to the many spinal syndesmophytes or spinal degenerative disease. Measurement of the anteroposterior BMD in the lumbar spine includes ligaments, joint capsules, tendons and both trabecular and cortical bone. Since fibrous tissues can be calcified in the later stage of disease, the transmission measurement cannot distinguish calcified spinal ligaments from bone mineral[7,28,29]. Will and Maillefert showed in two longitudinal studies in patients with early active AS that hip and spine BMD decrease in active AS, although these patients maintained normal spinal mobility[30,31]. Our study also shows reduced mobility of the thoracic and lumbar spine and chest expansion index in patients with low T score in hip region. This may be a result of the inflammatory process which affects the bone turnover in both cortical and trabecular bone resulting in bone loss within the vertebra and increase in cortical BMD.

The advantage of this study is that subjects were homogenous group of patients with established diagnosis of ankylosing spondylitis and that spinal mobility as well as BMD measurements in all patients were performed in the standardized manner. Furthermore, dual-energy X--ray absorptiometry is an important part of diagnostic algorithm in patients with ankylosing spondylitis. The main limitation of this study may be the lack of the con-

trol gender and age matched group and that the longitudinal follow-up has not been performed.

In conclusion, patients with ankylosing spondylitis may develop osteopenia or osteoporosis during the course of disease. Our data show decreased mobility of thoracic and lumbar spine and chest expansion index in patients with lower T score in lumbar and hip region. If physical examination reveals decreased spinal mobility in patients with ankylosing spondylitis, it would be advisable to perform the dual-energy X-ray absorptiometry in order to find out whether our patients are at risk of developing osteopenia or osteoporosis.

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OSTEOPOROZA, POKRETLJIVOST KRALJEŠNICE I INDEKS DISANJA U BOLESNIKA SA ANKILOZANTNIM SPONDILITISOM

SAŽETAK

U radu se želi odrediti postoji korelacija između mineralne gustoće kostiju i pokretljvosti kralješnice i indeksa disanja u bolesnika sa ankilozantnim spondilitisom. Istraživanjem je uključeno osamdeset bolesnika sa potvrđenom dijagnozom ankilozantnog spondilitisa. Klinički pregled bolesnika obuhvatio je mjerenje pokretljivosti kralješnice i indeksa disanja. Mineralna gustoća kosti (MGK) lumbalne kralješnice (L1–L4, anteroposterior pogled) i lijevog kuka mjerene su dvostrukom apsorpciometrijom X zraka standardnim načinom. Temeljem WHO klasifikacije osteoporoze, bolesnici su podijeljeni u tri skupine (normalan, ostepenija ili osteoporoza) ovisno o osteoporotskom statusu u području lumbalne kralješnice, kuka i području vrata femura. Osamdeset bolesnika (46 muškaraca i 24 žene; raspon godina 25–73) uključeni su u istraživanje. Srednja vrijednosti MGK lumbalne kralješnice iznosila je 1,104±1,043 (T vrijednost: 0,67±2,15) i za područje kuka 1,057±0,899 (T vrijednost: –0,28±2,34). Značajna razlika u pokretljivosti torakalne kralješnice uočena je u bolesnika sa osteoporozom lumbalne kralješnice i područja femura obzirom na WHO klasifikaciju (p=0,031, Oneway Anova za osteoporozu u lumbalnoj kralješnici; p=0,022, Oneway Anova za osteoporozu u području kuka). Srednja vrijednost indeksa disanja iznosila je 3,07±1,66 cm. Indeks disanja značajno je smanjen u bolesnika koji imaju osteoporozu u lumbalnoj kralješnici i u području kuka (p=0,015, Oneway Anova za osteoporozu u lumbalnoj kralješnici; p=0,038, Oneway Anova za osteoporozu u području kuka). Budući da je u bolesnika sa smanjenom MGK u slabinskoj kralješnici i u području kuka uočena ograničena pokretljivost torakalne i lumbalne kralješnice i indeksa disanja, u bolesnika sa ankilozantnim spondilitisom osteoporozu bi se trebalo češće detektirati.