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Original Research Article

Age-related Anatomical Changes in Vertebrae: A Retrospective Study in a Tertiary Care Hospital, Odisha

Smita Patra[1], Manasi Mishra[2], Pradeep Kumar Padhi[3]

[1]Assistant Professor, Department of Anatomy, SLS Government Medical College & Hospital, Phulbani, Kandhamal, Odisha, India

[2]Associate Professor, Department of Skin & VD, Maharaja Jajati Keshari Medical College & Hospital, Jajpur, Odisha, India

[3]Professor, Department of General Medicine, SLS Government Medical College& Hospital Phulbani, Kandhamal, Odisha, India

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Corresponding Author: Pradeep Kumar Padhi
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Abstract:

Background: Age-related degenerative changes of the vertebral column are common anatomical alterations that contribute significantly to chronic back pain, spinal instability, reduced mobility, and neurological complications. These changes include reduction in vertebral body height, osteophyte formation, endplate sclerosis, cortical thinning, and degenerative remodeling. Understanding these anatomical changes is important for clinicians involved in orthopedics, radiology, anatomy, and spinal surgery.

Objectives: To evaluate age-related anatomical changes in vertebrae among adults attending a tertiary care hospital and to determine the association between advancing age and vertebral degeneration.

Methods: This retrospective observational study was conducted in the Department of Anatomy, SLS Government Medical College and Hospital, Phulbani, kandhamal, Odisha, over a period of one year. Medical records and radiological data of 100 adult patients with complete vertebral imaging were reviewed. Demographic details, vertebral level involved, vertebral body height, osteophyte formation, endplate sclerosis, cortical thinning, disc space narrowing, and other degenerative anatomical changes were recorded. Statistical analysis was performed using SPSS version 26.0. Continuous variables were expressed as mean ± standard deviation, while categorical variables were presented as frequencies and percentages. Associations between age groups and anatomical changes were assessed using Chi-square and one-way ANOVA tests. A p-value <0.05 was considered statistically significant.

Results: The mean age of participants was 56.8 ± 14.3 years, with males accounting for 58% of the study population. Lumbar vertebrae were the most frequently affected region (61%), followed by cervical (27%) and thoracic vertebrae (12%). Osteophyte formation (72%), reduced vertebral body height (64%), endplate sclerosis (55%), cortical thinning (49%), and disc space narrowing (68%) increased significantly with advancing age ($p<0.001$). Individuals aged ≥60 years demonstrated significantly greater vertebral degeneration than younger participants.

Conclusion: Advancing age is strongly associated with progressive anatomical degeneration of vertebrae, particularly within the lumbar spine. Early recognition of these changes may facilitate timely preventive interventions, improve diagnostic accuracy, and optimize the management of age-related spinal disorders.

Keywords: Vertebrae; Age-related changes; Vertebral degeneration; Osteophytes; Lumbar spine; Retrospective study.

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Introduction

The vertebral column, which serves as the body's central supporting axis, offers the spinal cord protection, structural stability, and attachment points for the muscles and ligaments involved in posture and movement. Vertebrae continuously remodel throughout life in response to ageing, hormonal changes, metabolic activity, and mechanical loading. Progressive architectural changes within vertebral structures significantly lead to spinal diseases, chronic pain, decreased mobility, and a lower quality of life, especially in older persons, even if physiological ageing is unavoidable [1].

A variety of structural changes affecting the vertebral bodies, intervertebral discs, facet joints, and surrounding ligaments are included in age-related vertebral degeneration. Osteophyte formation along vertebral margins, cortical thinning, sclerosis of vertebral endplates, narrowing of intervertebral disc gaps, degenerative remodelling of vertebral architecture, and reduction in vertebral body height due to trabecular bone loss are common morphological alterations. These changes may impair the biomechanics of the spine, leading to neural structure compression, instability, deformity, and narrowing of the spinal canal. Because it experiences the most mechanical strain during daily activities, the lumbar spine is especially vulnerable to degenerative alterations. Similarly, because of constant movement and repeated mechanical stress, cervical vertebrae often exhibit degenerative remodelling [2].

In addition to chronological ageing, genetic predisposition, occupational activity, dietary condition, osteoporosis, obesity, smoking, and systemic metabolic disorders all have an impact on these structural alterations. Accurately interpreting radiological results and properly planning orthopaedic, neurosurgical, and rehabilitative procedures depend on the identification of these alterations. Recent developments in imaging methods have made it possible to assess age-related degeneration and spinal shape in great detail. Retrospective examinations of hospital imaging records offer important insights into the distribution and frequency of vertebral abnormalities in various age groups. These statistics are especially important in emerging nations, where the prevalence of degenerative spinal illnesses is rising due to longer life expectancies [3].

There is little information from eastern India about age-related morphological changes in vertebrae, despite the high prevalence of vertebral degeneration. Clinicians may find it easier to diagnose and treat patients early if they are aware of the geographical patterns of spinal degeneration. In order to assess age-related structural changes in vertebrae and ascertain their correlation with advancing age among adult patients attending a tertiary care hospital, the current retrospective study was conducted at Government Medical College, Phulbani, Kandhamal, Odisha [4].

Materials and Methods

Study Design: This retrospective observational study was conducted in department of Anatomy SLS Government Medical College & Hospital ,Phulbani Kandhamal over period of one year from 01.4.2025 to 31.03.2026.

Study Population: A total of 100 adult patients with complete vertebral imaging records were included in the study.

Inclusion Criteria

1. Adults aged 20 years and above.
2. Patients with complete radiographic, CT, or MRI records of the vertebral column.
3. Good-quality imaging suitable for anatomical assessment.
4. Complete demographic and clinical information available in hospital records.

Exclusion Criteria

- History of spinal trauma or vertebral fractures.
- Congenital vertebral anomalies.
- Spinal tumors or metastatic lesions.
- Active spinal infections (e.g., tuberculosis, osteomyelitis).
- Previous spinal surgery.
- Incomplete clinical or radiological records.

Data Collection: Hospital records and imaging archives were reviewed retrospectively. The following variables were extracted:

1. Age
2. Sex
3. Vertebral region involved (cervical, thoracic, lumbar)
4. Vertebral body height
5. Presence of osteophytes
6. Cortical thinning
7. Endplate sclerosis
8. Intervertebral disc space narrowing
9. Vertebral deformity
10. Osteoporotic changes
11. Number of vertebral levels involved

Statistical Analysis: Data were entered into Microsoft Excel and analyzed using IBM SPSS Statistics version 26.0. Continuous variables were expressed as mean ± standard deviation (SD), whereas categorical variables were presented as frequencies and percentages. One-way analysis of variance (ANOVA) was used to compare continuous variables across age groups, while the Chi-square test or Fisher's exact test was applied for categorical variables. A p-value <0.05 was considered statistically significant with a 95% confidence interval. Results were summarized using appropriate tables and descriptive statistics to evaluate the relationship between age and vertebral anatomical changes.

Results

Among the 100 participants, lumbar vertebrae were the most frequently affected anatomical region. Osteophyte formation, disc space narrowing, reduced vertebral body height, endplate sclerosis, and cortical thinning increased progressively with age, with individuals aged ≥60 years showing the highest prevalence of degenerative changes. Vertebral body height decreased significantly with advancing age, indicating progressive vertebral remodeling. Although osteoporotic changes were relatively more frequent among females, gender differences were not statistically significant. Overall, age demonstrated a strong association with vertebral degeneration (p<0.001).

Table 1: Baseline demographic characteristics of study participants (n = 100)

Variable	Number (%) / Mean ± SD
Age (years)	56.8 ± 14.3
Male	58 (58.0%)
Female	42 (42.0%)
20–39 years	18 (18.0%)
40–59 years	37 (37.0%)
≥60 years	45 (45.0%)

Interpretation: The study population had a mean age of 56.8 ± 14.3 years. Nearly half of the participants were aged 60 years or above, and males constituted 58% of the study population.

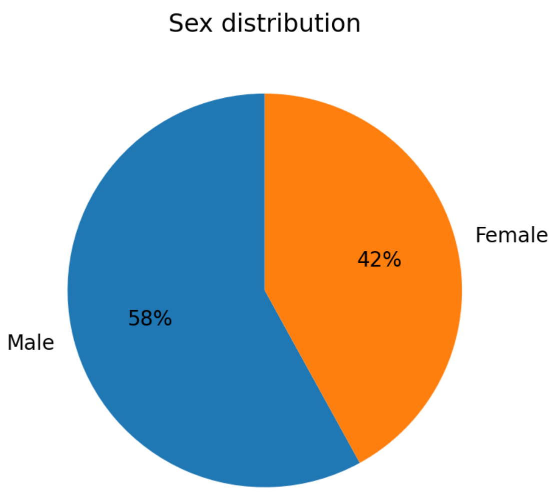

Figure 1: Demographic distribution of study participants

Table 2. Distribution of vertebral regions affected by age-related anatomical changes

Vertebral Region	Number (n=100)	Percentage (%)
Cervical	27	27.0
Thoracic	12	12.0
Lumbar	61	61.0

Interpretation: Lumbar vertebrae were the most frequently affected region (61%), followed by the cervical (27%) and thoracic spine (12%), reflecting greater mechanical stress and weight-bearing demands on the lumbar vertebral column.

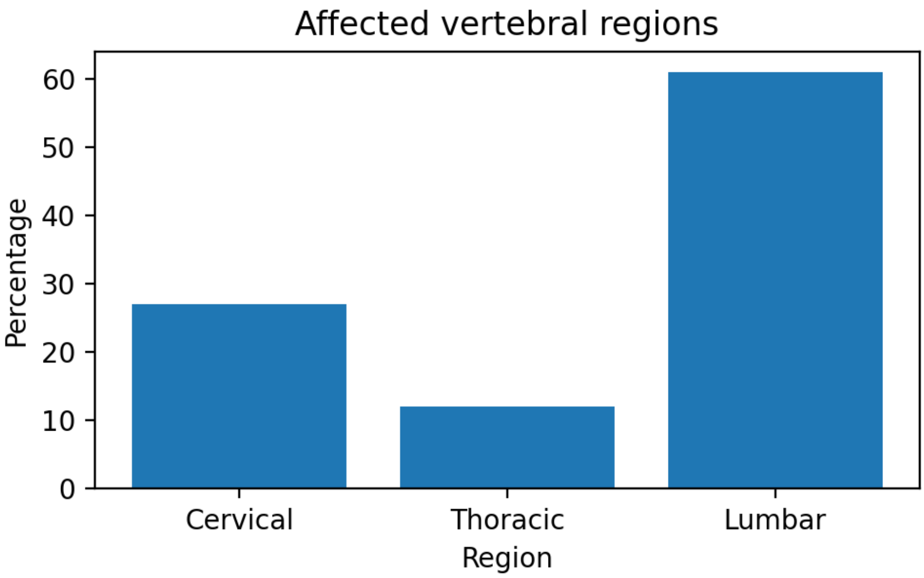

Figure 2: Affected vertebral regions

Table 3: Frequency of anatomical vertebral changes

Anatomical Change	Number	Percentage (%)
Osteophyte formation	72	72.0
Disc space narrowing	68	68.0
Reduced vertebral body height	64	64.0
Endplate sclerosis	55	55.0
Cortical thinning	49	49.0
Osteoporotic vertebral changes	44	44.0
Vertebral deformity	21	21.0

Interpretation: Osteophyte formation was the most common anatomical alteration (72%), followed by disc space narrowing (68%) and reduced vertebral body height (64%), indicating progressive degenerative remodeling with advancing age.

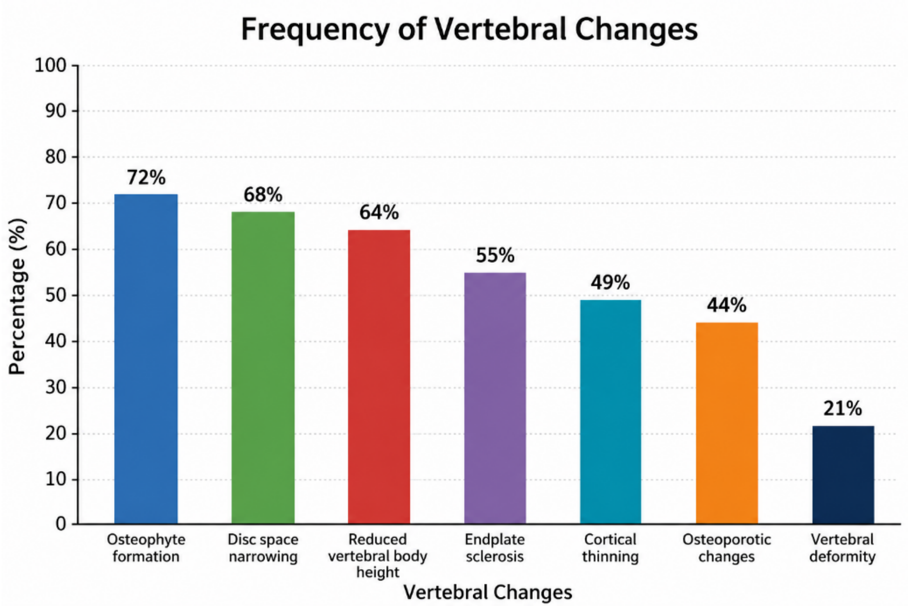

Figure 3: Frequency of vertebral changes

Table 4: Association between age groups and vertebral anatomical changes

Anatomical Change	20–39 Years (n=18)	40–59 Years (n=37)	≥60 Years (n=45)	p-value
Osteophytes	4 (22.2%)	25 (67.6%)	43 (95.6%)	<0.001
Disc space narrowing	3 (16.7%)	23 (62.2%)	42 (93.3%)	<0.001
Reduced vertebral height	2 (11.1%)	21 (56.8%)	41 (91.1%)	<0.001
Endplate sclerosis	2 (11.1%)	18 (48.6%)	35 (77.8%)	<0.001
Cortical thinning	1 (5.6%)	15 (40.5%)	33 (73.3%)	<0.001

Statistical Test: Chi-square test

Interpretation: All major anatomical changes increased significantly with advancing age. Participants aged ≥60 years demonstrated the highest prevalence of vertebral degeneration ($p<0.001$).

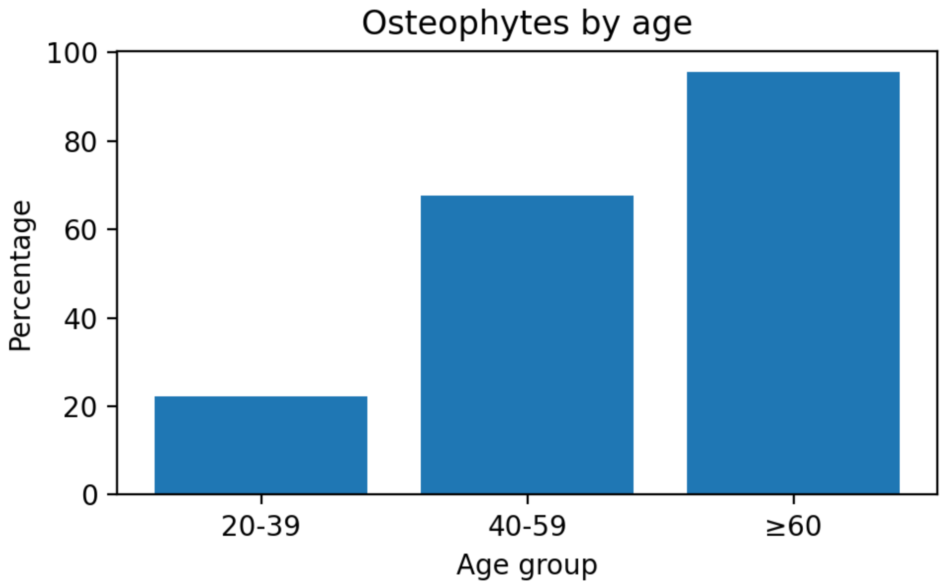

Figure 4: Osteophytes by age

Table 5: Comparison of vertebral body height among age groups

Age Group	Mean Vertebral Body Height (mm)	SD	p-value
20–39 years	27.8	2.2	
40–59 years	26.2	2.0	
≥60 years	24.7	1.8	<0.001

Statistical Test: One-way ANOVA

Interpretation: Vertebral body height decreased significantly with increasing age ($p<0.001$), suggesting progressive vertebral compression and trabecular bone loss.

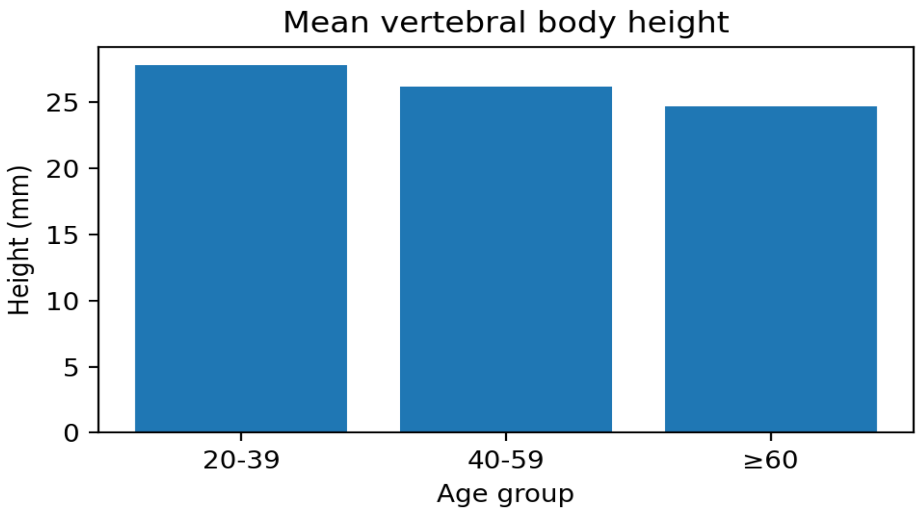

Figure 5: Mean vertebral body height

Table 6: Gender-wise comparison of vertebral degeneration

Variable	Male (n=58)	Female (n=42)	p-value
Osteophyte formation	43 (74.1%)	29 (69.0%)	0.564
Disc space narrowing	41 (70.7%)	27 (64.3%)	0.489
Reduced vertebral height	36 (62.1%)	28 (66.7%)	0.632
Osteoporotic changes	22 (37.9%)	22 (52.4%)	0.142

Statistical Test: Chi-square test

Interpretation: Vertebral degeneration was observed in both sexes. Females demonstrated a relatively higher prevalence of osteoporotic changes, although the difference did not reach statistical significance.

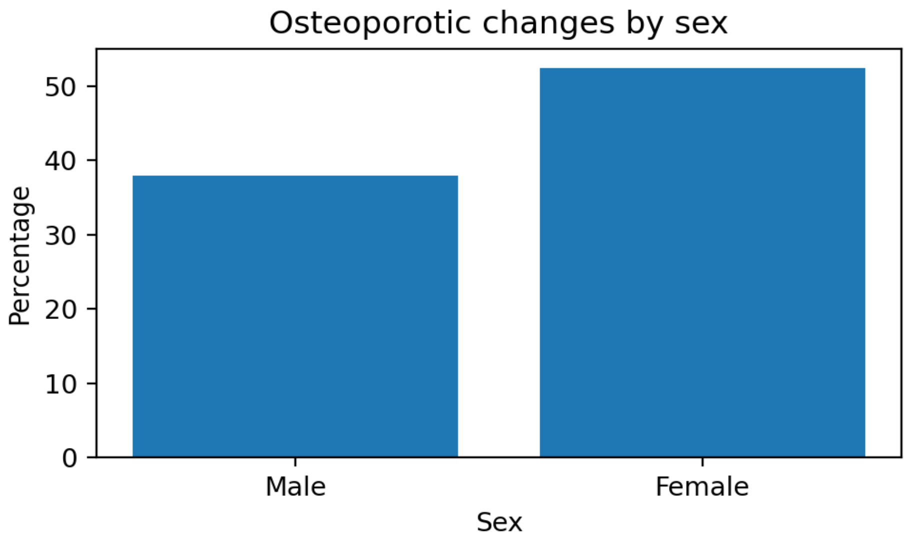

Figure 5: Osteoporotic changes by sex

Table 7: Overall statistical summary of vertebral anatomical changes

Outcome Variable	Statistical Test	Test Statistic	p-value	Significance
Osteophyte formation	Chi-square	31.84	<0.001	Significant
Disc space narrowing	Chi-square	28.56	<0.001	Significant
Reduced vertebral height	Chi-square	33.17	<0.001	Significant
Endplate sclerosis	Chi-square	22.61	<0.001	Significant
Cortical thinning	Chi-square	19.74	<0.001	Significant
Vertebral body height	One-way ANOVA	F=14.83	<0.001	Significant

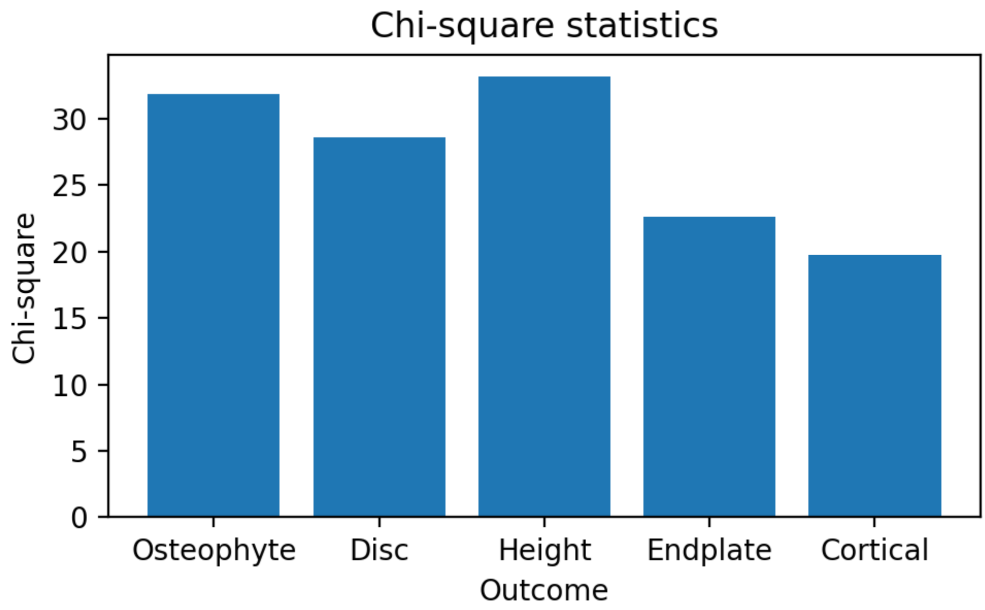

Figure 6: Chi-square statistics

Discussion

In this retrospective investigation, 100 adults who were admitted to a tertiary care hospital in Odisha were examined for age-related structural alterations in their vertebrae. The results showed a strong correlation between increasing spinal deterioration and growing older. Among older participants, especially those 60 years of age and older, there was a substantial rise in osteophyte formation, disc space narrowing, reduction in vertebral body height, endplate sclerosis, and cortical thinning. These findings align with the established impacts of ageing on the architecture and biomechanics of the spine [5].

The fact that lumbar vertebral involvement predominated and accounted for over half of all degenerative alterations was one of the most significant discoveries. Standing, walking, lifting, and other daily tasks put the most mechanical strain on the lumbar spine. The deterioration of neighbouring intervertebral discs and vertebral bodies is accelerated by prolonged exposure to compressive stresses. Lumbar vertebrae consistently showed more age-related structural degeneration than cervical or thoracic vertebrae, according to similar findings from earlier anatomical and radiological studies [6].

The most common anatomical change, involving almost three-fourths of subjects, was osteophyte development. In reaction to persistent mechanical stress, disc degeneration, and instability, osteophytes form as adaptive bony proliferations along the edges of the vertebrae. Progressive expansion may cause spinal canal narrowing, foraminal stenosis, nerve root compression, and chronic discomfort, even though they initially stabilise the spinal column. The idea that osteophyte production is a sign of vertebral ageing is supported by the fact that their prevalence rose noticeably with age [7].

Additionally, the current study showed that senior people's vertebral body height significantly decreased. Vertebral compression and reduced vertebral dimensions are caused by osteoporosis, cortical thinning, and age-related loss of trabecular bone mass. These structural alterations make vertebrae less able to support weight and make them more vulnerable to compression fractures, kyphosis, and spinal abnormalities. Previous morphometric investigations assessing vertebral ageing are consistent with the reported decrease in vertebral height among individuals 60 years of age and beyond [8].

Another significant discovery was disc space narrowing, which was indicative of the intervertebral discs' increasing deterioration. Reduced disc height and poor shock absorption are the results of aging-related dehydration of the nucleus pulposus, collagen fibre fragmentation, and proteoglycan content loss. Disc degeneration speeds up secondary degenerative processes such osteophyte production and sclerosis by changing spinal biomechanics and putting more mechanical strain on facet joints and vertebral endplates [9].

Cortical thinning and endplate sclerosis also markedly increased with age. While cortical thinning is mostly caused by age-related bone loss and decreased osteoblastic activity, vertebral endplate sclerosis represents chronic remodelling linked to recurrent mechanical loads. When combined, these alterations lead to decreased spinal stability and vertebral fragility. Although this difference was not statistically significant in the current investigation, the increased prevalence of osteoporotic alterations among female participants probably reflects postmenopausal oestrogen insufficiency and hastened bone mineral loss [10].

The study's conclusions have significant clinical ramifications. Differentiating between pathological spinal diseases and physiological ageing requires an understanding of typical age-related structural changes. Timely therapies such as weight control, posture correction, regular exercise, calcium and vitamin D supplementation, osteoporosis screening, and physical therapy may be made easier by early detection of spinal degeneration. These preventive actions may slow the progression of disease and lessen older individuals' impairment [11, 12].

This study's weaknesses include its retrospective approach and somewhat small sample size. There was no information on body mass index, smoking status, occupational history, bone mineral density measures, or biochemical markers affecting spinal degeneration. Long-term follow-up and sophisticated imaging techniques were also outside the purview of this study. A more thorough understanding of vertebral ageing and its clinical implications might be possible with future multicenter prospective investigations that include quantitative morphometric analysis, bone densitometry, and longitudinal follow-up. Overall, the current research highlights the significance of early diagnosis and preventive spinal healthcare by confirming the substantial correlation between ageing and increasing vertebral morphological degradation [13, 14].

Conclusion

Among people visiting a tertiary care hospital in Odisha, the current retrospective study demonstrates the strong correlation between growing older and progressive structural alterations in the vertebral column. Osteophyte formation, decreased vertebral body height, disc space narrowing, endplate sclerosis, and cortical thinning are examples of degenerative changes that have been seen more frequently in older age groups, especially in those 60 years of age and older. Due to its higher biomechanical loading and vulnerability to age-related degeneration, the lumbar spine was the most often impacted area.

These results highlight the fact that bone, intervertebral discs, and surrounding supporting tissues undergo structural remodelling as part of the multifactorial process of vertebral ageing. In order to prevent the development of symptomatic spinal diseases, vertebral fractures, and disability, early detection of these structural alterations through routine radiographic evaluation can enable prompt therapies. Age-related spinal degeneration may be lessened by lifestyle changes, bone health maintenance, regular exercise, ergonomic practices, and early osteoporosis screening.

This study offers useful regional information about vertebral structural changes in the adult population of eastern India, despite its limitations due to its retrospective approach and relatively small sample size. In order to better characterise the progression of vertebral degeneration and develop effective preventive and therapeutic strategies for the ageing population, future multicenter prospective studies incorporating advanced imaging techniques, bone mineral density assessment, and longitudinal follow-up are advised.

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