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Original Article

Modic Changes on MRI Lumbar Spine and Their Risk Factors in Patients Presenting to A Tertiary Care Hospital

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ABSTRACT

Background: Modic changes are vertebral endplate and adjacent bone marrow signal abnormalities detected on magnetic resonance imaging and are considered part of the degenerative disc disease spectrum. Their prevalence and associated risk factors have been widely studied internationally, but local data from Pakistan remain limited. Objective: To determine the frequency and subtype distribution of Modic changes on lumbar spine MRI and evaluate their association with demographic, anthropometric, lifestyle, and occupational risk factors among adults presenting to a tertiary care hospital. Methods: This cross-sectional observational study included 186 patients aged 30 years and above who underwent lumbar spine MRI at the Department of Diagnostic Radiology, Combined Military Hospital, Abbottabad. Demographic data, residence, BMI, smoking status, smoking exposure, occupational workload, and MRI findings were recorded. Modic changes were classified into Type I, Type II, and Type III according to standard MRI signal characteristics. Data were analyzed using SPSS version 23, and associations were assessed using the chi-square test, with $p \leq 0.05$ considered statistically significant. Results: The mean age was 54.26 ± 14.23 years, and the mean BMI was 27.35 ± 3.74 kg/m². Modic changes were identified in 53 patients (28.5%), with Type II being the most frequent subtype. The presence of Modic changes was not significantly associated with gender, residence, BMI category, or occupational workload, while smoking showed a borderline association. Lesion burden was significantly associated with smoking status ($p = 0.036$) and occupational workload ($p = 0.018$), with multiple Modic changes more frequent among heavy labor workers. Conclusion: Modic changes were common among adults undergoing lumbar spine MRI, with Type II changes predominating. Heavy occupational workload was associated with greater lesion burden, suggesting a possible role of mechanical stress in vertebral endplate degeneration. Keywords: Modic changes, lumbar spine MRI, vertebral endplate, degenerative disc disease, occupational workload, low back pain.

INTRODUCTION

Low back pain is one of the leading causes of musculoskeletal disability worldwide and imposes a substantial clinical and socioeconomic burden, particularly among adults with recurrent or chronic symptoms. Degenerative pathology of the lumbar spine is frequently implicated in these patients, and magnetic resonance imaging has become the principal imaging modality for evaluating intervertebral discs, vertebral endplates, bone marrow, ligaments, and neural structures because of its superior soft-tissue contrast and ability to detect early degenerative changes (1). Among MRI-detected degenerative findings, Modic changes are of particular clinical interest because they represent signal alterations in the vertebral endplate and adjacent bone marrow, reflecting structural and biological changes within the disc endplate marrow complex (2).

Modic changes were originally described as vertebral body marrow signal abnormalities adjacent to degenerated intervertebral discs and are classified into three types according to MRI signal characteristics and histopathological correlates. Type I changes appear hypointense on T1-weighted images and hyperintense on T2-weighted images, corresponding to marrow edema, inflammation, and vascular granulation tissue. Type II changes are hyperintense on T1-weighted images and iso- to hyperintense on T2-weighted images, indicating fatty replacement of bone marrow. Type III changes are hypointense on both T1- and T2-weighted images and are associated with subchondral sclerosis (3). This classification is clinically important because different Modic subtypes may represent different stages of vertebral endplate degeneration and may vary in their relationship with symptoms, particularly chronic low back pain.

The clinical relevance of Modic changes has been increasingly investigated over recent decades. Several studies have reported an association between Modic changes and low back pain, with Type I changes often considered more strongly related to active inflammatory pain because of their association with edema and inflammatory remodeling of the vertebral endplate region (4). The vertebral endplate plays a central role in mechanical load transmission and nutritional diffusion between the vertebral body and intervertebral disc. Disruption of this interface may impair disc nutrition, promote inflammatory responses, and contribute to mechanical instability, thereby linking Modic changes to the broader spectrum of degenerative disc disease and pain generation.

International studies have reported variable prevalence rates of lumbar Modic changes, commonly ranging from approximately 20% to 50% depending on population characteristics, symptom status, imaging criteria, and spinal level assessed. Age is a consistently reported determinant, as progressive disc dehydration, cumulative mechanical loading, and microstructural endplate damage become more frequent with advancing age (5). In addition to age, several potentially modifiable factors have been proposed. Increased body mass index may contribute to lumbar degeneration by increasing axial loading on intervertebral discs and vertebral endplates (6). Similarly, occupations involving heavy physical work, repetitive lifting, prolonged bending, or sustained spinal loading may expose the lumbar spine to repeated microtrauma and accelerate degenerative change in the disc–endplate complex (7).

Smoking has also been examined as a possible contributor to Modic changes and degenerative spinal disease. Nicotine and other components of cigarette smoke may impair microvascular circulation, reduce oxygen delivery, and interfere with nutrient diffusion to the intervertebral disc and vertebral endplate. These mechanisms provide biological plausibility for a relationship between smoking and endplate degeneration, although published findings remain inconsistent, with some studies reporting positive associations and others showing weak or non-significant relationships (8). This uncertainty highlights the need to evaluate smoking alongside other demographic and biomechanical risk factors in specific populations.

The pathophysiology of Modic changes is increasingly understood as a dynamic process rather than a static imaging finding. Longitudinal imaging studies suggest that Type I changes may evolve into Type II changes as inflammatory activity subsides and fatty marrow replacement develops, supporting the concept that Modic changes reflect different biological phases of disc–endplate degeneration (9). Therefore, assessment of both the presence and subtype of Modic changes may provide clinically meaningful information when interpreting lumbar spine MRI in patients with spinal symptoms.

Despite growing international evidence, data from South Asian populations remain limited, and evidence from Pakistan is particularly scarce. This is important because occupational patterns, lifestyle factors, body composition, healthcare access, and exposure to manual labor may differ from populations in which most previous studies have been conducted. Local studies of degenerative lumbar spine disease have often focused broadly on disc degeneration or other MRI abnormalities, with less attention to vertebral endplate signal changes and their associated risk factors (10). Establishing the prevalence and determinants of Modic changes in a Pakistani tertiary-care population may therefore improve radiological interpretation, support risk stratification, and help clinicians counsel patients regarding modifiable exposures such as obesity, smoking, and occupational workload (11).

Accordingly, this study aimed to determine the frequency and subtype distribution of Modic changes on lumbar spine MRI among adults aged 30 years and above presenting to a tertiary care hospital and to evaluate their association with demographic and lifestyle-related risk factors, including age, gender, body mass index, smoking status, and occupational physical workload.

MATERIALS AND METHODS

This cross-sectional observational study was conducted in the Department of Diagnostic Radiology, Combined Military Hospital, Abbottabad, over a six-month period after approval of the study synopsis and institutional ethical clearance. The study was designed to determine the frequency and MRI subtype distribution of Modic changes in the lumbar spine and to evaluate their association with selected demographic, anthropometric, lifestyle, and occupational risk factors among adults undergoing lumbar spine MRI for low back pain or related spinal symptoms. Ethical approval was granted under synopsis approval number RAD-2021-012-3525 and Ethical Ref. No. CPSP/REU/RAD-2021-012-3525. Written informed consent was obtained from all participants before enrollment, and patient confidentiality was maintained throughout data collection, image review, data entry, and statistical analysis.

The study population consisted of adult male and female patients aged 30 years and above who were referred from orthopedic and neurosurgery clinics for MRI evaluation of the lumbar spine because of low back pain or other clinically suspected lumbar spinal pathology. Patients were recruited from the radiology department through non-probability consecutive sampling until the required sample size was achieved. Eligible participants included all patients meeting the age criterion who underwent lumbar spine MRI during the study period and agreed to participate. Patients with a history of acute spinal trauma, known primary spinal tumor, metastatic disease, or spinal infection, including spinal tuberculosis, were excluded to reduce diagnostic confounding because these conditions may independently produce vertebral endplate or bone marrow signal abnormalities resembling degenerative Modic changes.

The sample size was calculated using the Epi Info statistical calculator by taking an expected prevalence of Modic changes of 22.4%, a 95% confidence level, and an acceptable margin of error of 6%. On the basis of these assumptions, a minimum sample size of 186 patients was required. Consecutive eligible patients were enrolled until this sample size was completed, thereby minimizing selection gaps during the defined recruitment period.

Data were collected using a structured data collection proforma after informed consent. Demographic and clinical information included age, gender, place of residence, smoking status, occupation, height, and body weight. Body mass index was calculated as weight in kilograms divided by height in meters squared and categorized into standard BMI groups. Smoking exposure was recorded according to smoking status, and smoking pack-years were calculated where applicable. Occupational physical workload was categorized as sedentary or light work versus heavy labor on the basis of the patient's usual occupational activity, with heavy labor representing work involving substantial physical effort, repetitive lifting, prolonged bending, or sustained axial loading of the lumbar spine.

All MRI examinations were performed using a 1.5-Tesla MRI scanner according to the standard lumbar spine imaging protocol used in the department. The protocol included sagittal T1-weighted, sagittal T2-weighted, and axial T2-weighted sequences of the lumbar spine. MRI images were reviewed by a consultant radiologist experienced in musculoskeletal imaging. Each scan was assessed for vertebral endplate and adjacent bone marrow signal abnormalities consistent with Modic changes. The presence or absence of Modic changes was recorded for each patient, and identified changes were classified into Type I, Type II, or Type III according to established MRI signal characteristics. Type I Modic changes were defined as low signal intensity on T1-weighted images and high signal intensity on T2-weighted images, consistent with marrow edema and inflammatory change. Type II changes were defined as high signal intensity on T1-weighted images and iso- to high signal intensity on T2-weighted images, consistent with fatty marrow replacement. Type III changes were defined as low signal intensity on both T1- and T2-weighted images, consistent with subchondral sclerosis.

The primary outcome variable was the presence of Modic changes on lumbar spine MRI. Secondary outcome variables included Modic subtype and the number of Modic changes, categorized as none, single, or multiple. Independent variables included age, gender, residence, BMI category, smoking status, smoking pack-years, and occupational workload. Standardized MRI criteria were applied during image interpretation to reduce classification variability, while predefined eligibility criteria were used to limit confounding from non-degenerative causes of vertebral signal alteration such as trauma, malignancy, metastasis, and infection. Data were entered using coded variables to maintain consistency, and all completed proformas were reviewed for completeness before statistical analysis.

Statistical analysis was performed using Statistical Package for Social Sciences version 23. Continuous variables, including age, BMI, and smoking pack-years, were summarized as mean and standard deviation. Categorical variables, including gender, residence, smoking status, BMI category, occupation, presence of Modic changes, Modic subtype, and number of Modic changes, were summarized as frequencies and percentages. Associations between Modic changes and categorical risk factors were assessed using the chi-square test. Associations between Modic subtype or number of Modic changes and demographic, lifestyle, and occupational variables were also evaluated using chi-square analysis. A p-value of ≤0.05 was considered statistically significant. Data integrity was supported through structured data collection, standardized MRI acquisition, predefined operational classification of imaging findings, and statistical analysis using a uniform coding framework.

RESULTS

A total of 186 patients undergoing lumbar spine MRI were included. The mean age was 54.26 ± 14.23 years, with an age range of 30–79 years. The mean BMI was 27.35 ± 3.74 kg/m², indicating that the overall study population was in the overweight range. Smoking exposure showed wide variability, with a mean smoking burden of 3.45 ± 7.41 pack-years. The continuous baseline characteristics are presented in Table 1.

Table 1. Descriptive Statistics of Continuous Variables Among Study Participants

Variable	Minimum	Maximum	Mean ± SD
Age, years	30	79	54.26 ± 14.23
BMI, kg/m²	18.0	35.8	27.35 ± 3.74
Smoking exposure, pack-years	0	29	3.45 ± 7.41

The demographic and clinical distribution of the study population is shown in Table 2. Of the 186 participants, 98 patients (52.7%) were male and 88 (47.3%) were female. Urban residents constituted 101 patients (54.3%), while 85 (45.7%) were from rural areas. Most participants were non-smokers (136, 73.1%), while 50 (26.9%) were smokers. Regarding BMI, 87 patients (46.8%) were overweight and 46 (24.7%) were obese, showing that excess body weight was common in this cohort. Occupationally, 121 participants (65.1%) were engaged in sedentary or light work, whereas 65 (34.9%) were involved in heavy labor. Modic changes were identified in 53 patients (28.5%; 95% CI: 22.0%–35.0%), while 133 patients (71.5%) had no Modic changes.

Table 2. Distribution of Demographic Variables, Risk Factors, and MRI Findings

Variable	Category	Frequency	Percentage (%)
Gender	Male	98	52.7
	Female	88	47.3
Residence	Urban	101	54.3
	Rural	85	45.7
Smoking status	Smoker	50	26.9

Variable	Category	Frequency	Percentage (%)
	Non-smoker	136	73.1
BMI category	Underweight	1	0.5
	Normal weight	52	28.0
	Overweight	87	46.8
	Obese	46	24.7
Occupation	Sedentary/light work	121	65.1
	Heavy labor	65	34.9
Modic changes	Present	53	28.5
	Absent	133	71.5

Associations between Modic changes and demographic or clinical risk factors are summarized in Table 3. Modic changes were observed in 25 of 98 males (25.5%) and 28 of 88 females (31.8%), with no statistically significant gender-based association (p = 0.341). Rural residence showed a lower unadjusted odd of Modic changes compared with urban residence, but this association was not statistically significant (OR = 0.79; 95% CI: 0.41–1.50; p = 0.469). Smoking status showed a borderline association with Modic changes: 9 of 50 smokers (18.0%) had Modic changes compared with 44 of 136 non-smokers (32.4%) (OR = 0.46; 95% CI: 0.21–1.03; p = 0.055). Occupational workload was not significantly associated with the presence of Modic changes, as changes were present in 19 of 65 heavy labor workers (29.2%) and 34 of 121 sedentary/light workers (28.1%) (OR = 1.06; 95% CI: 0.54–2.06; p = 0.871). BMI category also showed no statistically significant association with Modic changes (p = 0.217).

Table 3. Association Between Modic Changes and Demographic or Clinical Risk Factors

Variable	Category	Modic Present, n (%)	Modic Absent, n (%)	Odds Ratio (95% CI)	p-value
Gender	Male	25 (25.5)	73 (74.5)	0.73 (0.39–1.39)	0.341
	Female	28 (31.8)	60 (68.2)	Reference	
Residence	Rural	22 (25.9)	63 (74.1)	0.79 (0.41–1.50)	0.469
	Urban	31 (30.7)	70 (69.3)	Reference	
Smoking status	Smoker	9 (18.0)	41 (82.0)	0.46 (0.21–1.03)	0.055
	Non-smoker	44 (32.4)	92 (67.6)	Reference	
Occupation	Heavy labor	19 (29.2)	46 (70.8)	1.06 (0.54–2.06)	0.871
	Sedentary/light work	34 (28.1)	87 (71.9)	Reference	
BMI category	Underweight	0 (0.0)	1 (100.0)	Not estimated	0.217
	Normal weight	15 (28.8)	37 (71.2)	Reference	
	Overweight	20 (23.0)	67 (77.0)	0.74 (0.34–1.61)	
	Obese	18 (39.1)	28 (60.9)	1.59 (0.68–3.68)	

The distribution of Modic subtypes across demographic and lifestyle variables is presented in Table 4. Type II changes were the most frequent subtype, followed by Type I and Type III. Among males, Type II changes were seen in 17 patients, while Type I changes were seen in 8 patients. Among females, Type II changes were seen in 16 patients, Type I in 9 patients, and Type III in 2 patients. No statistically significant association was found between Modic subtype and gender (p = 0.560), residence (p = 0.407), smoking status (p = 0.205), or occupation (p = 0.147). The distribution indicates that although Type II changes predominated overall, subtype variation did not differ significantly across the evaluated demographic or lifestyle categories.

Table 4. Distribution of Modic Subtypes According to Demographic and Lifestyle Variables

Variable	Category	None	Type I	Type II	Type III	p-value
Gender	Male	73	8	17	0	0.560
	Female	61	9	16	2	
Residence	Urban	70	8	22	1	0.407
	Rural	64	9	11	1	
Smoking status	Smoker	42	3	5	0	0.205
	Non-smoker	92	14	28	2	
Occupation	Sedentary/light work	88	9	24	0	0.147
	Heavy labor	46	8	9	2	

The relationship between selected risk factors and the number of Modic changes is shown in Table 5. Gender was not significantly associated with lesion burden, as multiple Modic changes were observed in 7 males and 6 females (p = 0.762). Residence also showed no significant association (p = 0.429). Smoking status was significantly associated with the number of Modic changes (p = 0.036). Among smokers, 8 patients had a single Modic change and none had multiple changes, whereas among non-smokers, 30 patients had a single change and 13 patients had multiple changes. Occupation was also significantly associated with lesion burden (p = 0.018). Multiple Modic changes were more frequent among heavy labor workers (9 patients) than among sedentary/light workers (4 patients), indicating a greater burden of vertebral endplate signal abnormality among participants exposed to heavier physical workload. BMI category was not significantly associated with the number of Modic changes (p = 0.390).

Table 5. Association Between Number of Modic Changes and Risk Factors

Variable	Category	None	Single	Multiple	p-value
Gender	Male	73	18	7	0.762
	Female	62	20	6	
Residence	Urban	70	22	9	0.429
	Rural	65	16	4	
Smoking status	Smoker	42	8	0	0.036
	Non-smoker	93	30	13	
Occupation	Sedentary/light work	89	28	4	0.018
	Heavy labor	46	10	9	
BMI category	Underweight	1	0	0	0.390
	Normal weight	38	9	5	
	Overweight	68	15	4	
	Obese	28	14	4	

Overall, Modic changes were present in 28.5% of adults undergoing lumbar spine MRI, with Type II changes forming the dominant subtype. The presence of Modic changes was not significantly associated with gender, residence, BMI category, or occupational workload, while smoking status showed a borderline association. When lesion burden was assessed, smoking status and occupational workload showed statistically significant associations, with heavy labor workers demonstrating a higher frequency of multiple Modic changes.

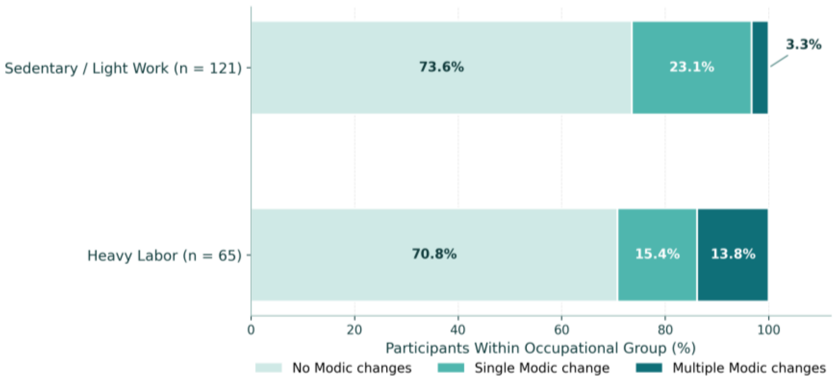

Figure 1. Occupational Workload and Lumbar Modic Lesion Burden

In the occupational workload comparison, participants engaged in heavy labor showed a higher burden of multiple Modic changes than those performing sedentary or light work. Multiple Modic changes were present in 13.8% of heavy labor workers compared with 3.3% of sedentary/light workers, representing an approximately 4.2-fold higher proportion. In contrast, the proportion without Modic changes was similar between groups, at 70.8% in heavy labor workers and 73.6% in sedentary/light workers, suggesting that occupational workload was more strongly related to lesion multiplicity than to the overall absence or presence of Modic changes.

DISCUSSION

The present study found that Modic changes were present in 28.5% of adults undergoing lumbar spine MRI, indicating that vertebral endplate and adjacent bone marrow signal abnormalities represent a frequent degenerative finding in patients evaluated for low back pain or related lumbar spinal symptoms. This prevalence is clinically relevant because Modic changes are increasingly recognized as part of the degenerative disc–endplate–marrow complex rather than isolated incidental MRI findings. The observed frequency is broadly consistent with previous literature showing that Modic changes are common among symptomatic individuals undergoing lumbar spine imaging, although reported prevalence varies according to population characteristics, imaging criteria, spinal levels assessed, and whether the study population includes symptomatic or asymptomatic participants (12). The finding supports the importance of systematically assessing vertebral endplate signal abnormalities during lumbar MRI interpretation, particularly in middle-aged and older adults with suspected degenerative spinal disease.

Type II Modic changes were the predominant subtype in this cohort, followed by Type I and Type III changes. This distribution is consistent with the concept that Type II changes often represent a more chronic stage of vertebral endplate degeneration, characterized by fatty marrow replacement after earlier inflammatory or edematous change. Type I changes, which are commonly interpreted as reflecting active inflammatory or edematous marrow alteration, have been more frequently associated with symptomatic low back pain in several studies, whereas Type II changes may indicate more established degenerative remodeling (13). The predominance of Type II changes in the present cohort may therefore reflect chronic degenerative pathology among patients presenting for lumbar spine MRI rather than predominantly acute inflammatory endplate disease. The very low frequency of Type III changes is also expected, as sclerotic Modic change is generally less commonly detected than Type I or Type II changes in routine lumbar MRI populations.

The study did not demonstrate a statistically significant association between gender and the presence or subtype of Modic changes. Modic changes were identified in 25.5% of males and 31.8% of females, but this difference did not reach statistical significance. Previous studies have reported inconsistent findings regarding sex-based differences in Modic changes, with some suggesting that hormonal status, bone mineral density, occupational exposure, and biomechanical differences may influence endplate degeneration, while others have found no independent association after accounting for age and degenerative disc disease (14). The present findings suggest that, within this cohort, Modic changes were not confined to one sex and may be more strongly influenced by cumulative degenerative and mechanical factors than by gender alone.

Residence was also not significantly associated with Modic changes. Although urban participants showed a slightly higher proportion of Modic changes than rural participants, the difference was not statistically meaningful. Residence may be an indirect marker of lifestyle, occupational activity, healthcare access, or referral behavior, but it is not itself a direct biological determinant of vertebral endplate degeneration. The absence of a significant association in this study suggests that urban–rural classification alone may be too broad to capture meaningful differences in spinal loading, physical activity, or healthcare-seeking patterns. More detailed measures of occupational exposure, physical activity intensity, sedentary behavior, and socioeconomic context would provide greater explanatory value than residence alone.

BMI was not significantly associated with the presence or number of Modic changes despite the fact that most participants were overweight or obese. The mean BMI was 27.35 ± 3.74 kg/m^2, and 71.5% of participants were either overweight or obese. Although increased BMI is biologically plausible as a contributor to lumbar degeneration through higher axial loading and increased mechanical stress on the disc–endplate complex, the relationship between BMI and Modic changes has not been uniform across studies. Some investigations have reported associations between body weight and Modic changes, while others suggest that BMI may be less influential than age, disc degeneration severity, occupational loading, or genetic susceptibility (15). In the present study, obese participants had a numerically higher proportion of Modic changes than normal-weight and overweight participants, but this did not reach statistical significance, indicating that excess body weight alone may not explain the distribution of vertebral endplate changes in this sample.

Smoking showed a borderline association with the presence of Modic changes and a statistically significant association with lesion burden; however, the direction of the finding was unexpected. Modic changes were present in 18.0% of smokers compared with 32.4% of non-smokers, and multiple Modic changes were observed among non-smokers but not among smokers. This differs from the commonly proposed biological mechanism in which smoking contributes to disc and endplate degeneration by impairing microvascular circulation, reducing oxygenation, and interfering with nutrient diffusion to spinal tissues (16). The unexpected direction may reflect residual confounding, underreporting of smoking exposure, differences in age or occupation between smokers and non-smokers, limited subgroup size, or the use of simple smoker/non-smoker categories rather than dose-response modeling using pack-years. Therefore, the smoking-related findings should be interpreted cautiously and should not be considered evidence of a protective effect of smoking.

Occupational workload emerged as a clinically meaningful factor when Modic lesion burden was considered. Although occupation was not significantly associated with the overall presence of Modic changes, heavy labor workers had a higher frequency of multiple Modic changes than participants performing sedentary or light work. Multiple lesions were present in 13.8% of heavy labor workers compared with 3.3% of sedentary/light workers, suggesting that heavy physical workload may be more strongly related to the extent of endplate involvement than to the binary presence or absence of any Modic change. This pattern is biologically plausible because repetitive lifting, prolonged bending, axial loading, and sustained mechanical stress can increase intradiscal pressure and contribute to microdamage at the vertebral endplate. Prior evidence has similarly linked workload-related mechanical stress with Modic changes and degenerative spinal findings, particularly in populations exposed to physically demanding labor (17).

The distinction between Modic presence and Modic burden is important. A binary classification may fail to capture clinically relevant gradients of disease severity, whereas lesion number may better reflect cumulative mechanical or degenerative stress across the lumbar spine. In this study, occupational workload was not associated with simply having any Modic change but was associated with multiple changes, suggesting that occupational exposure may influence the spread or burden of degenerative endplate involvement. This supports the value of reporting lesion burden in addition to Modic subtype and presence. Future lumbar MRI reporting frameworks may benefit from describing not only whether Modic changes are present, but also their number, level distribution, subtype, and relationship to adjacent disc degeneration.

The biological basis of Modic changes is likely multifactorial. Mechanical stress, disc degeneration, endplate disruption, inflammatory signaling, altered marrow composition, and impaired nutrient exchange may interact in the development of vertebral endplate signal changes. Recent studies have emphasized the disc–endplate–bone marrow unit as a dynamic biological interface, where mechanical injury and inflammatory responses may produce MRI-visible marrow changes (18). Complement activation, cytokine-mediated inflammation, and disc–bone marrow cross-talk have also been proposed as contributors to Modic pathobiology, although these mechanisms were not directly evaluated in the present study (19). The predominance of Type II changes and the association between heavy labor and multiple lesions are consistent with a chronic mechanical-degenerative model, but the cross-sectional design does not allow temporal sequencing of these processes.

The findings have practical relevance in settings where physically demanding occupations are common and patients may present late in the course of degenerative spinal disease. Recognition of Modic changes on MRI may help clinicians contextualize low back pain in relation to structural endplate degeneration, particularly when changes are multiple or occur alongside other degenerative findings. The association between heavy labor and greater lesion burden suggests that occupational history should be considered when interpreting lumbar MRI findings and counseling patients with degenerative spinal symptoms. Ergonomic interventions, safer lifting practices, workload modification, and early clinical assessment may be useful preventive strategies for individuals exposed to repeated lumbar mechanical stress, although interventional studies are required to determine whether such measures reduce Modic progression or symptom burden.

This study has several limitations. Its cross-sectional design prevents causal inference and does not establish whether occupational workload preceded the development of Modic changes or whether patients with spinal degeneration changed their work patterns over time. The study was conducted at a single tertiary care hospital, which may limit generalizability to the wider population. Participants were symptomatic patients referred for MRI, so the prevalence may not reflect asymptomatic community populations. MRI interpretation was based on standard Modic criteria, but single-reader assessment may introduce observer variability. In addition, smoking and occupational workload were analyzed using broad categories, which may not fully capture exposure intensity, duration, or cumulative dose. The absence of adjusted multivariable modeling also limits the ability to separate independent associations from confounding among age, BMI, smoking, occupation, and degenerative spinal burden.

Despite these limitations, the study contributes useful local evidence on the frequency and risk-factor profile of lumbar Modic changes in adults undergoing MRI evaluation. The findings indicate that Modic changes are relatively common, Type II changes predominate, and heavy occupational workload is associated with a higher burden of multiple Modic lesions. These results reinforce the importance of evaluating vertebral endplate signal changes as part of routine lumbar spine MRI assessment and of considering mechanical workload as a potentially relevant clinical factor in patients with degenerative lumbar spine disease. Larger multicenter studies with standardized exposure definitions, blinded imaging assessment, level-wise Modic mapping, and adjusted statistical modeling would further clarify the relationship between demographic, lifestyle, and occupational factors and Modic change patterns in this population (20,21).

CONCLUSION

In conclusion, Modic changes were identified in a considerable proportion of adults undergoing lumbar spine MRI, with Type II changes being the most frequent subtype. The presence of Modic changes was not significantly associated with gender, residence, BMI category, or occupational workload, while smoking status showed only a borderline association with overall Modic presence. When lesion burden was assessed, occupational workload demonstrated a significant relationship, with heavy labor workers showing a higher frequency of multiple Modic changes than those engaged in sedentary or light work. Smoking status was also significantly associated with the number of Modic changes, although the observed pattern requires cautious interpretation because multiple lesions were more frequent among non-smokers. These findings suggest that Modic changes are common degenerative vertebral endplate abnormalities in symptomatic lumbar spine patients and that heavy physical workload may contribute more strongly to lesion multiplicity than to the simple presence of Modic changes. Larger prospective studies with standardized exposure assessment and adjusted analysis are needed to clarify the clinical implications and progression of Modic changes in this population.

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