DOI: 10.7860/JCDR/2025/75090.20706

Original Article

Orthopaedics Section

Assessment of Radiological Parameters of Lordosis in Chronic Low Back Pain: A Case-control Study

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ABSTRACT

Introduction: Low Back Pain (LBP) is a global health problem with a multifactorial aetiology. Many clinicians believe that changes in lumbar lordosis contribute to LBP. The normal range of lordosis has not yet been agreed upon; hence, the practice of assessing the parameters of lordosis on sagittal radiographs becomes irrelevant, adding to treatment costs and exposing patients to radiation risk. Consequently, the practice of measuring lordosis needs to be re-evaluated.

Aim: To determine the Lumbar Lordotic Angle (LLA) and Lumbosacral Angle (LSA) in individuals with and without LBP.

Materials and Methods: This case-control study was conducted from November 2022 to March 2024 at Teerthankar Mahaveer Medical College, a tertiary care hospital, Moradabad, Uttar Pradesh, India. One hundred patients aged between 18 and 50 years with chronic non specific LBP were recruited as cases, matched for age, gender and Body Mass Index (BMI). Similarly, 100 healthy volunteers were taken as controls, also matched for these parameters. LSA and LLA were recorded on sagittal radiographs of all subjects, and the data were analysed statistically.

Results: The cases and controls were similar with respect to age (p-value=0.407), gender (p-value=0.315), and mean BMI (p-value=0.239). The mean LSA was 34.17±5.86° (M: 35.19±6.86°; F: 33.55±5.07°) in the case group and 36.69±6.72° (M: 37.68±6.78°; F: 35.87±6.63°) in the control group (p-value=0.001). The mean LLA was 50.04±9.09° (M: 53.99±8.93°; F: 48.25±8.55°) in cases and 49.60±9.77° (M: 48.78±9.69°; F: 50.30±9.88°) in controls (p-value=0.737). LBP cases showed decreased LSA in individuals aged 31-40 years (p-value=0.013), in females (p-value=0.02), and in overweight individuals (p-value=0.002), alongside increased LLA in males (p-value=0.001); however, the difference in angles was only observed in the 20-40 years age range. LLA and LSA did not show any significant association or correlation with age, gender, BMI and VAS.

Conclusion: The results indicate that LLA does not vary between those with and without LBP. The LSA was significantly lower in patients with LBP. Both LSA and LLA do not demonstrate a clear association and show an insignificant weak correlation with age, gender, BMI and VAS in both cases and controls.

Keywords: Lumbosacral angle, Lumbar lordosis, Lumbar lordotic angle, Sagittal radiograph, Spino-pelvic parameter

INTRODUCTION

The LBP is a global health problem that causes exorbitant medical expenses, loss of workdays and reduced productivity [1,2]. Chronic Low Back Pain (CLBP) is defined as pain located above the inferior gluteal folds and below the costal border, lasting more than 12 weeks, with or without leg pain [3]. LBP is labeled as non specific if there is no known pathoanatomical cause [3,4]. Lifetime prevalence of LBP has been reported to be 60-80% among adults and approximately 10-15% of these cases become chronic, with around 85% of individuals with CLBP lacking a specific diagnosis [5]. The aetiology of non specific LBP is multifactorial and relatively enigmatic. In the absence of any known pathoanatomical cause, the focus of clinicians should be on relieving pain and its effects [4].

The diagnostic approach for acute LBP is well codified, but for CLBP, it is less consistent. In cases of non specific CLBP, the relevance of imaging is debatable [3]. Most clinical guidelines for LBP recommend that in the absence of red flags, there is no indication to perform spinal imaging [3]. However, many clinicians believe that changes in lumbar lordosis are a cause of LBP, although not all agree, as varying results have been reported [6-12]. It is generally believed that lordosis in an individual depends on multiple factors, such as age, gender, BMI and ethnicity and this has been extensively reported [13-15]. The normal range of lordosis has not yet been agreed upon for any gender, race, age, or geographical area [13]. In the absence of agreement on the normal range of lumbar lordosis, the practice of assessing LLA and LSA on sagittal radiographs becomes irrelevant, as it adds to the cost of treatment and exposes patients to radiation risk. Consequently, the practice of measuring lordosis and other parameters in sagittal radiographs needs to be re-evaluated. Present study evaluated the LLA, which denotes lordosis and the LSA, which denotes sacral slope, as the LSA is inversely related to lordosis [16].

The aim of the study was to determine the LLA and LSA in individuals with and without CLBP and to analyse the correlation of age, gender, BMI, duration of symptoms and pain severity with LLA and LSA. The null hypothesis assumes that there is no difference in the radiological parameters of lumbar lordosis between those with CLBP and those without CLBP. The alternative hypothesis assumes that there is a significant difference in the radiological parameters of lumbar lordosis between individuals with CLBP and those without.

MATERIALS AND METHODS

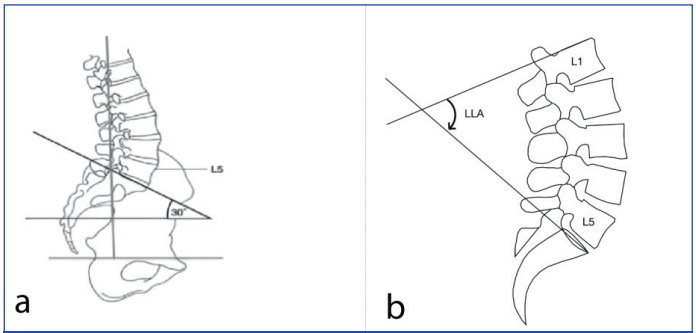
The case-control study was conducted at Teerthankar Mahaveer Medical College and Research Centre, Moradabad, Uttar Pradesh, India after the study proposal was approved by the College Research Committee (CRC) and the Institutional Ethical Committee (IEC) (TMU/IEC/2021-22/123) from November 2022 to March 2024. All participants were enrolled after providing written and informed consent.

Inclusion criteria: One hundred adult subjects of both genders, aged between 18 and 50 years, who presented to the outpatient department with complaints of LBP for more than three months and were diagnosed with non specific LBP, were enrolled as cases.

Exclusion criteria: If there was any suspicion or history of "Red Flags," i.e., (i) significant trauma; (ii) malignancy; (iii) steroid use; (iv) drug abuse; (v) immunocompromised state; (vi) spinal and/or

lower limb structural deformities; (vii) inflammatory or infective conditions of the spine; (viii) neuromuscular conditions affecting the spine or lower limbs; (ix) systemic diseases with concomitant signs of infection; (x) cauda equina syndrome or radiculopathy; and (xi) degenerative and osteoporotic spine. Similarly, age- and gender-matched controls consisting of 100 healthy volunteers aged 18 to 50 years with no complaints of LBP were selected. The demographic profile (age, gender and BMI) of all subjects was recorded. Pain severity was recorded using the Visual Analog Scale (VAS) score [17]. Subjects were stratified as underweight (<18.5 kg/m^2), normal (18.5-24.9 kg/m^2), overweight (25-29.9 kg/m^2) and obese (>30 kg/m^2) according to their BMI [18].

Two radiological parameters, LLA and LSA [Table/Fig-1], were selected for evaluation on digital radiographs to assess lumbar lordosis. The lateral view of the lumbar spine was taken with the patient standing in a relaxed posture at a distance of 90 cm from the X-ray tube. An expert radiologist, blinded to the subjects' clinical findings, calculated and recorded the LSA and LLA on DICOM images using HOROS Software. LSA was defined as the angle between the superior endplate of the first sacral vertebra and a horizontal reference on sagittal imaging of the lumbosacral spine [Table/Fig-1a] [19]. LLA was defined as the angle between the superior endplate of L1 vertebra and the superior endplate of S1 vertebra [Table/Fig-1b] [20].



[Table/Fig-1]: a) Lumbosacral Angle (LSA); b) Lumbar Lordotic Angle (LLA).

STATISTICAL ANALYSIS

The statistical analysis was conducted using Statistical Package for the Social Science (SPSS) software (version 25.0) by IBM, Chicago and Stats Direct software. The independent t-test was applied to evaluate the comparison of quantitative variables in both inter and intra group comparisons. Analysis of Variance (ANOVA) was used to determine the association of quantitative variables for more than two categories in intra group comparisons. The Chi-square test was implemented for the comparison of all variables, which were qualitative in nature, in both intra and inter group comparisons. In all statistical tests, a confidence interval (CI) of 95% was adopted and a p-value <0.05 was considered significant.

RESULTS

There were 100 subjects in both the case group and the control group. The mean age of subjects in the case group was 38.24±9.35 years, while in the control group, it was 37.19±8.5 years (p-value=0.407). The age-wise distribution of subjects in each age group was similar: 18-30 years (p-value=0.858), 31-40 years (p-value=0.529) and 41-50 years (p-value=0.479) [Table/Fig-2].

The mean BMI of the case group was 26.43±4.35 kg/m^2 and that of the control group was 27.25±5.37 kg/m^2. The number of subjects in the overweight category was significantly higher in the case group (p-value=0.013). However, in the obese category, the number of normal healthy subjects was significantly greater than that of the LBP group (p-value=0.011). In the underweight and normal weight categories, the number of subjects was comparable in both the LBP group and the healthy group (p>0.05). Overall, both the case and control groups were similar with respect to age (p-value=0.407), gender (p-value=0.315) and mean BMI (p-value=0.239). One subject had mild pain, 60 subjects had moderate pain and 39 had severe pain, with a mean VAS score of 6.21±1.43 [Table/Fig-2].

Parameters		Cases (n=100)	Controls (n=100)	p-value	Chi-square test value
Age (years)	18-30	19	20	0.858†	0.032
	31-40	26	30	0.529†	0.397
	41-50	55	50	0.479†	0.501
	Mean±SD	38.24±9.35	37.19±8.5	0.407‡	
Gender	Female	62 (62)	55 (55)	0.315†	1.009
	Male	38 (38)	45 (45)		
BMI (kg/m^2)	Underweight	2 (2)	2 (2)	1*	
	Normal	34 (34)	35 (35)	0.882†	0.022
	Overweight	45 (45)	28 (28)	0.013†	6.234
	Obese	19 (19)	35 (35)	0.011†	6.494
	Mean±SD	26.43±4.35	27.25±5.37	0.239‡	
VAS score	No pain (0)	00	100	-	-
	Mild pain (1-2)	01	0		-
	Moderate pain (3-6)	60	0		-
	Severe pain (7-10)	39	0		-
	Mean±SD	6.21±1.43	0	-	-

[Table/Fig-2]: Showing demographic profile of subjects.
†Chi-square test; ‡Independent t-test; *Fisher's exact test

Lumbosacral Angle (LSA): The mean LSA was recorded as 34.17±5.86° (Male: 35.19±6.86°; Female: 33.55±5.07°) in the case group and as 36.69±6.72° (Male: 37.68±6.78°; Female: 35.87±6.63°) in the control group, which was significantly less than in the controls (p-value=0.001) [Table/Fig-3].

The study results show that LSA did not vary significantly among age subgroups in the LBP group (p-value=0.702) or in normal healthy subjects (p-value=0.894). However, the LSA was significantly less in LBP cases aged 31-40 years (p-value=0.013). LSA did not differ between males and females in the LBP group (p-value=0.095) or in healthy individuals (p-value=0.168). However, LBP females had significantly less LSA than healthy females (p-value=0.02). LSA was similar across BMI categories in healthy individuals (p-value=0.766). The LSA in cases (p-value=0.02) was significantly less than that of healthy individuals (p-value=0.766). The LSA of LBP patients and the healthy population in the underweight, normal and obese categories did not differ (p-value >0.05), but in the overweight category, the LBP cases showed significantly less LSA (p-value=0.002) than in healthy individuals. LSA did not vary significantly with VAS in the mild, moderate and severe pain categories (p-value=0.997) [Table/Fig-3].

In controls, there was an insignificant and very weak positive correlation found between LSA and age (r=0.004, p-value=0.966) and BMI (r=0.057, p-value=0.567). In cases, there was also an insignificant and very weak positive correlation found between LSA and age (r=0.022, p-value=0.820) and a very weak negative correlation of LSA with BMI (r=-0.018, p-value=0.852) and with VAS (r=-0.066, p-value=0.508) [Table/Fig-4].

Lumbar Lordotic Angle (LLA): The mean LLA was recorded as 50.04±9.09° (Male: 53.99±8.93°; Female: 48.25±8.55°) in cases and as 49.60±9.77° (Male: 48.78±9.69°; Female: 50.30±9.88°) in controls, which was similar to the controls (p-value=0.737) [Table/Fig-5]. The LLA was similar across all age subgroups in both cases (p-value=0.855) and controls (p-value=0.363). The LLA in each age subgroup was similar in cases and controls (p-value >0.05). The LLA was similar among females of both groups (p-value=0.231), but males showed higher values of LLA in LBP patients (p-value=0.001). The study also indicates that LLA was similar across all BMI sub-categories in both cases (p-value=0.719)

Parameters		Cases (n=100) (°)	Controls (n=100) (°)	p-value	Odds ratio (95% CI)
Age (years)	18-30	34.21±6.33	36.09±5.29	0.137‡	0.923 (0.826-1.033)
	31-40	33.39±6.03	36.96±5.77	0.013‡	0.882 (0.793-0.98)
	41-50	34.5±5.68	36.76±7.78	0.085‡	0.958 (0.899-1.02)
	p-value	0.702§	0.894§		
Gender	Female	33.55±5.07	35.87±6.63	0.02‡	0.929 (0.868-0.994)
	Male	35.19±6.86	37.68±6.78	0.082‡	0.942 (0.879-1.01)
	p-value	0.095‡	0.168‡		
BMI	Underweight	39.90±0.85	33.15±1.91	0.090‡	1.9 (0.452-7.992)
	Normal	35.49±6.01	36.19±7.51	0.310‡	0.981 (0.912-1.056)
	Overweight	32.70±4.96	36.75±5.73	0.002‡	0.869 (0.785-0.962)
	Obese	34.70±6.65	37.30±6.86	0.161‡	0.933 (0.846-1.028)
	p-value	0.02§	0.766§		-
VAS score	No pain (0)	-	-	-	-
	Mild pain (1-2)	34.2±0	-		-
	Moderate pain (3-6)	34.18±6.13	-		-
	Severe pain (7-10)	34.15±5.59	-		-
	p value	0.997§	-	-	-
Overall	LSA	34.17±5.86	36.69±6.72	0.001‡	0.935 (0.891-0.981)

[Table/Fig-3]: LSA in different variables.
§ANOVA; ‡Independent t-test; Reference value taken as 1 and odd's calculated against control

Group	Variables	Mean±SD	Pearson correlation and coefficient value (r)	p-value
Controls	LSA	37.21±6.72	0.004	0.966
	Age	37.19±8.5		
	LSA	37.21±6.72	0.057	0.567
	BMI	27.25±5.37		
Cases	LSA	34.3±5.86	0.022	0.820
	Age	38.24±9.35		
	LSA	34.3±5.86	-0.018	0.852
	BMI	26.43±4.35		
	LSA	34.3±5.86	-0.066	0.508
	VAS score	6.21±1.43		

[Table/Fig-4]: Correlation of variables with LSA.

Parameters		Cases (n=100) (°)	Controls (n=100) (°)	p-value	Odds ratio (95% CI)
Age (years)	18-30	49.12±9.67	50.34±9.61	0.679‡	0.966 (0.905-1.031)
	31-40	49.86±9.13	51.32±9.6	0.545‡	0.991 (0.939-1.046)
	41-50	50.44±9.01	48.27±9.95	0.125‡	1.035 (0.989-1.083)
	p-value	0.855§	0.363§		
Gender	Female	48.25±8.55	50.3±9.88	0.231‡	0.973 (0.934-1.013)
	Male	53.99±8.93	48.78±9.69	0.001‡	1.059 (1.007-1.114)
	p-value	0.855§	0.363§		
BMI	Underweight	56.7±1.56	42.4±6.51	0.094‡	1.473 (0.741-2.93)
	Normal	49.94±9.21	48.67±9.3	0.543‡	1.017 (0.964-1.073)
	Overweight	50.22±8.66	49.17±10.6	0.646‡	1.012 (0.962-1.065)
	Obese	49.01±10.4	51.28±9.67	0.441‡	0.977 (0.922-1.034)
	p-value	0.719§	0.468§		-
VAS score	No pain (0)	-	-	-	-
	Mild pain (1-2)	45.0±0	-		-
	Moderate pain (3-6)	51.23±8.55	-		-
	Severe pain (7-10)	49.15±9.91	-		-
	p-value	0.255§	-	-	-
Overall		50.04±9.09	49.60±9.77	p=0.737	1.005 (0.975-1.036)

[Table/Fig-5]: LLA in different variables.
§ ANOVA; ‡Independent t-test; Reference value taken as 1 and odd's calculated against control

Group	Variables	Mean±SD	Pearson correlation and coefficient value (r)	p-value
Controls	LLA	49.62±9.77	-0.082	0.415
	Age	37.19±8.5		
	LLA	49.62±9.77	0.119	0.236
	BMI	27.25±5.37		
Cases	LLA	50.43±9.09	0.056	0.577
	Age	38.24±9.35		
	LLA	50.43±9.09	0.047	0.635
	BMI	26.43±4.35		
	LLA	50.43±9.09	-0.160	0.109
	VAS score	6.21±1.43		

[Table/Fig-6]: Correlation of variables with LLA.

and controls (p-value=0.468). The LLA in patients was similar to that of healthy individuals in each BMI sub-category (p-value >0.05). The LLA was also similar in the mild, moderate and severe subgroups of VAS (p-value=0.255) [Table/Fig-5]. A non significant very weak negative correlation was found between LLA and age (r=-0.082, p-value=0.415) and a weak positive correlation was found with BMI (r=0.119, p-value=0.236) in controls. The case group showed a non significant very weak positive correlation of LLA with age (r=0.056, p-value=0.577) and BMI (r=0.047, p-value=0.635), along with a very weak negative correlation of LLA with the VAS score (r=-0.160, p-value=0.109) [Table/Fig-6].

DISCUSSION

Individuals above 50 years of age were not included to avoid the presence of individuals with osteoporotic conditions and degenerative spine issues with marginal osteophytes. A review of published literature provided conflicting views on the influence of age [8,15,21,22], gender [8,21-23] and body weight [8,15,23,24]. Therefore, authors decided to maintain a homogeneous composition of study groups, as much as possible, in present study to overcome the biases of age, gender and BMI as confounding factors. The age, gender and BMI of the subjects were similar in the case and control groups, indicating that the composition of the groups was homogeneous (p-value >0.05), except that the number of subjects in the overweight BMI category was higher in the healthy group (p-value=0.013).

Although the LSA values in the case group as a whole (p-value=0.001) and in the 31-40 years age subgroup (p-value=0.013) were significantly less than in the normal population, the difference was only 20-30 years. The LSA values among the age subgroups in cases (p-value=0.702) and in the normal population (p-value=0.894)

were similar, showing no association of LSA with age. Present study results are supported by other authors [8,9,19,22,25,26]. Similarly, present study showed no gender differences in LSA values between cases and healthy subjects, which was also supported by other researchers [15,22,24]. Regarding BMI, LSA values are similar in all subgroups of BMI in the normal population, indicating no relation between LSA and BMI. However, in cases, LSA was significantly lower in the overweight category. Many researchers believe that higher BMI is associated with higher lumbar lordosis [8,23,24], while another author has reported that lordosis is independent of BMI [15]. This decrease in LSA values in cases did not correspond to an increase in LLA values. Similarly, patients with LBP in the underweight category showed higher LSA values, while those in the overweight category showed lower LSA values compared to healthy individuals in the same BMI category. However, this change was not reciprocated in the LLA values in cases. No find any association between sacral slope and the severity of pain was found, as the LSA was similar in those experiencing mild, moderate, or severe pain.

In healthy individuals, only an insignificant and very weak positive correlation between LSA and age (r=0.004, p-value=0.966) and BMI (r=0.057, p-value=0.567) was found. Back pain patients also showed an insignificant and very weak positive correlation with age (r=0.022, p-value=0.820) and a very weak negative correlation with BMI (r=-0.018, p-value=0.852) and VAS (r=-0.066, p-value=0.508).

In present study, LLA values in CLBP patients were similar to those of healthy subjects (p=0.737) across all age, gender and BMI categories, as well as in all respective subgroups, denoting no association of CLBP with LLA. The LLA values were similar in CLBP patients categorised as having mild, moderate, or severe pain, showing no relationship between LLA and back pain. The results of this study are supported by some researchers [7-10,22] but are also refuted by others [11,15,27].

Present study has shown an insignificant and very weak negative correlation with age (r=-0.082, p-value=0.415) and a weak positive correlation with BMI (r=0.119, p-value=0.236) in the control group. The case group shows a non significant, very weak positive correlation with age (r=0.056, p-value=0.577) and BMI (r=0.047, p-value=0.635) with a very weak negative correlation with the VAS score (r=-0.160, p-value=0.109).

It has been reported that lumbar lordosis is influenced by a multitude of factors, which complicates its use as a diagnostic measure and variations in lumbar lordosis are common in the general population, which are not necessarily indicative of pathology [13,16]. Additionally, it has been reported that a reciprocal relationship between the sacral slope and lumbar curvature exists and both are essential components of the overall sagittal alignment of the spine [16]. Authors did not find this concept to hold true in present study. LBP patients who showed a significant decrease in LSA values by 2-3° failed to show any corresponding increase in LLA; moreover, when the lordosis decreased, the sacral slope did not exhibit any reciprocal change in LSA. The variation of 20-40° is well within the normative values of LLA (300-800) and LSA (330-490) [28]. These minimal variations can be attributed to measuring error due to marginal osteophytes and should not be taken as a conclusive sign.

The results of present study indicate that it cannot be said with certainty that the significantly lower values of LSA in patients compared to the normal population are the “cause of” or the “effect of” back pain. Present study hypothesis was that if lower values of LSA are the “cause,” then it should also be reflected across all subcategories of BMI. Secondly, we do not have the values of these parameters prior to the onset of pain to assert with certainty that pain is the only variable affecting this change.

In light of the analysis of present study results, we believe that the assessment of LSA and LLA in sagittal radiographs of non specific CLBP patients does not differ from that of healthy individuals, demonstrating that our null hypothesis was correct and can be accepted. Therefore, assessing these parameters would not provide any additional insights into the pathophysiology of pain or assist clinicians in formulating treatment plans; thus, it should be discouraged. Present study findings are supported by recent published literature indicating no role of LSA and LLA in LBP [10,12,13,21-24]. Moreover, recent Clinical Practice Guidelines (CPGs) for the treatment of LBP do not mention any radiological assessment of lumbar lordosis [29].

Limitation(s)

One of the major limitations of this study was that it was a single-centre study. To reproduce similar outcomes and validate these results, a multicentric study design must be adopted. Secondly, the radiological parameters were assessed at the time of patient presentation in the outpatient department, i.e., only once. In order to more accurately understand the relationship between the LSA and LLA with back pain, we should have radiographs of the lumbar spine taken and angles measured at two different time points. The first radiograph should be taken when pain is present and the second radiograph should be taken after the pain has been relieved following treatment. Only by comparing the LSA and LLA at these two points in time can we truly assess the relationship between lordosis and back pain. The absence of data at two points in time acts as a confounding factor. Therefore, authors suggest that future studies encompass multicentric, longitudinal designs with larger sample sizes and more diverse groups, utilising data collected at two-time points to reach more meaningful conclusions.

CONCLUSION(S)

The results have shown that LLA does not vary between those with and without LBP. The LSA was significantly lower in patients with LBP. LSA and LLA do not demonstrate a clear association and exhibit an insignificant weak correlation with age, gender, BMI and VAS in both cases and controls.

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PLAGIARISM CHECKING METHODS: [Jain H et al.]
- Plagiarism X-checker: Sep 19, 2024
- Manual Googling: Dec 14, 2024
- iThenticate Software: Dec 17, 2024 (24%)

ETYMOLOGY: Author Origin

EMENDATIONS: 7

AUTHOR DECLARATION:
- Financial or Other Competing Interests: None
- Was Ethics Committee Approval obtained for this study? Yes
- Was informed consent obtained from the subjects involved in the study? Yes
- For any images presented appropriate consent has been obtained from the subjects. Yes

Date of Submission: **Sep 18, 2024**
Date of Peer Review: **Oct 12, 2024**
Date of Acceptance: **Dec 19, 2024**
Date of Publishing: **Mar 01, 2025**