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QUANTIFICATION AND STATISTICAL ASSESSMENT OF LUMBAR INTERVERTEBRAL DISC SPACES

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ABSTRACT

Lower back pain is a common musculoskeletal condition with multiple aetiologies. Disc degeneration, characterised by reduced disc height, is one of the common causes. Diagnostic tools such as X-rays, MRI, and CT scans are commonly used to visualise deformities in the lower back. Targeting an Indian population with diverse demographics, including varying ages, BMI ranges, and representation of both men and women, this study utilised X-ray data from the ChanRe Rheumatology and Immunology Centre and Research, Bengaluru (India), to diagnose lower back pain resulting from degenerative disc disorders. Intervertebral disc spaces were quantified using image processing techniques, and the quantified values were compared with the mean values of healthy subjects to highlight deviations indicative of disc degeneration. Risk factors such as age, gender, and body mass index (BMI) were identified as significant contributors to disc degeneration. Statistical analyses, like the Mann-Whitney U Test, were conducted to assess the impact of these factors on the quantified data. The mean ranks and p values revealed that age >50 years, BMI > 30, and females significantly contribute to the worsening lumbar spine health. These insights may help doctors prioritise these factors for managing lower back pain, encouraging additional care and precautions during treatment.

Keywords: Disc degeneration, lower back pain, intervertebral disc spaces

INTRODUCTION

Lower back pain (LBP) is a pervasive condition that affects a substantial share of the population, often leading to the discomfort, disability, and a diminished quality of life. This type of pain can arise from various causes, including muscle or ligament strain, herniated discs, arthritis, or skeletal irregularities (Katz *et al*., 2007; Davis *et al.,* 2018). Disc degeneration is one of the most common causes of back pain (Boden *et al.,* 1990). The intervertebral-discs act as cushion between vertebrae and are composed of a tough outer layer called ‘annulus fibrosis’ and a gel-like centre called ‘nucleus pulposus’. Over time, these discs deform due to ageing, repetitive stress, or injury. As the discs lose fluid and elasticity, they become less effective at absorbing shock, which can strain the spine and surrounding nerves.

Age is a risk factor as the ageing process causes discs to lose water content, leading to its slow wear and tear. A high body mass index (BMI) also contributes to disc degeneration due to increased stress on the spine (Schmid *et al.,* 2012). Gender also plays a role; research suggests that men and

women may experience disc degeneration differently, likely due to differences in hormones and body structure of disc.

Image-based studies are vital to confirm the diagnosis and determine the extent of disc degeneration. X-rays can show irregularities in the spine, and magnetic resonance imaging (MRI) offers detailed imageries of discs, allowing assessment of disc height, hydration, and the amount of herniation or nerve compression. Different dyes may be injected into the disc to detect abnormalities using computed tomography (CT) or discography (Hopper *et al.,* 2021). Disc degeneration is a progressive condition that can lead to various symptoms. In severe cases, disc degeneration can result in spinal instability or the development of bone spurs, which can further worsen pain and nerve impingement (Ferguson *et al.,* 2005; Chou *et al.,* 2007).

Numerous researchers have focused on improving the accuracy of diagnosing LBP due to degenerative disc disease. A comprehensive examination of lumbar spine and sacrum reveals the anatomical structures, functions, and biomechanical properties including patho-physiology of lumbar disorders (Bogduk *et al.,* 2005). This resource became invaluable for clinicians and researchers in developing effective treatments. Richardson *et al.* (1999) have explored the causes and clinical implications of degenerative disc disease (DDD), discussing its impact on spinal mechanics and reviewing diagnostic methods and treatment options, both conservative and surgical.

Recent research on pathophysiology, clinical features, and treatment modalities have explored the role of DDD in chronic LBP (Anand *et al.,* 2010). MRI method is employed for quantitatively measuring the intervertebral disc spaces. Additionally, manual and automated measurement techniques have been compared which indicated that automation improves consistency and reduces subjective variability, thus enhances diagnostic efficacy (Anand *et al.,* 2010; Smith *et al.,* 2015; Lee *et al.,* 2017). Miller *et al.* (2016) have shown significant differences in disc space measurements between younger and older individuals, stressing on the need for age-specific diagnostic criteria. Green *et al.* (2018) in a comparative study on disc space measurements have identified variations between healthy individuals and patients with spinal disorders, thus supporting the use of precise measurements for early diagnosis. Much emphasis is presently laid on the diagnostic imaging particularly MRI and CT scans in evaluating LBP. The use of normality tests in medical data analysis is also of greater significance in revealing the pathophysiology of spinal disc degeneration and developing a multifaceted approach for management of LBP (Zar *et al.,* 1993; Weiner *et al.,* 2007 Jarvik *et al.,* 2011). Based on these findings, the present study was aimed to quantify intervertebral disc spaces using X-ray images and statistically tools to assess the impact of risk factors like age, gender, and BMI on disc degeneration.

MATERIALS AND METHODS

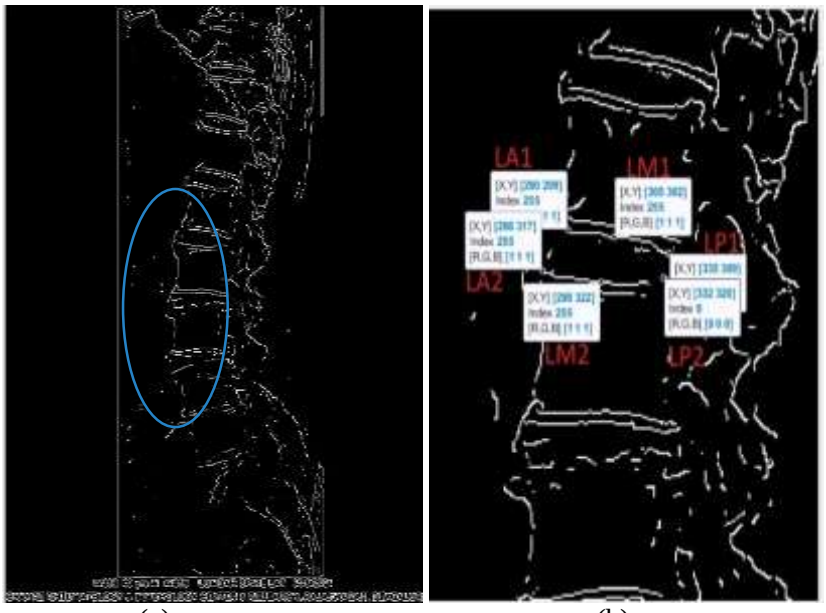
Quantification of intervertebral disc space

The research focused on studying lower back pain (LBP) in the Indian population with diverse demographics, incorporating participants of different ages, BMI classifications, and genders. It aimed to analyse X-ray images and quantify intervertebral disc spaces in individuals with and without LBP caused by degenerative discs. The dataset was sourced from Chanre Rheumatology & Immunology Centre and Research (CRICR), Bengaluru, India (Praveen *et al*., 2020). The study focused on lateral X-ray images due to their superior ability to provide detailed information about intervertebral disc spaces (Smith *et al*., 2022). This focus was crucial for the objectives of study, which included identifying the differences in disc spaces between individuals with LBP and those without, thus offering valuable insights into the structural factors associated with LBP. The lateral X-ray images were processed using image processing techniques involving image acquisition, pre-processing, segmentation, feature extraction and analysis.

The study involved 286 LBP subjects and 34 non-LBP (normal) with an average age of 46.6 ± 1.2 years, including both male and female participants. The CRICR's Ethical Committee approved the study. The informed consent was acquired from all the participants. X-ray images of lumbar spine were collected, focusing on individuals with LBP. Using MATLAB, the X-ray images were subjected to pre-processing techniques like applying a Gaussian filter to reduce the noise. The Gaussian filtering resulted in the images with reduced noise while preserving edge information, which is necessary for further analysis. Edge detection was carried out using the Canny edge detection method, which preserved edge clarity crucial for precisely measuring intervertebral spaces, making it an integral part of segmentation process. The spaces between each lumbar spine pair (L1-L2, L2-L3, L3-L4, and L4-L5) were measured using the Euclidean distance method at three specific points: Lateral-Anterior (LA), Lateral-Middle (LM), and Lateral-Posterior (LP) [Fig. 1]. Manual identification of paired points was performed in three regions - LA, LM, and LP - and labelled as LA1, LA2, LM1, LM2, LP1, and LP2. The Euclidean distance formula (eq. 1) was used to calculate the distance between each pair of points, forming a key step in the feature extraction process.

$$Euclidean\ Distance = \sqrt[2]{\left((x_2 - x_1)^2 + (y_2 - y_1)^2\right)} \rightarrow \text{Eq.1}$$

Where (X_1, Y_1) and (X_2, Y_2) are pixel coordinates



(a) (b)

Fig. I: a) Edge detected x-ray image of an LBP subject; b) Pair points marked in LA, LM, LP regions

To reduce variations in measurements, each intervertebral space was measured manually three times for each person, and average measurements used. The X-ray images of lumbar spine from 286 people were processed to measure spaces between their intervertebral discs. For accuracy, measurements were taken in three areas - LA, LM, and LP - on each image, and then these measurements were averaged to get a single for each area. This process was repeated for different cases of LBP in dataset, with the measurements averaged over 3 attempts. The averaged and normalised values were analysed using statistical methods.

Statistical analyses

The normalised quantified intervertebral disc spaces were subjected to statistical analyses to examine the impact of specific risk factors, including age (> 50 and < 50 years), body mass index (BMI) (< 30 and > 30), and gender (male and female) (Praveen *et al.*, 2021). The dataset, comprising lateral X-ray images from 286 subjects with an average age of 46.6 ± 1.2 years, included both male (122) and female (164) participants. Subjects were categorised based on age [< 50 yr (152) and > 50 yr (134)], BMI [<30 (137), >30 (149)] and gender. Normality tests, including the Kolmogorov-Smirnov and Shapiro-Wilk tests, were conducted to determine if the distribution of quantified lumbar spine measurements was usual across the demographic groups. The results produced substantial p-values, representing a non-normal distribution, necessitating non-parametric methods for further analysis.

The student's t-tests were performed to compare the means of lumbar spine measurements between the two groups for age, BMI, and gender. Mann-Whitney U tests were conducted for individual demographic categories to validate these results, producing significant U statistics and p-values that ranged with the t-test results.

RESULTS AND DISCUSSION

Quantification

The X-ray image dataset consisted of 286 subjects with lower back pain (LBP) and 34 subjects without (Non-LBP). Measurements of intervertebral space between L1 and L5 were categorised by lateral posterior, lateral middle, and lateral anterior regions for both LBP and normal subjects (Table 1).

Table 1: Intervertebral space between L1-L5 for an LBP subject

Region[a]	Lumbar spine pairs[b]							
	LBP subjects				Normal subjects			
	L1-L2 (mm)	L2-L3 (mm)	L3-L4 (mm)	L4-L5 (mm)	L1-L2 (mm)	L2-L3 (mm)	L3-L4 (mm)	L4-L5 (mm)
Lateral posterior	8.03	7.97	7.09	11.6	8.642	9.166	9.527	10.441
Lateral middle	9.34	9.19	6.29	9.2	10.062	12.150	14.271	13.257
Lateral anterior	11.01	8.32	5.07	10.3	15.582	12.295	16.139	16.151
Mean value	9.46	8.49	6.15	10.4	11.430	11.200	13.310	13.280

[a] The distance between the pair points marked at three regions: LA, LM, LP

[b] The measurements show Euclidian distance between pair points in all lumbar spine regions L1-L2, L2-L3, L3-L4, and L4-L5 in mm

After calculating the mean and standard deviation (SD) for the intervertebral disc spaces of normal subjects (Table 2), these values served as a baseline for comparison with LBP subjects, aiding in recognising deviations in vertebral well-being. For instance, an LBP subject's quantified intervertebral disc spaces exhibited significant deviations from normal values, particularly in L3-L4 region, where the space measured 6.15 mm compared to the normal value of 11.6 ± 1.8 mm (Table 2). Further analysis of the remaining LBP subjects revealed a high prevalence of degenerative discs, particularly at L4-L5 level (Table 3).

Table 2: **Mean and SD of intervertebral disc spaces for normal subjects**

Lumbar spine pair	Mean and SD of intervertebral disc space[a]
L1-L2	9.63 ± 1.8
L2-L3	9.55 ± 1.6
L3-L4	11.6 ± 1.8
L4-L5	11.3 ± 2.1

The mean values, along with the standard deviation shows up for each lumbar spine pair

Table 3: **Distribution of subjects with degenerative discs across lumbar pairs**

Lumbar spine pair	Subjects affected (No.)
L1-L2	40
L2-L3	52
L3-L4	48
L4-L5	146

Statistical analysis

Normality tests: The normality test was applied to the dataset of quantified intervertebral disc spaces of lumbar spine of LBP patients of various ages, BMIs, and genders and the results are presented in Tables 4, 5 and 6, respectively. The results of normality tests based on age, BMI, and gender were summarised for four lumber spine levels (L1-L2, L2-L3, L3-L4, and L4-L5). Table 4 analyses the age, comparing groups above and below 50 years. Both groups display significant non-normality at L1-L2 and L2-L3, with > 50-year age group showing borderline significance at L3-L4. At L4-L5, significant non-normality was evident

Table 4: Tests of normality of lumber spine pairs based on age

Lumbar spine pairs	Age groups (years)	Kolmogorov-Smirnov[a]			Shapiro-Wilk[b]		
		Statistic	df	Sig.	Statistic	df	Sig.
L1-L2	> 50	0.099	134	0.003	0.943	134	0.000
	< 50	0.089	152	0.005	0.943	152	0.000
L2-L3	> 50	0.080	134	0.033	0.957	134	0.000
	< 50	0.092	152	0.003	0.956	152	0.000
L3-L4	> 50	0.076	134	0.058	0.954	134	0.000
	< 50	0.085	152	0.010	0.946	152	0.000
L4-L5	> 50	0.093	134	0.006	0.954	134	0.000
	< 50	0.061	152	0.200	0.968	152	0.001

[a]Kolmogorov-Smirnov test applied to the quantified dataset on various lumbar spine pairs based on age groups (above and below 50 years age)

[b]Shapiro-Wilk test applied to the quantified dataset on various lumbar spine pairs based on age groups (above and below 50 years of age)

Table 5: Tests of normality of lumber spine pairs based on body mass index (BMI)

Lumbar spine pairs	BMI	Kolmogorov-Smirnov[a]			Shapiro-Wilk[b]		
		Statistic	df	Sig.	Statistic	df	Sig.
L1-L2	> 30	0.100	149	0.001	0.936	149	0.000
	< 30	0.096	137	0.003	0.948	137	0.000
L2-L3	> 30	0.093	149	0.003	0.939	149	0.000
	< 30	0.094	137	0.005	0.934	137	0.000
L3-L4	> 30	0.086	149	0.009	0.945	149	0.000
	< 30	0.091	137	0.007	0.945	137	0.000
L4-L5	> 30	0.096	149	0.002	0.945	149	0.000
	< 30	0.084	137	0.019	0.957	137	0.000

[a] Kolmogorov-Smirnov test applied to the quantified dataset on various lumbar spine pairs based on body mass index (> and < 30 BMI)

[b] Shapiro-Wilk test applied to the quantified dataset on various lumbar spine pairs based on body mass index (> and < 30 BMI)

Table 6: Tests of normality of lumber spine pairs based on gender

Lumbar spine pairs	Gender	Kolmogorov-Smirnov[a]			Shapiro-Wilk[b]		
		Statistic	df	Sig.	Statistic	df	Sig.
L1-L2	Male	0.094	122	0.010	0.933	122	0.000
	Female	0.101	164	0.000	0.930	164	0.000
L2-L3	Male	0.116	122	0.000	0.938	122	0.000
	Female	0.082	164	0.009	0.951	164	0.000
L3-L4	Male	0.090	122	0.017	0.943	122	0.000
	Female	0.082	164	0.009	0.950	164	0.000
L4-L5	Male	0.087	122	0.025	0.956	122	0.001
	Female	0.062	164	0.200	0.963	164	0.000

[a]Kolmogorov-Smirnov test applied to the quantified dataset on various lumbar spine pairs based on gender.

[b]Shapiro-Wilk test applied to the quantified dataset on various lumbar spine pairs based on gender

in > 50 year age groups, while the < 50 year age group had non-significant Kolmogorov-Smirnov (K-S) result but significant Shapiro-Wilk (S-W) result. Table 5 examines the BMI, contrasting individuals with a BMI > 30 and those between 25 and 29.99. Both groups demonstrated significant non-normality at all lumbar levels, indicating that lumbar spine measurements were not normally distributed across BMI categories. Table 6 assesses gender differences. Both males and females showed significant non-

normality at L1-L2 level. At L2-L3, males exhibited strong non-normality, while females showed slightly better S-W results. Males consistently showed significant non-normality at L3-L4 and L4-L5, whereas females showed border-line normality in K-S test at L4-L5 but still indicated non-normality in S-W test. Overall, the results highlight significant deviations from normality across all the demographic groups and lumbar spine levels, suggesting the need for non-parametric statistical methods in subsequent analyses.

T-tests

The t-tests were applied to a dataset of quantified intervertebral disc spaces of lumbar spine patients with LBP, categorised by age, BMI, and gender. The group statistics and independent samples t-tests are presented in Tables 7a & 7b, 8a & 8b and 9a & 9b. These tables compare the means across three demographic categories: age groups (> 50 and < 50), BMI categories (> 30 and < 30), and gender (male and female). Each t-test examined differences in lumbar spine measurements across four lumbar levels (L1-L2, L2-L3, L3-L4, and L4-L5).

Table 7a: Group statistics of lumber spine pairs based on age

Lumbar spine pair	Age groups (yrs)	N	Mean	Standard deviation	Standard error
L1-L2[a]	> 50	134	9.1136	0.71977	0.06218
	< 50	152	10.3626	0.65534	0.05316
L2-L3	> 50	134	9.1892	0.63951	0.05525
	< 50	152	10.2473	0.53668	0.04353
L3-L4	> 50	134	10.4619	0.72229	0.06240
	< 50	152	11.7427	0.93321	0.07569
L4-L5	> 50	134	10.6614	0.88702	0.07663
	< 50	152	11.7251	0.94148	0.07636

[a] This presents the group statistics of t-test based on age, showing mean, standard deviation, and standard error mean for each lumbar spine pair in subjects above and below 50 years age.

Table 7b: **Independent samples test of lumber spine pairs based on age**

Lumbar spine pair	t-test for equality of means			
	T	Df	Sig. (2-tailed)	Mean difference
L1-L2[a]	-15.359	284	0.000	-1.24905
L2-L3	-15.210	284	0.000	-1.05812
L3-L4	-12.851	284	0.000	-1.28076
L4-L5	-9.796	284	0.000	-1.06371

[a] Presents independent samples t-tests based on age, highlighting significant differences in lumbar spine pair measurements with strong t-values, degrees of freedom (df), p-values (Sig.), and mean differences across age groups.

Table 8a: Group statistics of lumber spine pairs based on BMI

Lumbar spine pair	BMI	N	Mean	SD	SEM
L1-L2[a]	> 30	149	8.8826	0.74667	0.06117
	< 30	137	10.3323	0.65565	0.05602
L2-L3	> 30	149	9.1070	0.68367	0.05601
	< 30	137	10.2239	0.58887	0.05031
L3-L4	> 30	149	10.5052	0.75163	0.06158
	< 30	137	11.7723	0.91815	0.07844
L4-L5	> 30	149	10.8542	0.90785	0.07437
	< 30	137	11.6453	1.01958	0.08711

[a] Presents the group statistics of t -test based on BMI, showing mean, standard deviation, and standard error mean for each lumbar spine pair in subjects above and below 30 BMI.

The results show significant differences in lumbar spine measurements across all examined categories. Individuals below 50 years have consistently higher mean measurements than those above 50 (p-value (sig.) < 0.001), suggesting age-related variations in lumbar spine structure, possibly indicating a degenerative process in older individuals. Similarly, individuals with a BMI <30 exhibit higher mean lumbar spine measurements compared to those with a BMI >30 (p-value (sig.) < 0.001), implying that obesity may contribute to spinal issues. Additionally, males have significantly higher mean lumber spine measurement than females

Table 8b: Independent samples test of lumber spine pairs based on BMI

Lumbar spine pair	t-test for equality of means			
	T	df	Sig. (2-tailed)	Mean difference
L1-L2[a]	-17.384	284	0.000	-1.44972
L2-L3	-14.743	284	0.000	-1.11689
L3-L4	-12.812	284	0.000	-1.26709
L4-L5	-6.940	284	0.000	-0.79110

[a] Presents independent samples t-tests based on BMI, highlighting significant differences in lumbar spine pair measurements with strong t-values across BMI groups.

Table 9a: Group statistics of lumber spine pairs based on gender

Lumbar spine pair	Gender	N	Mean	Std. deviation	Std. error mean
L1-L2[a]	Male	122	8.4897	0.3120	0.0282
	Female	164	7.8498	0.4038	0.0315
L2-L3	Male	122	8.5184	0.3087	0.0279
	Female	164	7.6298	0.3432	0.0268
L3-L4	Male	122	10.4457	0.3531	0.0320
	Female	164	9.7463	0.2546	0.0199
L4-L5	Male	122	10.1689	0.2867	0.0259
	Female	164	9.4341	0.2697	0.0211

[a] This presents the group statistics of the T-test based on gender, showing the mean, standard deviation, and standard error mean for each lumbar spine pair in male and female subjects.

Table 9b: Independent samples test of lumber spine pairs based on gender

Lumbar spine pair	t-test for equality of means			
	T	df	Sig. (2-tailed)	Mean difference
L1-L2[a]	14.565	284	0.000	0.63992
L2-L3	22.595	284	0.000	0.88860
L3-L4	19.464	284	0.000	0.69940
L4-L5	22.179	284	0.000	0.73477

[a] Displays independent samples t-tests based on gender, showing highly significant differences in lumbar spine pair measurements between male and female subjects.

across all levels (p-value (sig.) < 0.001), reflecting potential biological differences in body composition and spine loading mechanics between genders. The extremely low p-value of less than 0.001 supports the conclusion that the observed difference is real and not due to random variation.

Mann-Whitney U test

The Mann-Whitney U test is a non-parametric test used to compare differences between two independent groups when the assumption of normality is unmet. The tests were applied to a dataset of quantified intervertebral disc spaces of the lumbar spine of lower back pain (LBP) patients, categorised by age, BMI, and gender. The tables 10a & 10b, 11a & 11b, and 12a & 12b gives the tabulated ranks and test statistics.

The results of Mann-Whitney U test, a non-parametric statistical method, presented in pair of tables 10a and 10b, 11a and 11b and 12a and 12b show significant differences between age groups (< 50 and > 50 yrs age) and between different BMI groups (> 30 and < 30) amongst males and females, respectively. Higher mean ranks suggest the

Table 10a: The Mann-Whitney test ranks of lumber spine pairs based on age

Lumbar spine pair	Age groups (yrs)	N	Mean rank[a]	Sum of ranks[b]
L1-L2	> 50	134	85.36	11438.00
	< 50	152	194.76	29603.00
L2-L3	> 50	134	84.35	11303.50
	< 50	152	195.64	29737.50
L3-L4	> 50	134	90.56	12135.00
	< 50	152	190.17	28906.00
L4-L5	> 50	134	100.27	13436.50
	< 50	152	181.61	27604.50

[a] Presents Mann-Whitney test ranks based on age, giving mean rank for each lumbar spine pair across age groups; [b]shows sum of ranks indicating cumulative ranking scores for subjects > 50 & < 50 yrs age

Table 10b: Test statistics of lumber spine pairs for age

Particulars	L1-L2	L2-L3	L3-L4	L4-L5
Mann-Whitney U	2393.0	2258.5	3090.0	4391.5
Wilcoxon W	11438.0	11303.5	12135.0	13436.5
Z	-11.163	-11.356	-10.164	-8.299
Asymp. Sig. (2-tailed)	0.000	0.000	0.000	0.000

[a] This displays the Mann-Whitney U, Wilcoxon W, Z-values, and Asymptotic Significance (2-tailed), highlighting significant differences in lumbar spine measurements across age groups.

Table 11a: **Mann-Whitney test ranks of lumber spine pairs based on BMI**

Lumbar spine pair	BMI	N	Mean rank[a]	Sum of ranks[b]
L1-L2	>30	149	86.55	12896.5
	<30	137	205.43	28144.5
L2-L3	>30	149	92.25	13745.5
	<30	137	199.24	27295.5
L3-L4	>30	149	97.29	14495.5
	<30	137	193.76	26545.5
L4-L5	>30	149	115.04	17140.5
	<30	137	174.46	23900.5

[a]This presents the Mann-Whitney Test ranks based on BMI, highlighting the mean rank for each lumbar spine pair across BMI groups;

[b]shows the sum of ranks, indicating the cumulative ranking scores for subjects above and below 30 BMI.

Table 11b: **Test statistics of lumber spine pairs for BMI**

Particulars	L1-L2	L2-L3	L3-L4	L4-L5
Mann-Whitney U	1721.5	2570.5	3320.5	5965.5
Wilcoxon W	12896.5	13745.5	14495.5	17140.5
Z	-12.144	-10.929	-9.855	-6.070
Asymp. Sig. (2-tailed)	0.000	0.000	0.000	0.000

[a] This displays the Mann-Whitney U, Wilcoxon W, Z-values, and Asymptotic Significance (2-tailed), highlighting significant differences in lumbar spine measurements across BMI groups.

Table 12a: The Mann-Whitney test ranks of lumber spine pairs based on gender

Lumbar spine pair	Gender	N	Mean rank[a]	Sum of ranks[b]
L1-L2	Male	122	204.45	24943.0
	Female	164	98.16	16098.0
L2-L3	Male	122	221.81	27061.0
	Female	164	85.24	13980.0
L3-L4	Male	122	214.53	26172.5
	Female	164	90.66	14868.5
L4-L5	Male	122	221.20	26986.0
	Female	164	85.70	14055.0

[a] This presents Mann-Whitney test ranks based on gender, highlighting the mean rank for each lumbar spine pair across males and females

[b] shows the sum of ranks indicating cumulative ranking scores for male and female subjects.

larger disc spaces, while lower mean ranks indicate smaller ones. Sum of ranks represent the represents the total rank sum for each group, which reflects the overall ranking contribution of the group based on its size. This metric supports the trend observed in mean ranks. Lower U-values (e.g., 450.000 for L2-L3 in gender comparison) indicate strong differences between the two groups. Negative and high absolute Z-values indicate strong evidence against the null hypothesis. For all comparisons, the p-values are .000, showing statistically significant differences in disc spaces across age, BMI, and gender groups.

This study emphasises the significant influence of demographic factors *viz*., age, BMI, and gender on lumbar spine health, particularly in the individuals experiencing lower back pain (LBP). Younger individuals tend to possess healthier spines, while elevated BMI is associated with weaker discs. Men often exhibit larger spines than women, likely due to inherent biological differences. Consequently, it becomes evident that older age, higher BMI, and female gender are associated with an increased risk of degenerative disc disease. This insight empowers healthcare providers to prioritise these factors when managing lower back pain, enabling them to offer more targeted and effective treatment strategies. A deeper understanding of

Table 12b: Test statistics of lumber spine pairs for gender

Particulars	L1-L2	L2-L3	L3-L4	L4-L5
Mann-Whitney U	2568.0	450.0	1338.5	525.0
Wilcoxon W	16098.0	13980.0	14868.5	14055.0
Z	-10.750	-13.812	-12.528	-13.704
Asymp. Sig. (2-tailed)	0.000	0.000	0.000	0.000

[a] Presents Mann-Whitney U, Wilcoxon W, Z-values, and Asymptotic significance (2-tailed), highlighting significant differences in lumbar spine measurements between male and female groups.

how demographics influence spinal health can significantly improve patient outcomes and LBP management.

Ethical statement: This study was conducted after approval from the Ethics Committee of CRICR, Bengaluru (Ref: IEC-CRICR/SN-123/048/2020). All the participants involved in the study were informed about its purpose, and their consent was obtained.

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