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MRI MORPHOMETRY OF LUMBAR DISCS AND VERTEBRAL BODIES IN CORRELATION WITH SERUM VITAMIN D LEVEL

MORFOMETRIA DE RM DE DISCOS LOMBARES E CORPOS VERTEBRAIS EM CORRELAÇÃO COM O NÍVEL SÉRICO DE VITAMINA D

MORFOMETRÍA DE RM DE DISCOS LUMBARES Y CUERPOS VERTEBRALES EN CORRELACIÓN CON EL NIVEL SÉRICO DE VITAMINA D

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ABSTRACT

Introduction: The knowledge of the intervertebral disc morphology and its relation with the vertebrae is vital for managing degenerative spine disease. It is imperative to study the role of preventable and treatable causes, such as Vitamin D deficiency, so that standard guidelines can be framed for apt management. Objective: To evaluate the correlation between serum vitamin D levels and MRI morphometry of lumbar intervertebral discs. Methods: A total of 100 subjects (20-40 years) underwent an MRI of the lumbosacral spine. Intervertebral disc and vertebral body heights were measured, and disc degenerative changes were noted. Serum vitamin D levels were correlated with disc changes using the Pearson/Spearman rank correlation coefficient. A p-value of <0.05 was considered significant. Results: Vitamin D deficiency showed a high prevalence in patients with disc degenerative diseases, even in young adults and females with more severe vitamin D deficiency than males (p-value < 0.001). However, a significant relationship between vitamin D levels and disc or vertebral body heights could not be established. Conclusion: Vitamin D deficiency is more prevalent in patients with disc degenerative changes; however, its effect on disc and vertebral body heights needs to be extrapolated further in larger studies. ***Level of Evidence I; Cross-Sectional, Observational Study.***

Keywords: Spine; Intervertebral Disc; Vertebral Body; Intervertebral Disc Degeneration; Vitamin D.

RESUMO

Introdução: O conhecimento da morfologia do disco intervertebral e sua relação com as vértebras é vital para o manejo da doença degenerativa da coluna. É imperativo estudar o papel das causas evitáveis e tratáveis, como a deficiência de vitamina D, para que possam ser elaboradas diretrizes padrão para um manejo adequado. Objetivo: Avaliar a morfometria da ressonância magnética dos discos intervertebrais lombares em correlação com os níveis séricos de vitamina D. Métodos: Um total de 100 indivíduos (20-40 anos) foram submetidos a ressonância magnética da coluna lombossacra. As alturas do disco intervertebral e do corpo vertebral foram medidas e alterações degenerativas do disco foram anotadas. Os níveis séricos de vitamina D foram correlacionados com alterações discais usando o coeficiente de correlação de Pearson/Spearman. Um valor de p <0,05 foi considerado significativo. Resultados: A deficiência de vitamina D apresentou alta prevalência em pacientes com doenças degenerativas do disco, mesmo em adultos jovens e mulheres que apresentavam deficiência de vitamina D mais grave que os homens (valor p < 0,001). No entanto, não foi possível estabelecer uma relação significativa entre os níveis de vitamina D e a altura do disco ou do corpo vertebral. Conclusão: A deficiência de vitamina D é mais prevalente em pacientes com alterações degenerativas do disco, no entanto, seu efeito na altura do disco e do corpo vertebral precisa ser extrapolado em estudos maiores. ***Nível de Evidência I; Estudio Observacional Transversal.***

Descritores: *Coluna Vertebral; Disco Intervertebral, Corpo Vertebral; Degeneração do Disco Intervertebral; Vitamina D.*

RESUMEN

Introducción: El conocimiento de la morfología del disco intervertebral y su relación con las vértebras es vital para el tratamiento de las enfermedades degenerativas de la columna vertebral. Es imprescindible estudiar el papel de las causas prevenibles y tratables, como la deficiencia de vitamina D, para poder elaborar directrices estándar para un tratamiento adecuado. Objetivo: Evaluar la morfometría por resonancia magnética de los discos intervertebrales lumbares en correlación con los niveles séricos de vitamina D. Métodos: Un total de 100 individuos (20-40 años) se sometieron a una resonancia magnética de la columna lumbosacra. Se midieron las alturas del disco intervertebral y del cuerpo vertebral y se observaron cambios degenerativos en el disco. Los niveles séricos de vitamina D se correlacionaron con los cambios discales mediante el coeficiente de correlación Pearson/Spearman. Se consideró significativo un valor p <0,05. Resultados: La deficiencia de vitamina D mostró una elevada prevalencia en pacientes con enfermedad degenerativa discal, incluso en adultos jóvenes y mujeres que presentaban una deficiencia de vitamina D más grave que los hombres (valor p <

Study conducted by the Department of Radio-diagnosis, Vardhman Mahavir Medical College & Safdarjung Hospital, New Delhi.
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0,001). Sin embargo, no fue posible establecer una relación significativa entre los niveles de vitamina D y la altura del disco o del cuerpo vertebral. Conclusión: La deficiencia de vitamina D es más prevalente en pacientes con cambios degenerativos del disco; sin embargo, su efecto sobre la altura del disco y del cuerpo vertebral debe extrapolarse en estudios mayores. ***Nivel de Evidencia I; Estudio Observacional Transversal.***

Descriptores: *Columna Vertebral; Disco Intervertebral; Cuerpo Vertebral; Degeneración del Disco Intervertebral; Vitamina D.*

INTRODUCTION

Chronic low back pain (CLBP) is defined as pain or stiffness persisting for ≥ 12 weeks and localized below the costal margins and above the inferior gluteal folds, which may be accompanied by sciatica.[1] Low backache is one of the most common musculoskeletal pains of which degenerative disc changes contribute to significant morbidity and functional disability worldwide.[2]

The vertebral bodies (VB) are separated by intervertebral discs (IVD), comprising a soft deformable nucleus pulpous at the center surrounded by tough concentric layers of annulus fibrosus. An important mechanism in the pathogenesis of disc degeneration is the alteration in the extracellular matrix for which various inflammatory mediators have been identified.[3] When degeneration sets in, there is a reduction in the intervertebral discs' flexibility and height, leading to disc prolapse, spinal canal, and intervertebral foramina narrowing, resulting in compressive neuropathy.

CLBP, in clinical terms, is a multi-factorial process resulting from the interaction of somatic, psychosocial, and environmental factors. The relationship between serum vitamin D levels (S. Vit D) and its effect on the intervertebral disc, apart from the vertebral bodies, can be an important causative factor of pain. Vitamin D receptors have been identified in the disc's osteoblasts, chondrocytes, nucleus pulposus, and annulus fibrosus. The association of its genetic polymorphism with the development of lumbar disc degeneration and herniation has been documented.[4]

Only a few studies have dwelled on the influence of osteoporosis on the morphology of vertebral bodies, especially on the morphology of intervertebral discs; hence, no definite consensus has been reached.[5,6] Few previous reports on the relationship between vertebral and disc heights and osteoporosis are quite diverse, and range from decreased to preserved disc height or even increased disc height.[7,8] Furthermore, Modic changes on MRI are also more common in patients with low vitamin D levels.[9] Various studies involving research on genetic polymorphisms in IVD degeneration have found a definite role of Vit D receptors in increasing susceptibility for disc degeneration. Still, very few studies have tried to radiologically correlate the morphometric changes in IVD with changes in S. Vit D level. [4,10]

Since the advent of diagnostic radiology, various modalities such as plain radiography, computed tomography, and magnetic resonance imaging have been used to study the IVD space and related pathologies in patients with low back pain. Plain radiograph remains the first line of investigation to look for obvious IVD space narrowing. However, it has limited use due to low accuracy in delineating soft tissue pathologies and 2-dimensional projection images which are vulnerable to distortion and magnification errors.[11]

Computed tomography (CT scan) can also measure IVD space as the distance between adjacent VB; however, because of its poor soft-tissue resolution, the status of degenerative disc changes is not visualized.[12]

MRI is the standard imaging modality for IVD pathology due to the advantages of lack of radiation, multi-planar imaging capacity, excellent spinal-soft tissue contrast, and precise localization of pathology. However, until now, MRI has not been used to investigate the changes that occur in IVD following decreasing S. Vit D levels. The present cross-sectional MRI-based study endeavors to fill that void by looking at the morphometric changes in lumbar IVD and VB in young adult subjects suffering from CLBP and correlating the same with S. Vit D levels.

METHODS

A cross-sectional, observational study was conducted for a duration of 18 months at VMMC & Safdarjung Hospital, New Delhi. Inclusion criteria: One hundred young adult patients, aged 20-40 years, presenting with CLBP, persistent for ≥ 12 weeks were included in the study with approval from an institutional ethical committee (S No. IEC/VMMC/SJH/Thesis/October/2018-75). Written informed consent was obtained from the patients.

Exclusion criteria: Patients with radiological evidence of metastases, spondylolisthesis, infectious diseases, severe kyphoscoliosis, rheumatological disorders, history of spinal surgery/trauma, hormonal therapy or taking vitamin D supplements, pregnant/lactating females, and patients with contraindication to MRI were excluded from the study.

MRI of the lumbar spine was performed using a 1.5-Tesla (Philips Achieva) MR scanner. A series of sagittal T1 & T2W and axial T2WI were obtained at (TR = 3500 ms, TE = 120 ms, matrix = 512 × 281, field of view = 320 × 320 mm, slice thickness = 5 mm, inter-slice gap = 0.5 mm, number of signal acquisition = 2 and turbo spin-echo factor=17). MR images were analyzed at the central slice of each IVD and VB level by a single radiologist (8 years of experience). The key measurements were anterior IVD height (ADH) measured in the area connecting the tips of the anterior margin of the adjacent VBs, middle IVD height (MDH) measured in the area connecting the central portion of the lower margin of the upper lumbar vertebra and the central portion of the upper margin of the lower lumbar vertebra and posterior IVD height (PDH) measured in the area connecting the tips of posterior margin of the adjacent VB's. (Figure 1)

Disc desiccation was defined as loss of central high signal on T2WI.[13] A diffuse disc bulge was defined as a symmetrical extension of IVD beyond the margins of the adjacent VB. Disc herniation was defined as the displacement of intervertebral disc material beyond the normal confines of the disc but involving less than 25% of the circumference (to distinguish it from a disc bulge). Disc protrusion was defined as a focal, asymmetric extension of disc tissue beyond the VB margin when the base (mediolateral dimension along the posterior margin of the disc) was broader than any other dimension. Disc extrusion was a more pronounced version of protrusion with disruption of the outer fibers of the annulus, and the disc abnormality was greater in its anteroposterior dimension than at its base. When the extruded disc is removed, the sequestered disc loses its attachment to the parent disc.[14]

Spinal stenosis was labeled when either the disc caused compression over the thecal sac or compressed the traversing and/or exiting nerve roots.[14] Other parameters in VB: Anterior, middle, and posterior vertebral heights (AVH, MVH, and PVH) were measured by the line joining superior and inferior vertebral endplates anteriorly, in the center, and posteriorly. End plate Modic changes were mentioned as Absent/ Type1, Type 2, or Type3.[14]

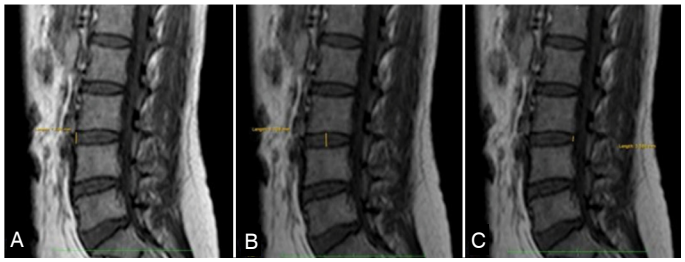

Figure 1. T1 weighted sagittal images showing measurement of disc height (A) Anterior disc height: measured by a line joining the anterior-most point in the adjacent vertebral endplate. (B) Mid-disc height is measured by a line joining the midpoint of the adjacent vertebral endplate. (C) A line joining the posterior-most point in the adjacent vertebral endplate measures the posterior disc height.

Serum vitamin D levels were measured by ELISA and considered sufficient if ≥30 ng/ml, insufficient if between 20 and 30 ng/ml, and deficient if <20 ng/ml.[15]

STATISTICAL ANALYSIS

The data was entered into the MS EXCEL spreadsheet, and analysis was done using Statistical Package for Social Sciences (SPSS version 21.0 Manufacturer: IBM Company, New Delhi, India). Categorical variables were presented in number and percentage (%) and continuous variables were presented as mean ± SD and median. The Kolmogorov-Smirnov test tested the normality of data. If the normality was rejected, then the non-parametric test was used. Quantitative variables were compared using the unpaired t-test/Mann-Whitney Test (when the data sets were not normally distributed) between vitamin D deficiency, insufficiency, and sufficiency. Qualitative variables were compared using the Chi-Square test /Fisher's exact test. Pearson/Spearman, rank correlation coefficients correlated lumbar IVD space with Vit D levels. A P-value of <0.05 was considered statistically significant.

RESULTS

Demographic data

The study comprised 42 male and 58 female patients aged 20-40 years, the mean age being 30.9 years. The mean value of S. Vit D levels was 27.8 ng/ml. Among the age subgroups, S. Vit D levels were the lowest among 36-40 yrs. the difference was statistically significant, with a p-value of 0.006 (Figure 2). It was lower in females (mean: 25.76ng/mL) as compared to males (mean: 29.38ng/mL) with 44% and 24% of females having deficient and insufficient levels respectively. The deficient S. Vit D group constituted largely of females (92.9%), with a p-value of 0.001. (Figure 3)

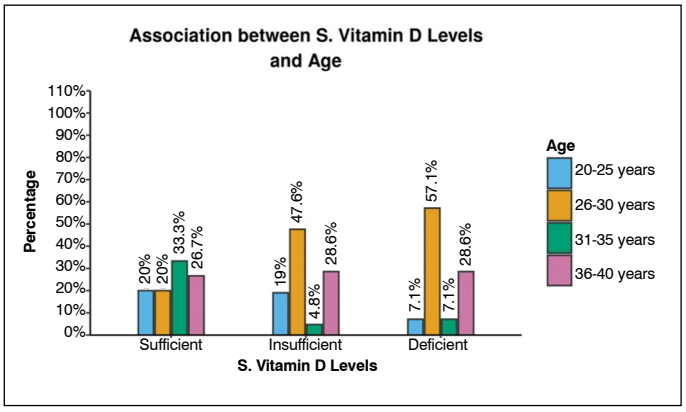

Figure 2. Association between S. Vitamin D Levels and Age.

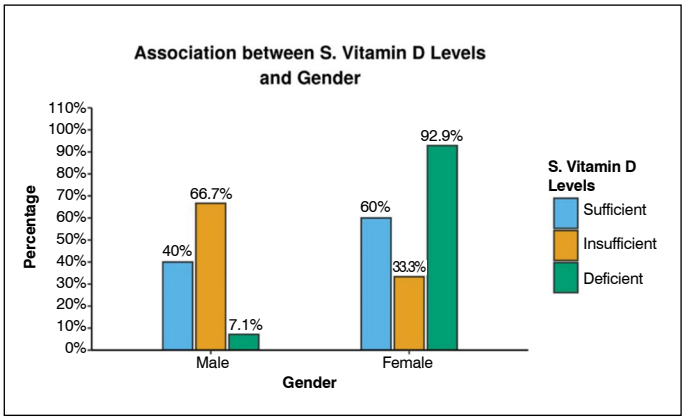

Figure 3. Association between S. Vitamin D Levels and Gender.

Relationship between Intervertebral Disc Height and Serum Vitamin D levels

In the present study, no significant correlation between IVD height and S. Vit D levels could be established. At the L1-L2 level, there was a weak positive correlation between ADH and S. Vit D levels, but it was not statistically significant (rho 0.06, p 0.421), and a weak negative correlation between MDH & PDH and S. Vit D levels, which was again not statistically significant (rho -0.01 & -0.07, p-value 0.831 & 0.819 respectively). At the L2-L3 level, there was a weak negative correlation between ADH & PDH and S. Vit D levels. Still, it was not statistically significant (rho -0.13 & -0.06, p-value 0.618 & 0.585 respectively). A weak positive correlation between MDH and S. Vit D levels was not statistically significant (rho 0.02, p-value 0.341). Similarly, no significant correlation was found at L3-L4 and L4-L5 disc levels. However, at the L5-S1 level, there was a weak negative correlation between ADH and S. Vit D levels, and this correlation was found to be statistically significant (rho -0.26, p-value 0.008). (Table 1)

Relationship between Intervertebral Disc Area and Serum Vitamin D levels

There was a weak positive correlation between the disc area and S. Vit D levels at the L1-L2 level, which was statistically significant (rho 0.21, p-value 0.013). For every 1 unit increase in disc area (L1-L2), the S. Vit D increases by 0.001 units. Conversely, for every 1 unit increase in S. Vit D, the disc area (L1-L2) increases by 9.60 units. Similarly, there was a weak positive correlation between disc area and S. Vit D levels at the L2-L3 level, but it was not statistically significant. On the contrary, there was a weak negative correlation between disc area and S. Vit D levels from L3-L4 to L5-S1 levels, which was again not statistically significant. (Table 2)

Relationship between Intervertebral Disc Degeneration and Serum Vitamin D levels

To compare the variables of disc degeneration characteristics, including disc desiccation, disc herniation, and spinal stenosis, they were distributed into two subgroups: absent or present. The variable S. Vit D (ng/mL) was not normally distributed in these two subgroups. Thus, a non-parametric test (Wilcoxon-Mann-Whitney U Test) was used to make group comparisons. There was a significant difference between the two subgroups of Disc desiccation in terms of S. Vit D, with S. Vit D being lowest in the group with Disc DesicL1-L2 to L5-S1 levels) (Table 3). Similarly, there was a significant difference between the two subgroups of Disc herniation, with S. Vit D being the lowest in the group with Disc herniation (L1-L2 to L5-S1 levels) (Table 4). Also, there was a significant difference between the two subgroups of Spinal stenosis, with S. Vit D being the lowest in the group with spinal stenosis (L3-L4 to L5-S1 levels). (Table 5)

Relationship between Vertebral Body height and Serum Vitamin D levels

The present study revealed no significant correlation between vertebral body heights and Serum Vitamin D levels. At the L4 level, MVH and PVH showed a statistically significant correlation (p-value 0.019 & 0.048 respectively). At the L5 level, AVH & PVH showed a statistically significant correlation (p-value 0.003 & 0.001 respectively). However, no significant correlation was found at the L1, L2, and L3 levels. (Table 6)

DISCUSSION

Lumbar intervertebral disc degeneration accounts for the leading cause of low backache in adults of all age groups. With a rapidly evolving lifestyle and nutritional habits, it is foreseeable that a mounting number of young individuals are developing low backaches with evidence of disc degeneration in imaging studies; hence, it is imperative to study these changes. As we know, vitamin D is crucial for bone metabolism and the pathogenesis of disc degeneration.[5] The present study was undertaken to evaluate the morphometry of

Table 1. Association between S. Vitamin D(ng/ml) and Intervertebral Disc height (mm).

Intervertebral Disc Height (mm)	Serum Vitamin D levels									P-value (for comparison of the three groups on each of the variables: Kruskal Wallis Test)		
	Sufficient			Insufficient			Deficient					
	Mean (SD)			Mean (SD)			Mean (SD)					
	ADH	MDH	PDH	ADH	MDH	PDH	ADH	MDH	PDH	ADH	MDH	PDH
L1-L2	4.91 (1.01)	6.97 (1.23)	3.87 (0.76)	4.90 (1.34)	6.88 (1.86)	4.10 (1.08)	4.57 (0.81)	6.78 (1.41)	3.87 (0.81)	0.421	0.831	0.819
L2-L3	5.55 (1.42)	8.11 (1.88)	4.06 (1.07)	5.34 (1.46)	7.58 (1.85)	3.95 (1.25)	5.69 (1.49)	7.72 (2.21)	3.78 (0.72)	0.618	0.341	0.585
L3-L4	6.71 (1.55)	9.27 (1.58)	4.45 (1.32)	6.75 (1.70)	8.88 (1.78)	4.53 (1.05)	6.66 (1.53)	8.59 (1.04)	4.27 (0.70)	0.850	0.249	0.702
L4-L5	8.61 (1.93)	10.25 (1.75)	4.94 (1.40)	8.29 (2.11)	9.63 (1.78)	4.49 (1.00)	8.04 (2.11)	9.55 (1.37)	5.22 (1.62)	0.537	0.348	0.182
L5-S1	8.60 (2.47)	9.92 (2.01)	4.85 (1.43)	9.07 (2.43)	9.37 (2.06)	4.69 (1.18)	11.05 (5.57)	9.66 (4.00)	6.94 (6.05)	0.008	0.546	0.134

ADH Anterior Intervertebral Disc Height. MDH Middle Intervertebral Disc Height. PDH Posterior Intervertebral Disc Height.

Table 2. Association between S. Vitamin D(ng/ml) and Intervertebral disc area (sq. mm).

Intervertebral Disc Area (sq.mm)	Serum Vitamin D levels			P-value	Spearman Correlation Coefficient
	Sufficient	Insufficient	Deficient		
	Mean (SD)	Mean (SD)	Mean (SD)		
L1-L2	4410.42 (807.75)	4232.02 (684.44)	3883.58 (464.55)	0.013	0.210
L2-L3	4902.36 (769.03)	4625.53 (765.33)	4431.72 (558.91)	0.100	0.150
L3-L4	4869.20 (1571.30)	5074.30 (809.04)	5106.12 (850.50)	0.957	-0.080
L4-L5	5611.25 (871.69)	5706.05 (819.89)	5673.85 (845.99)	0.631	-0.100
L5-S1	5170.36 (753.35)	5314.20 (856.59)	5624.88 (1410.06)	0.811	-0.260

Table 3. Association between S. Vitamin D(ng/ml) and Intervertebral disc desiccation.

Intervertebral Disc Desiccation	Serum Vitamin D levels			P-value
	Sufficient	Insufficient	Deficient	
L1-L2	0 (0.0%)	2 (4.8%)	6 (21.4%)	0.006
L2-L3	2 (6.7%)	4 (9.5%)	10 (35.7%)	0.007
L3-L4	4 (13.3%)	4 (9.5%)	10 (35.7%)	0.015
L4-L5	6 (20.0%)	24 (57.1%)	18 (64.3%)	0.001
L5-S1	4 (13.3%)	24 (57.1%)	20 (71.4%)	<0.001

Table 4. Association between S. Vitamin D(ng/ml) and Intervertebral disc herniation.

Intervertebral Disc Herniation	Serum Vitamin D levels			P-value
	Sufficient	Insufficient	Deficient	
L1-L2	0 (0.0%)	0 (0.0%)	4 (14.3%)	0.005
L2-L3	2 (6.7%)	2 (4.8%)	8 (28.6%)	0.009
L3-L4	2 (6.7%)	2 (4.8%)	10 (35.7%)	0.001
L4-L5	8 (26.7%)	24 (57.1%)	18 (64.3%)	0.008
L5-S1	4 (13.3%)	22 (52.4%)	20 (71.4%)	<0.001

Table 5. Association between S. Vitamin D(ng/ml) and Spinal stenosis.

Intervertebral Disc Herniation	Serum Vitamin D levels			P-value
	Sufficient	Insufficient	Deficient	
L1-L2	0 (0.0%)	0 (0.0%)	0 (0.0%)	1.000
L2-L3	2 (6.7%)	0 (0.0%)	2 (7.1%)	0.172
L3-L4	0 (0.0%)	0 (0.0%)	4 (14.3%)	0.005
L4-L5	2 (6.7%)	8 (19.0%)	12 (42.9%)	0.003
L5-S1	0 (0.0%)	8 (19.0%)	10 (35.7%)	0.002

IVD and VB on MRI in tandem with S. Vit D levels in young adults with chronic low backaches.

Most of the patients in the present study belonged to the age group 26-30 years, with the average age being 30.9 years, whereas in another similar study by Hong et al., the average age was 20.7 years.[16] In a study done by Çalik et al on chronic low back-leg pain, they found that 22.8% of patients had Vit D deficiency, 42.8% had insufficiency, and 34.5% had normal levels of Vit D.[15] These results were comparable to the present study where only 30% of patients had sufficient Vit D levels whereas 42% had insufficient and 28% had deficient levels, respectively.

In the present study, the average ADH at L1-L2, L2-L3, L3-L4, L4-L5, and L5-S1 levels was 4.81mm, 5.51mm, 6.71mm, 8.31mm, and 9.48 mm respectively as compared to the study by Hong et al., in which the average disc height at all levels was relatively more prominent, which may be due to the selection of patients without degenerative disc disease in the former.[16] The studies done by Kwok et al and Bagri et al had shown that a decline in bone mineral density (BMD) was associated with a decrease in VB height leading to an increase in the bi-concavity index and a decrease in the ADH & PDH along with an increase in MDH.[6,10] Several studies have shown a linear relationship between BMD and S. Vit D levels; however, the same results were not reciprocated while correlating IVD & VB height and S. Vit D levels, suggesting the involvement of other confounding factors in the mechanism.[17,18]

In the current study, 54 subjects had disc desiccation changes, the maximum being at L4-L5 and L5-S1 levels (each in 48 subjects) and the least at the L1-L2 level (8 subjects). On the other hand, disc herniation was noted in 52 subjects, the highest at the L4-L5 level (50 subjects) and the least at the L1-L2 level. Spinal stenosis was noted in 26 subjects at one/or more levels, being highest at the L4-L5 level (22 subjects). This was also in concordance with earlier studies, which revealed that disc degeneration occurred most commonly at the L4-L5 level. However, these studies were done in a wider age group and did not focus on young adults as their primary patient population.[19]

S. Vit D levels showed a significant correlation with all the three--disc degenerative parameters, i.e., disc desiccation, disc herniation, and spinal stenosis, with the median S. Vit D levels being the lowest in the group of patients showing these changes. This implies that S. Vit D levels are inversely related to disc degeneration changes and patients with lower Vit D levels are at higher risk of developing lumbar degenerative disc disease. This is in concordance with the study done by Zolfaghari et al., which showed a high prevalence of vitamin D deficiency in patients with degenerative diseases of the spine who are about to undergo spinal surgery.[20] These results of the present study were also consistent with that of another study by Xu HW et al., which analyzed the influence of vitamin D status on lumbar disc degeneration in postmenopausal women and found that S. Vit D levels <10ng/ml is a specific marker of severe disc degeneration and low back pain.[21]

Mattam et al. conducted a study on the Indian population and found that 80% of patients with CLBP had low S. Vit D levels. They also concluded that low S. Vit D levels were associated with Modic changes.[9] However, in the present study, no significant difference

Table 6. Association between S. Vitamin D(ng/ml) and Vertebral body height (mm).

Vertebral Body Height (mm)	Serum Vitamin D levels									P-value (for comparison of the three groups on each of the variables: Kruskal Wallis Test)		
	Sufficient			Insufficient			Deficient					
	Mean (SD)			Mean (SD)			Mean (SD)					
	AVH	MVH	PVH	AVH	MVH	PVH	AVH	MVH	PVH	AVH	MVH	PVH
L1	23.13 (1.31)	36.06 (54.65)	25.28 (1.14)	23.94 (2.33)	21.33 (4.42)	25.11 (2.23)	22.99 (2.24)	21.06 (1.47)	24.27 (1.65)	0.076	0.101	0.055
L2	24.69 (1.33)	22.08 (1.65)	26.43 (1.43)	24.21 (4.55)	22.50 (2.46)	26.61 (2.35)	24.24 (2.27)	19.01 (7.28)	25.79 (2.01)	0.149	0.065	0.224
L3	24.45 (1.59)	21.89 (1.62)	26.07 (1.72)	25.46 (2.49)	22.76 (2.29)	26.20 (2.45)	24.64 (2.63)	21.81 (1.90)	25.57 (2.29)	0.107	0.062	0.598
L4	24.87 (1.67)	20.87 (1.90)	24.65 (1.73)	25.22 (2.46)	21.14 (4.28)	25.39 (2.16)	24.45 (2.29)	20.97 (1.67)	24.51 (2.43)	0.312	0.019	0.048
L5	25.53 (2.11)	19.33 (2.65)	21.53 (1.77)	24.68 (1.99)	19.84 (2.17)	22.99 (2.42)	23.57 (3.20)	19.01 (2.28)	21.70 (1.58)	0.003	0.179	0.001

AVH Anterior Vertebral Body Height. MVH Middle Vertebral Body Height. PVH Posterior Vertebral Body Height.

was noted between the patients with/without Modic changes in terms of S. Vit D levels.

The potential limitations of the present study include a small sample size, whose application to a wide population, is yet to be evaluated. MRI was done in the recumbent position, with minimal axial load on the lumbar spine. The patient's weight, BMI, dietary habits, and sunlight exposure were also not taken into account.

Henceforth, multi-centric studies with a standardized technique, a much larger sample of subjects, and a wider spectrum of the population across diverse demographic and socio-economic backgrounds and ethnicities are needed for the corroboration of these results. Such studies should also consider correlating BMD and S. Vit D levels to understand disease pathogenesis better. Taking this study, a step further, a follow-up MRI can be done after the correction of Vit D deficiency to assess for reversibility of disc changes, which can be instrumental in supplementing Vit D in patients with early degenerative disc changes.

CONCLUSIONS

The correlation between disc degenerative changes and S. Vit D levels in the present study reveals that S. Vit D deficiency shows a high prevalence in patients with degenerative diseases of the disc, even in young adults and females who show more severe deficiency than males. However, contrary to expectations, we could not establish a significant relationship between S. Vit D deficiency and IVD and VB heights. It follows that S. Vit D deficiency accelerates lumbar disc degeneration; however, its effect on disc and vertebral body heights needs to be extrapolated further in larger studies.

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Availability of data and materials

The cases and the images are available from the Department of Radiodiagnosis, Vardhman Mahavir Medical College, and Safdarjung Hospital, New Delhi, India.

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