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Original Article

Prevalence of Osteoporosis and Sarcopenia in Middle-Aged Subjects with Low Back Pain

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Abstract

Objective The genesis of both osteoporosis and sarcopenia is multifactorial, complicated, and interrelated. The present study has been undertaken to analyze the prevalence of low bone mineral density (BMD) and the pattern of imaging markers of sarcopenia (paraspinal skeletal muscle area [SMA] and skeletal muscle index [SMI] with respect to clinicodemographic profile in middle-aged patients (30–45 years) undergoing evaluation for low back pain (LBP).

Materials and Methods Magnetic resonance imaging (MRI) of the lumbosacral spine and/or sacroiliac joints was done on 3T MRI. BMD of the lumbar spine (L1 to L4) was assessed using a dual-energy X-ray absorptiometry scan. SMA was calculated by measuring the cross-sectional area of paraspinal muscles (bilateral psoas, erector spinae, and multifidus), and SMI was calculated by dividing SMA by height^2.

Results The prevalence of osteoporosis was 12.1% in patients of age 30 to 45 years presenting with LBP. Both osteoporosis and paraspinal muscle mass were statistically associated with the duration of symptoms (p-value <0.05). No statistically significant difference was observed in different MRI findings, that is, normal, inflammatory, infective, and degenerative etiology.

Conclusion Low BMD and loss of muscle mass in cases with LBP are more related to duration of disease rather than etiology or gender in middle-aged subjects. Early intervention to manage LBP may prevent progression to osteoporosis and sarcopenia in young adults.

Keywords
- low back pain
- bone mineral density
- osteoporosis
- sarcopenia
- skeletal muscle area
- skeletal muscle index

Introduction

Osteoporosis is a systemic skeletal disease characterized by low bone mass and microarchitectural deterioration of bone tissue, leading to enhanced bone fragility and a consequent increase in fracture risk. Dual-energy X-ray absorptiometry (DEXA) is the technique of choice in assessing bone mineral density (BMD).[1] The World Health Organization (WHO) uses T-scores to define and classify BMD measurements in the elderly population. However, in men younger than 50 years, premenopausal women, and adolescents who have not yet reached peak bone mass, WHO uses Z-score, that is, BMD more than 2 standard deviations (SDs) below the mean BMD matched for age, gender, and ethnicity (Z-score < -2 SD).[2]

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Low back pain (LBP) is experienced in 60 to 80% of adults and 30% of adolescents at some point in life.[3] Osteoporosis can present as acute or chronic LBP with clinical fracture of the vertebral body.[4] According to a study conducted in southern India, the prevalence of osteoporosis is 10% in middle-aged patients attending orthopaedics outpatient department (OPD).[5] According to Hestbaek et al,[6] the annual LBP prevalence in young adults is 32.4%. Cases with nonspecific LBP have been associated with lower BMD values in various reports.[7,8]

Sarcopenia is defined as a pathological decrease in muscle mass, which affects performance.[9] Psoas and paraspinal cross-sectional area (CSA) measurement on computed tomography is a quick and easy method to assess sarcopenia.[10] Reports regarding the higher prevalence of sarcopenia in premenopausal osteoporotic women,[11] as well as implicating sarcopenia as the cause of LBP in the elderly population, have been published.[12] Iwahashi et al[13] reported that sarcopenic patients had exacerbated LBP and poor quality of life.

The genesis of osteoporosis and sarcopenia is multifactorial and interrelated; therefore, they need to be assessed and managed together. The available literature has cited them both as the cause and effect of LBP in the elderly population. Moreover, the two entities that are considered diseases of the elderly population may have their genesis at an early age. The present study has been undertaken to analyze the prevalence of low BMD and the pattern of imaging markers of sarcopenia (paraspinal skeletal muscle area [SMA] and skeletal muscle index [SMI] with respect to clinicodemographic profile in middle-aged patients (30–45 years) undergoing evaluation for LBP.

Materials and Methods

This prospective observational study was conducted after the approval of the institutional ethics committee. Subjects of the age group 30 to 45 years visiting our department between February 2021 and August 2022 for LBP evaluation using MRI of the lumbosacral (LS) spine and/or sacroiliac (SI) joints were included in the study after informed consent.

Patients having history of trauma consistent with imaging abnormality, chronic medical disease (diabetes, chronic kidney disease, chronic liver disease), medication for other indications (steroid, antiepileptic, thyroxin, heparin), endocrine diseases (hypogonadism, Cushing syndrome, growth hormone deficiency, hyperparathyroidism), kyphoscoliosis, malignancy, history of pelvic inflammatory disease, causing LBP in female subjects, congenital bony lesions, and pregnancy were excluded.

The sample size of 140 was calculated using the formula: $n = Z^2PQ/e^2$,

where n = sample size, $Z = 1.96$ at 95% confidence interval, P = prevalence (taking the prevalence of osteoporosis as 10% in middle-aged patients attending orthopaedics OPD as per a study conducted by Chitten and James[5]), $Q = 1 - P$, e = standard margin of error (taken as 5).

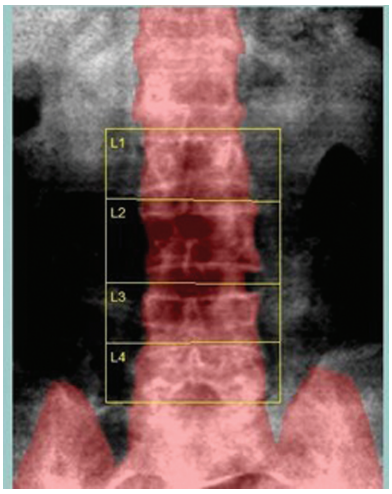

Fig. 1 Dual-energy X-ray absorptiometry (DEXA) image showing region of interest in lumber spine while assessing bone mineral density using DEXA scan.

BMD was assessed on bone densitometer MEDIX DR (MAX kVp 90, MAX mA/mAs 72). BMD was assessed using a DEXA scan at the lumbar spine (anteroposterior L1 to L4 vertebrae). The procedure was explained to the patients, and the patient's weight and height were recorded. The patient was positioned supine in the scanner, and a scan was done. The region of interest (ROI) was placed at L1 to L4 vertebrae, as shown in ►**Fig. 1**, and analysis was done.

MRI was done on 3 Tesla MRI GE Signa OT HDxt 32 channel MRI machine (WB0427). MRI of the LS spine and/or SI joint was done with standard sequences. The LS spine study used axial T2, sagittal T2, T1, short tau inversion recovery (STIR), coronal STIR, postcontrast (if needed) sagittal and axial fat-saturated T1 postcontrast sequences. The field of view was selected from the lower border of D11 to the tip of the coccyx. For the SI joint study, coronal T1, T2, STIR, axial T1, and STIR sequences were used. SMA and SMI were assessed on axial T2-weighted images at the L4–L5 level as a marker of sarcopenia. SMA was calculated by measuring and summating the CSA of bilateral multifidus and erector-spinae muscles as well as bilateral psoas muscles at the L4–L5 level by drawing ROI around the muscle bulk (►**Fig. 2**).

Statistical Analysis

The statistical analysis was done using SPSS (Statistical Package for Social Sciences) Version 21.0 Statistical Analysis Software. The values were represented in number (%) and mean ± SD. Mean, SD, chi-square test, Student's *t*-test, analysis of variance (ANOVA), and bivariate correlation were the statistical tools used for the analysis of data. A p-value <0.05 was considered significant.

Results

In the present study, 140 subjects were enrolled based on the inclusion criteria. The mean age of the subjects enrolled in the study was 36.89 ± 4.70 years. Demographic and clinical profile of the subjects are presented in ►**Table 1**. Out of 140

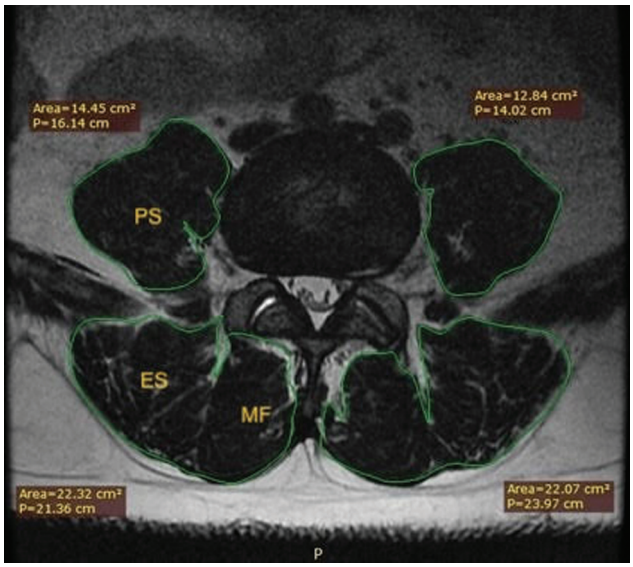

Fig. 2 Paraspinal muscle cross-sectional area measurement at L4–L5 level in axial T2 sequence of lumbar spine. ES, erector spinae; MF, multifidus; PS, psoas muscle.

patients, 17 (12.1%) had low BMD (►**Table 1**). The mean age of subjects with low BMD patients was high (39.53 ± 5.28 years) compared with subjects with normal BMD (36.52 ± 4.46 years).

►**Table 2** shows the bone BMD in males and females with respect to MRI observation. Though the prevalence of low BMD was higher among females than males (13.4 vs. 11.0%), this difference was not found to be significant (p-value = 0.654). There was no statistically significant difference among different MRI findings in both genders separately and combined.

The association of low BMD with a duration of symptoms is presented in ►**Table 3**. An incremental trend in the prevalence of low BMD was observed with increasing duration of symptoms, that is, ≤6 months (0.0%), 7 to 12 months (12.5%), 13 to 24 months (19.6%), and 25 to 36 months (25.0%). This difference was statistically significant (p-value <0.05). Duration of symptoms was significantly higher among low BMD cases (18.82 ± 8.00 months) as compared with normal BMD (13.68 ± 8.11 months).

The association of SMI and SMA with different patterns of MRI findings in males and females was analyzed with ANOVA and is presented in ►**Table 4**. Differences in SMI of patients with different MRI findings were not statistically significant in both genders.

The correlation of SMA and SMI with duration of symptoms is tabulated in ►**Table 5** and shown in ►**Fig. 3**. SMA and SMI of patients with abnormal MRI (degenerative, infective, and inflammatory) and normal MRI study were comparable in all the categories of duration of symptoms. However, in both the MRI categories (abnormal and normal), SMA and SMI decline with an increase in the duration of symptoms. This association was significant statistically. There was a moderate correlation and high significance in both genders.

Discussion

The genesis of both sarcopenia and osteoporosis is multifactorial, and several factors that play a role in osteoporosis are also thought to contribute to sarcopenia. Moreover, both entities cause significant morbidity in the elderly population with LBP, and both have an interrelated genesis. Concerns have been raised about the prevalence of low BMD and sarcopenia in young adults and its impact on their lifestyle due to the significant incidence of LBP encountered in this age group.[3] Osteoporosis and sarcopenia have been widely

Table 1 Clinicodemographic profile of patients

Variables		Groups	No of cases	Percentage
Age (y) 36.89 ± 4.70 (30–45) Mean age ± SD (range)		30–35	67	47.9
		36–40	38	27.1
		41–45	35	25.0
Gender		Male	73	52.1
		Female	67	47.9
Imaging findings	Normal		41	29.3
	Abnormal	Degenerative	83	59.3
		Inflammatory	10	7.1
		Infective	6	4.3
Duration (mo) 14.31 ± 8.24 (range: 3–36)		≤ 6 mo	38	27.1
		7–12 mo	48	34.3
		13–24 mo	46	32.9
		≥ 25 mo	8	5.7
BMD		Normal	123	87.9
		Low (Z-score < 2 SD)	17	12.1

Abbreviations: BMD, bone mineral density; SD, standard deviation.

Table 2 Association of normal and low BMD in different MRI findings

MRI findings	Males		Females		
	Normal BMD	Low BMD	Normal BMD	Low BMD	
Overall	65	8	58	9	
Normal	20 (30.8)	1 (12.5)	18 (31.0)	2 (22.2)	Chi-square test = 0.414; $p = 0.520$
Abnormal	45 (69.2)	7 (87.5)	40 (69.0)	7 (77.8)	
	Chi-square test= 1.612; $p = 0.634$		Chi-square test = 1.313; $p = 0.761$		
Degenerative	37 (56.9)	6 (75.0)	34 (58.6)	6 (66.7)	Chi-square test = 0.018; $p = 0.892$
Inflammatory	6 (9.2)	1 (12.5)	3 (5.2)	0 (0.0)	Chi-square test = 0.476; $p = 0.490$
Infective	2 (3.1)	0 (0.0)	3 (5.2)	1 (11.1)	Chi-square test = 0.600; $p = 0.439$
	Chi-square test = 1.547; $p = 0.671$		Chi-square test = 1.213; $p = 0.750$		

Abbreviations: BMD, bone mineral density; MRI, magnetic resonance imaging.
Note: Values in parenthesis represent percentage.

Table 3 Association of low BMD with duration of symptoms

SN	Duration of symptoms	Total ($n = 140$)	Low BMD ($n = 17$)		Normal BMD ($n = 123$)	
			N	%	*N*	%
1	$\leq$ 6 mo	38	0	0.0	38	100.0
2	7–12 mo	48	6	12.5	42	87.5
3	13–24 mo	46	9	19.6	37	80.4
4	$\geq$ 25 mo	8	2	25.0	6	75.0
	Chi-square test		Chi-square test =8.873; $p = 0.031$			
	Mean duration $\pm$ SD (range)		18.82 $\pm$ 8.00 (8–36)		13.68 $\pm$ 8.11 (3–36)	
	Student's *t*-test		$t = 2.453$; $p = 0.015$			

Abbreviations: BMD, bone mineral density; SD, standard deviation.

Table 4 Association of MRI findings with skeletal muscle index in both genders

SN	Parameters	Degenerative		Inflammatory		Infective		Normal		ANOVA	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	*F*	*p*-Value
1	Skeletal muscle area										
	Female	47.38	9.31	36.03	5.26	41.30	6.04	47.96	6.34	2.479	0.069
	Males	65.58	10.90	66.30	12.93	50.20	1.05	67.91	12.60	1.462	0.232
2	Skeletal muscle index										
	Female	19.62	3.99	15.40	1.44	17.33	2.64	19.89	2.84	1.884	0.141
	Male	22.96	3.99	23.69	4.63	17.80	0.83	23.68	4.56	1.258	0.296

Abbreviations: ANOVA, analysis of variance; MRI, magnetic resonance imaging; SD, standard deviation.

Table 5 Correlation of duration of symptoms with skeletal muscle area and skeletal muscle index

Sl. no.	Parameter	*r*	Level of correlation	*p*-Value	Level of significance
1	Skeletal muscle area	−0.666	Moderate	< 0.001	Highly significant
2	Skeletal muscle index	−0.648	Moderate	< 0.001	Highly significant

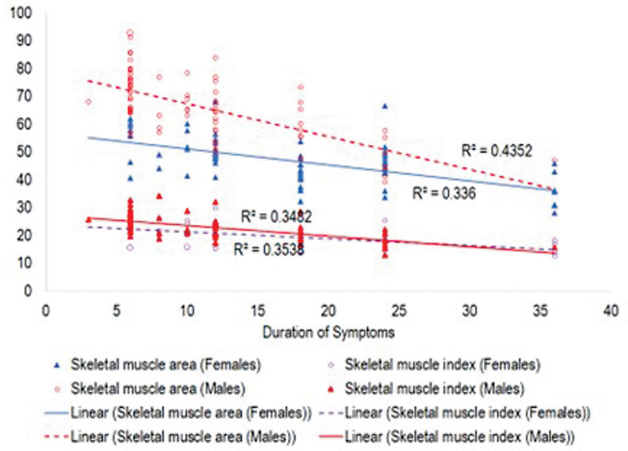

Fig. 3 Correlation of duration of symptoms with skeletal muscle area and skeletal muscle index in both genders.

studied in the elderly population and postmenopausal females and are clearly defined with active intervention by health care professionals. This study aimed to estimate the prevalence of osteoporosis and the pattern of paraspinal muscle mass in the lumbar spine in young adults presenting with LBP. Patients of the age group 30 to 45 years were selected because maximum peak bone mass is achieved till 25 to 30 years, and after 45 years, senile osteoporosis and postmenopausal osteoporosis set in, which have been thoroughly studied previously.

The most common imaging abnormality as the cause of LBP was degenerative spine disease, followed by normal imaging findings, inflammatory abnormality, and infective abnormality (pyogenic and tubercular spondylodiscitis) (►**Figs. 4**–**6**). This observation was consistent with the study done by Choudhary et al[14] and Evrim Ekin and Emre Altunrende,[15] which showed degenerative spine disease as the most common cause of LBP in young adults. The duration of LBP in our study ranged from 3 to 36 months, with a mean of 14.31 ± 8.24 months. Most patients ($n = 86$; 61.4%) had symptoms for $\leq$12 months. Only 5.7% of patients had symptoms for >2 years, suggesting early presentation of the cases in younger ages (►**Table 1**).

The prevalence of low BMD in our study was 12.1% (11% in males and 13.4% in females), which was consistent with the study by Chitten and James.[5] However, this was in contrast with a study done by Kim et al (2021),[16] which showed its

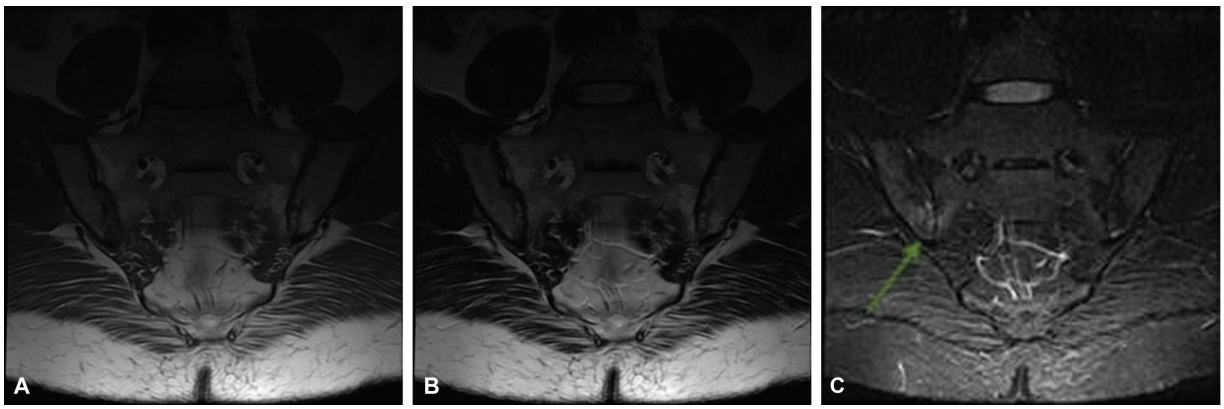

Fig. 4 Coronal T1 (A), T2 (B), and short tau inversion recovery (C) images showing sacroiliitis involving bilateral sacroiliac joints. Note active disease (edema) in the right sacroiliac joint (green arrow in C).

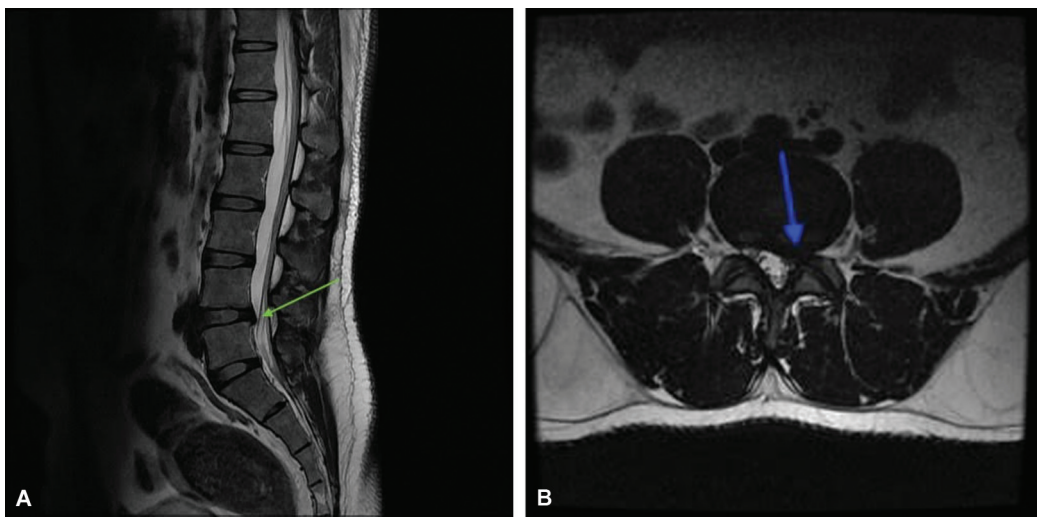

Fig. 5 Sagittal T2-weighted image (A) and axial T2-weighted image (B) showing diffuse disc bulge (green arrow) with left paracentral disc protrusion (blue arrow) at L4–L5 level.

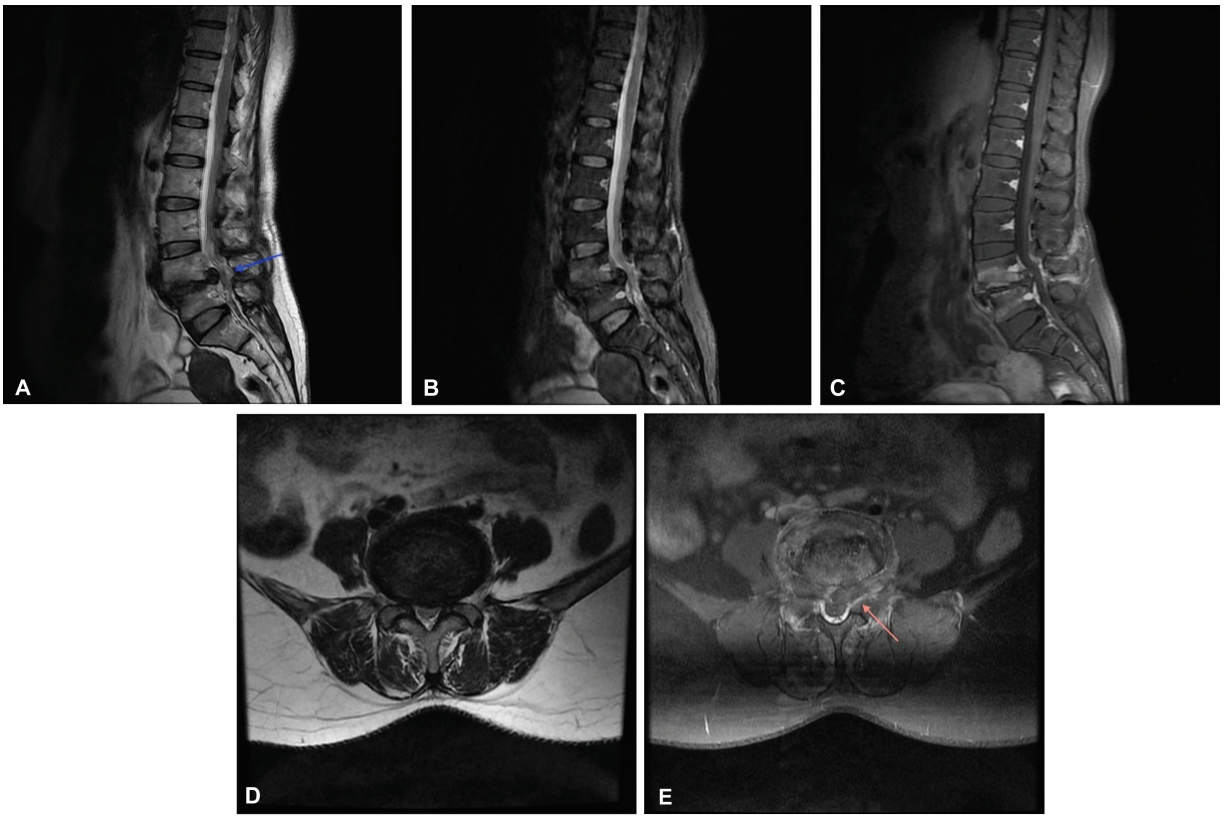

Fig. 6 Sagittal T2 (A), sagittal short tau inversion recovery (B), sagittal T1 fat-saturated postcontrast (C), axial T2 (D), and axial T1 fat-saturated postcontrast (E) sequences showing spondylodiscitis (orange arrow) involving L4–L5 level with compression over cauda equine nerve roots (blue arrow).

prevalence in healthy young adults to be 2.7% in males and 3.3% in females. This difference may be attributed to including symptomatic patients in our study. A similar low prevalence of low bone mass in the lumbar spine was observed in 579 Spanish premenopausal women aged 20 to 44 years.[17] The difference in the prevalence of osteoporosis compared with our study is probably due to the use of the T-score for defining osteoporosis in their study as opposed to the Z-score in our study. The prevalence of osteoporosis and/or fragility (vertebral) fractures can reach up to 15 to 50% in young subjects with secondary causes known to cause osteoporosis.[18–33] In our study, all the patients with secondary causes of osteoporosis were excluded, explaining relatively low prevalence.

Low BMD was evaluated in both genders and different MRI findings. There was no significant association of low BMD between both genders and in different MRI findings in both genders separately. In our study, the prevalence of low BMD was 14.5% in patients with degenerative spine, 10% in inflammatory etiology (spondyloarthropathy), 16.7% in infective etiology, and 7.3% in patients with no significant imaging abnormality. Grams et al,[34] in their study, were able to demonstrate lower BMD with increasing severity of degenerative changes in the spine. This was interpreted to indicate that the negative correlation between the degenerative changes of the spine and the BMD could be a local phenomenon. In ankylosing spondylitis (AS), two opposite bone remodeling processes take place in close vicinity within the spine; these are pathologic new bone formation in the cortical zone of the vertebrae, the zygapophyseal joints, and the ligamentous apparatus and excessive trabecular bone loss in the center of the vertebral body leading to osteoporosis. The new bone formation that is characteristic of AS causes an overestimation of the total BMD, and values can be normal or high, even when osteoporosis is present. Klingberg et al[35] showed the prevalence of osteoporosis to be 5% in patients with AS who were under the age of 50 years. In our study, the prevalence was 10%. However, this value may be overestimated due to a smaller number of cases with inflammatory etiology as a cause of LBP ($n = 10$, accounting for 7.1% of total subjects) and overestimation of DEXA-BMD due to ongoing new bone formation. Bone loss in pyogenic spondylodiscitis patients is usually rapidly progressive and highly destructive.[36] In our study, the prevalence of osteoporosis was 16.7% in patients with infective spondylodiscitis. In our study, 29.3% ($n = 41$) of patients had no imaging abnormality as the cause of LBP; 7.3% of these patients had low BMD (10% females and 4.8% males). This can be explained by reduced physical activity in LBP patients, accounting for the gradual loss of bone mass. Snider et al[8] studied 63 individuals; 16 of them had LBP and showed that the patients with LBP had significantly lower BMD values at the lumbar spine than those without LBP.

In our study, there was a significant association of low BMD with duration of LBP, showing an incremental trend with increasing duration of LBP in both the genders and all MRI findings. This suggests bone loss secondary to limited

physical activity because of LBP in low BMD patients. No previous studies have shown similar findings in this age group.

Iwahashi et al[13] showed that the patients with sarcopenia had exacerbated LBP and poor quality of life due to a decrease in antigravity muscles and vertebral body fractures. Our study calculated the SMA and SMI to estimate muscle mass. There was no significant association of SMA and SMI with different MRI findings in the setting of LBP in both genders. For all the etiologies of LBP in our study, except infective etiology, the SMA and SMI of male patients were significantly higher than their female counterparts. A similar finding was shown in a study by Kalichman et al,[37] where it was demonstrated that paraspinal muscle density is higher in men than in women, and it decreases with age. Walsh et al[12] showed the prevalence of sarcopenia in premenopausal osteopenic women was higher compared with those with normal BMD. Hides et al[38] found marked wasting of multifidus on the symptomatic side, isolated to one vertebral level in patients with LBP. Danneels et al[39] showed that in chronic LBP, L4 multifidus muscle density was reduced in association with facet joint arthropathy or spondylolisthesis at the L4–L5 level.

SMA and SMI of patients with abnormal MRI study (degenerative, infective, and inflammatory etiology) and normal MRI of the LS spine study were comparable in all the categories of duration of symptoms. However, in both the MRI categories (abnormal and normal), SMA and SMI decline with an increase in duration of symptoms. This association was significant statistically, with p-value <0.001. The association of reduced SMA and SMI as markers of sarcopenia has been sparsely studied. Hao et al[40] reported a positive association between SMI and physical activity. However, there is limited knowledge regarding the association between skeletal muscle mass changes and the amount of physical activity for individuals aged 30 to 60 years. A study by Murata et al[41] indicated that exercise burning 900 kcal/week, including daily movement such as commuting on foot, attenuates erector muscle area loss in male subjects. LBP patients have limited physical activity due to the discomfort and accentuation of pain, which could decrease paraspinal muscle mass over a longer period. O'Sullivan et al[42] reported good clinical efficacy (decreased pain intensity and functional disability) of specific training of muscles surrounding the spine in individuals with spondylolysis and spondylolisthesis. This suggests that SMA and SMI, as imaging markers of sarcopenia, decrease significantly with an increase in the duration of symptoms, and therefore, early intervention is recommended to treat the cause of LBP. Sarcopenia is a marker of falling leading to impaired balance, and thus, the risk of vertebral fracture in the background of osteoporosis increases manyfold.[43] Therefore, combining low BMD and low muscle mass could indicate a higher fracture risk.

Limitation

Additional larger studies are needed to establish and validate this observation and establish the normal cutoff values to diagnose paraspinal sarcopenia in males and females in different age groups. This would enable the identification of pathological deviations in sarcopenia parameters and the development of prevention and treatment strategies for LBP.

Conclusion

There was no significant association between osteoporosis and sarcopenia with different MRI findings of LS spine in both male and female genders in this age group undergoing evaluation for LBP. However, there was a statistically significant association between these entities and LBP duration. These common clinical conditions, if not addressed adequately and early, might cause poor quality of life in future, including higher fragility fracture risk. Also, both sarcopenia and osteoporosis presenting in old age as a debilitating condition may have their onset at a very early age.

Ethical Approval

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards.

Informed Consent

Informed consent was obtained from all individual participants included in the study.

Conflict of Interest

None declared.

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