

Original Article

Significance of Correlation Between Spinopelvic Parameters in Patients of Chronic Low Back Pain

Waqas Noor Chughtai, Azhar Rashid, Muhammad Adeel Razzaque, Manqoosh-ur-Rehman

Tahira Fatima, Muhammad Asad Ullah

Bakhtawar Amin Medical College and Hospital, Multan

ABSTRACT

Objective: To determine the significance of the correlation between spinopelvic parameters in patients with chronic low back pain.

Materials and Methods: 129 patients with chronic low back pain of a minimum of 03 months duration were included in our study from September 2020 to February 2023. Sagittal standing spinopelvic radiographs were done on all patients. Various spinopelvic measurements were done including PI, PT, LLA, SLA L1 – L3, SLA L3 – S1, LSA, SHA, and SIA. Pearson correlation was used to determine the correlation coefficient.

Results: The mean age was 36.45 ± 9.54 years. Males were 59 and females 70. Mean and SD of spine pelvic measures were LLA = 57.32 ± 12.45 , SLA L1-L3 = 15.31 ± 3.75 , SLA L3 – S1 = 42.46 ± 8.34 , LSA = 8.94 ± 4.72 , SHA = 38.10 ± 7.94 , SIA = 52.42 ± 6.84 , PT = 11.21 ± 5.83 , PI = 48.72 ± 8.90 . PI has a significant positive correlation with LLA ($r = 0.492$ and $p\text{-value} < 0.001$).

Conclusion: PI and LLA are important spinopelvic parameters and have significant correlation with other spinopelvic parameters and derangement of one of them can affect the overall spine sagittal balance resulting in chronic low back pain.

Keywords: Spinopelvic parameters, Lumbar Lordosis Angle (LLA), Segmental lumbar Lordosis Angle (SLA), lumbosacral Angle (LSA), Sacral Horizontal Angle (SHA), Sacral Inclination Angle (SIA), Pelvic Tilt (PT), Pelvic Incidence (PI), (BMI) Body mass index).

Corresponding Author: Waqas Noor Chughtai
Bakhtawar Amin medical college and Hospital, Multan.
Email: drwaqas220@gmail.com

Date of Submission: 10-04-2023
Date of Revision: 15-06-2023
Date of Acceptance: 20-06-2023
Date of Online Publishing: 30-06-2023
Date of Print: 30-06-2023

DOI: 10.36552/pjns.v27i2.874

INTRODUCTION

There is no specific scientific-based definition of sagittal curvature of the spine. At birth, the child has a whole kyphotic curvature of the spine from the cervical to the coccyx region. When the child attains the upright posture, spinal curvatures become prominent. Initially, there is the development of the lordosis curve of the lumbar region and later on, thoracic kyphosis develops.^{1,2}

Thoracic kyphosis is measured by Cobb's angle by taking the upper-end plate of most tilted vertebrae cranially and the lower-end plate of most tilted vertebrae caudally. Normal thoracic kyphosis range is 10 to 60 degrees. Kyphosis gradually increases in old age due to degeneration in the spine. Thoracic kyphosis is more obvious in the male gender. It is always assessed based on the overall alignment of the spine. The thoracolumbar region that extends from T10 to L2 vertebrae is slightly kyphotic^{3,5}.

The lumbar lordosis angle is somewhat higher than thoracic kyphosis. Lumbar lordosis is more prominent in females as compared to males.⁴ It is measured from the cranial surface of L1 and the caudal endplate of L5. The angle ranges from 40 to 60 degrees. Lumbar lordosis angle slowly decreases in the elderly due to degeneration changes in the spine. Anatomical spine sagittal alignment of the spine is measured by drawing a plumb line from the center of the C2 vertebrae Odontoid or the center of the C7 vertebrae cranially to the posterior end of the sacrum S1 caudally. The sagittal alignment is considered to be positive if the gravity line is drawn anterior to the femoral heads and is considered to be negative if the line is drawn posterior to the sacrum.^{4,5}

Nowadays the measurement of pelvic incidence has emerged, this is the angle formed by 2 lines.⁶ One line is drawn perpendicular to the upper endplate of S1 vertebrae and the other line is drawn by joining the midpoint of the upper endplate of S1 to the center of both heads of the femur. Pelvic incidence is the only morphometry of the spine pelvic dimension that remains constant throughout the life of an individual.^{6,7} A strong correlation is found between the lumbar lordosis angle and the pelvic incidence. An important fact is that pelvic incidence regulates the sagittal balance of the spine and pelvis. On common grounds, the lumbar lordosis angle is 10 degrees greater than the pelvic incidence.^{5,8}

The sagittal balance of the spine plays a

significant role in the development of various spine pathologies. Every person has a unique spine posture and spinopelvic dimensions based on age, gender, BMI, and pelvic anatomy.⁹ Spinopelvic parameter plays a pivotal role in maintaining the balanced posture of individuals and various spine disorders of a normal population.^{12,31} An important question remained unclear what is the influence of spinopelvic parameters in the development of low back pain? In the past few decades, there is more emphasis on the quantitative measurements of the spinopelvic parameters and their rising implication in the treatment of spinopelvic pathologies.¹⁰ Chaleat-Valayer et al, did a study on 198 patients with a mean age of 39.4 having a PI of 50.6. Golbakhsh et al, did a study on patients with low back pain.¹⁶ He found no difference while comparing PI in these patients with or without spine instability at L3 – L4, L4 – L5, and L5 – S1 levels. Servain et al, did a study and found a relationship between the PI and shear stresses of the intervertebral discs in our study we studied 129 patients having chronic low back pain and found $PI\ 48.72 \pm 8.90$.³² We will study various spinopelvic parameters quantitatively and will assess their correlation with one another in patients with chronic low back pain. We hypothesize that there is a significant and positive correlation between spinopelvic parameters especially PI and LLA and the aberration in one of these parameters disturbs the overall anatomy of spine balance leading to chronic low back pain.^{11,33} No such study was being done in our area about this topic. As patients with low back pain are increasing exponentially, we have to determine the factors that predispose an individual to the development of low back pain.^{12,34}

MATERIALS AND METHODS

Study design and setting

This was a cohort study that was done in the

Neurosurgery Department at Bakhtawar Amin medical college and Hospital Multan from September 2020 to February 2023.

Inclusion Criteria

129 patients 22 to 56 years old with chronic low back pain of a minimum 3 months duration were included in our study.

Exclusion Criteria

Patients having spine pathologies like spondylolisthesis, spine or pelvic tumors, infection of the spine, spine deformities like scoliosis and kyphosis, patients having neurological deficits, bedridden patients, and patients having a contraindications to radiation exposure like pregnancy were not included in this study.

Sampling Technique and Sample Size

129 patients were taken by simple random sampling technique in this study. Software G Power version 3.1.9.4 was used to calculate the sample size. Values of effect size were considered as 0.3, alpha as 0.05, and power of the test as 80% resulting in a sample size of 140. However, a

sample size of 129 patients was taken in this study.

Radiological Management

Every patient was clinically evaluated by a consultant neurosurgeon. Standing and sagittal spinopelvic radiographs were done on all patients. In the radiology department during the X-ray, all patients were told to stand straight and fully relaxed. Both anteroposterior and lateral X-rays were done. The patient's elbows were flexed and knees extended. The distance of the film to the focus region was 02 meters.^{11,12}

Data collection

Data was taken from the patients. Following spine pelvic measurements (Figures 1 & 2) were calculated^{2,8} (Table1).

Statistical Analysis

SPSS 24.0 was used to do statistical analysis. Categorical variables were evaluated by percentages. Numeric variables were assessed by mean and SD. An Independent sample t-test was

Table 1: Spinopelvic measurements.

Angles	Description
Lumbar lordosis angle (LLA)	This is the angle that is formed by joining the lines along the cranial end of L1 vertebrae and the caudal end of L5 vertebrae
Segmental lumbar lordosis angle (SLA) L1 – L3	This is the angle formed by joining the lines between the cranial end of L1 and the cranial end of L3
Segmental lumbar lordosis angle (SLA) L3 – S1	This is the angle formed by joining the lines between the cranial end of L3 and the cranial end of S1
Lumbo-sacral angle (LSA)	This is the angle between the cranial endplate of S1 and the caudal endplate of the L5 vertebra
Sacral Horizontal angle (SHA)	This is the angle formed by joining two lines. One line is along the horizontal axis and another line is along the cranial and S1 vertebrae.
Sacral inclination angle (SIA)	This is the angle formed by joining two lines. One line is along the vertical axis and another line is along the posterior border of S1 vertebrae.
Pelvic tilt (PT)	This is an angle that is formed by joining 2 lines. One line is formed by joining the center points of the biconvex femoral heads (hip axis) and the center of the S1 end plate and the second line is the reference vertical axis.
Pelvic incidence (PI)	This is an angle that is formed by joining 2 lines. One line is formed by joining the center

points of the biconvex femoral heads (hip axis) and the center of the S1 cranial border and a second line is perpendicular to the S1 endplate.

used to assess the difference in the mean of the quantitative variables. Pearson correlation was used to analyze the correlation coefficient between the quantitative variables. A 5% level of significance was taken and $p < 0.05$ was considered significant.

RESULTS

Demographic Analysis

The demographic analysis was done on 129 patients. Mean and SD was calculated for age, height, weight, and BMI. Results are shown in Table 2.

Table 2: Demographic Analysis.

Variables	Results
Age	36.45 ± 9.54
Gender	
• Males	59 = 45.7 %
• Females	70 = 54.3 %
Height	1.53 ± 0.07
Weight	64.3 ± 9.3
BMI	26.16 ± 2.49

Spine-Pelvic Parameters

Various sagittal spinopelvic parameters were analyzed and the following Table shows the mean and SD of these various parameters (Table 3).

Table 3: Spinopelvic parameters.

Radiographic parameter	Mean ± SD
Lumbar lordosis angle (LLA)	57.32 ± 12.45
Segmental lumbar lordosis angle (SLA) L1 – L3	15.31 ± 3.75
Segmental lumbar lordosis angle (SLA) L3 – S1	42.46 ± 8.34
Lumbo-sacral angle (LSA)	8.94 ± 4.72
Sacral Horizontal angle (SHA)	38.10 ± 7.94
Sacral inclination angle (SIA)	52.42 ± 6.84

Pelvic tilt (PT)	11.21 ± 5.83
Pelvic incidence (PI)	48.72 ± 8.90

Correlation of Spino-Pelvic Parameters

The correlation was assessed of various spinopelvic parameters. Pelvic incidence was taken and its correlation was assessed concerning other parameters, age, and BMI of patients of the study group. The significance of the correlation was also assessed by using an independent sample t-test by comparing the means of these variables. The correlation between PI and SHA, SIA, and PT was positive but between PI and LSA it was negative. The correlation coefficient r between PI and LLA ($r = 0.492$), PI and SHA ($r = 0.691$), PI and SIA ($r = 0.409$), PI and PT ($r = 0.456$), PI and LSA ($r = -0.184$). A significant correlation of $p < 0.001$ is found between PI and LLA, SHA, and PT. A nonsignificant correlation having a p -value > 0.05 was found between PI and LSA and SIA. In our study, we found a positive correlation of $r = 0.26$ between PI and age and p -value 0.632. Between PI and BMI, the positive correlation $r = 0.319$ was found to have a p -value of 0.072 (Table 4).

Table 4: Correlation of PI and other spinopelvic parameters.

Correlation of PI with	r-value	p-value
LLA	0.492	0.001
LSA	-0.184	0.310
SHA	0.691	0.001
SIA	0.409	0.080
PT	0.456	0.001
AGE	0.26	0.632
BMI	0.319	0.072

Lumbar lordosis was taken and its correlation was assessed concerning other parameters, age, and BMI of patients of the study group. The significance of the correlation was also assessed by using an independent sample t-test by

comparing the means of these variables. A positive correlation was found between LLA and PI, LSA, SHA, and SIA, and a negative correlation with PI. The correlation coefficient r between LLA

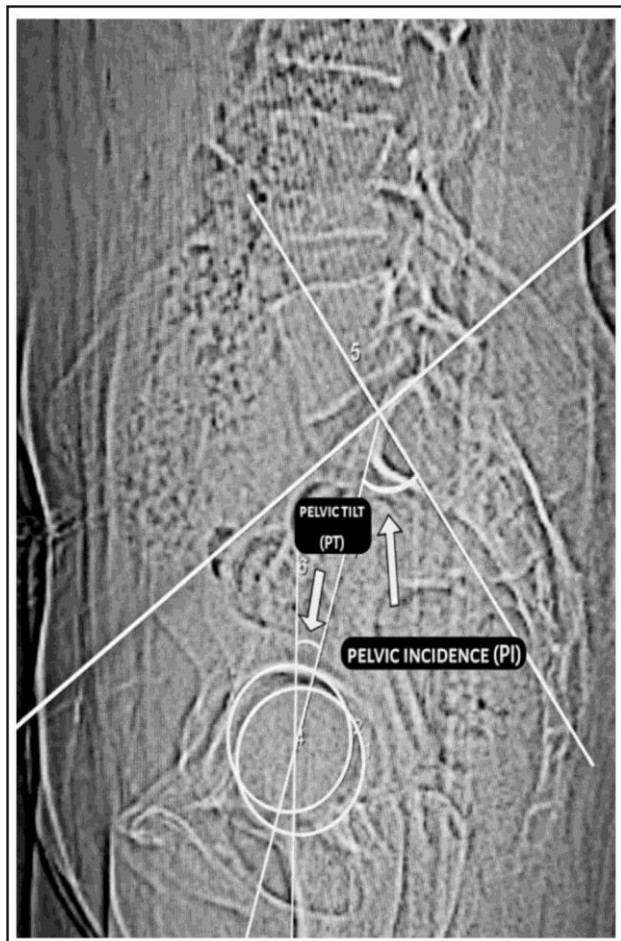


Figure 1: Spino-Pelvic parameters (PI: Pelvic incidence, PT: Pelvic tilt). Image included with patient's permission.

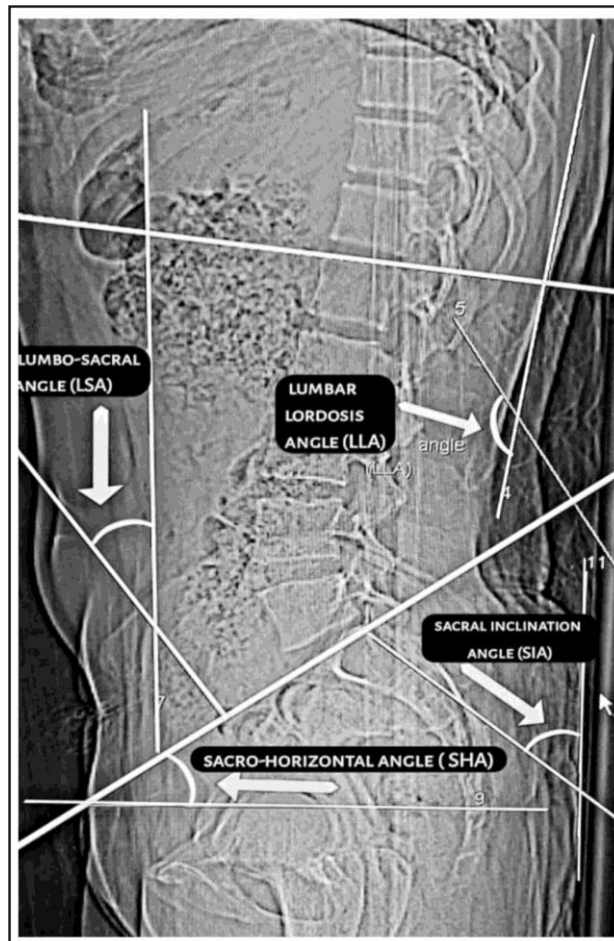


Figure 2: Spino-pelvic parameters (LLA: Lumbar lordosis angle, LSA: Lumbosacral angle, SHA: Sacro-horizontal angle, SIA: Sacral inclination angle). Image included with patient's permission.

Table 5: Correlation of LLA and other spinopelvic parameters.

Correlation of LLA with	r value	p-value
PI	0.492	0.001
LSA	0.184	0.284
SHA	0.794	0.001
SIA	0.721	0.001
PT	- 0.132	0.212
AGE	- 0.131	0.319
BMI	0.084	0.713

and PI ($r = 0.492$), LLA and LSA ($r = 0.184$), LLA and SHA ($r = 0.794$), LLA and SIA ($r = 0.721$), LLA and PT ($r = - 0.132$) Significant correlation of p -value < 0.001 is found between PI, SHA, and SIA. A nonsignificant correlation having a p -value > 0.05 was found between LLA and LSA and PT. In our study, we found a negative correlation of $r = - 0.131$ between LLA and age and p -value 0.319. Between LLA and BMI, the positive correlation $r = 0.084$ was found to have a p -value of 0.713 (Table 5).

DISCUSSION

Spine sagittal balance is an important factor in maintaining a proper posture of the body, absorbing various loads by the spine, and performing paraspinal musculature.^{1,2} The sagittal balance of the spine is determined by various curves of the spine, thoracic spine kyphosis, lumbar lordosis, pelvis position and angulation, hip joints, and knee joint alignments. The key component in the compensation process of sagittal balance is the role of the pelvis, so it is highly recommended to determine the relation between the pelvis and the spine.^{3,4} This thing becomes more important in patients having spine deformity. These patients need corrective surgery. Before surgery, we have to do surgical planning on preoperative radiographs and measure sagittal curvatures and the correlation between pelvis and hip joints.⁵ The spine and pelvis show a chain of correlation. This is evident that if we properly evaluate pelvis morphology, we can easily evaluate spinopelvic balance. Spinopelvic measurements that were taken in this study were pelvic tilt, sacral horizontal angle, and pelvic incidence. PT and SHA were measurements that were taken as vertical and horizontal reference lines concerning the orientation of the pelvis.^{6,8} Pelvic incidence is a very important anatomical parameter in the position and orientation of the pelvis. This is the angle that is formed by joining 2 lines. One line is formed by the center points of the biconvex femoral heads (hip axis) and the center of the sacrum upper-end plate and a second line is perpendicular to the sacrum upper-endplate. It is a stable anatomical measurement for the maintenance of spine sagittal curvatures. In our study, we had taken these spine parameters of the pelvis and also various spine parameters like lumbar lordosis angle, segmental lumbar lordosis angle, and lumbosacral angle in chronic low back pain patients. We hypothesize that in chronic low back pain patients there is a

significant positive correlation between spinopelvic parameters.^{9,10,21}

Pelvic incidence is the key measurement in the complex framework of spine sagittal balance.¹⁴ It has been studied that PI becomes static at the age of 10 years and remain unchanged in adolescent and adults. It is altered in the disease process that modifies the anatomy of the sacrum or acetabulum. It is the sum of SHA and PT. $PI = SHA + PT$. PI had been studied in various studies and different pathologies.^{15,18} Barrey et al, studied PI in 25 patients having herniated discs and disc degeneration with an age range of 43.7 ± 11.6 years with a mean PI of 49.8 ± 11.4 .²⁹ In scoliosis, multiple researchers measured PI as Legaye et al, did on 66 patients having PI 51.7 ± 9.7 , scoliosis KING I curve by Mac-Thiong et al, on 32 patients having PI 57.0 ± 15.7 ,³⁴ scoliosis King II curve PI 59.1 ± 12.4 , Scoliosis King III curve with PI 56.3 ± 13.7 .²⁵ In spondylolisthesis pelvic incidence has a very key role. Patients having high PI have a high risk of presenting with spondylolisthesis and increase PI predispose them to the progression of spondylolisthesis and clinical manifestations.^{17,34} Huang et al, studied PI in spondylolisthesis on 14 patients with a mean age of 15.4 ± 6.0 years and with a mean PI of 52.6 ± 13.8 .³¹ Vialle et al, also studied 244 patients having spondylolisthesis with a mean age of 13.9 ± 2.8 years with a mean PI 63.1 ± 11.3 .³⁰ In patients of low back pain, various studies were done to determine PI. Chaleat-Valayer et al, did a study on 198 patients with a mean age of 39.4 years having PI 50.6.¹⁶ Golbakhsh et al, did a study on patients with low back pain.²¹ He found no difference while comparing PI in these patients with or without spine instability at L3 – L4, L4 – L5, and L5 – S1 levels. Servain et al, did the study and found a relationship between the PI and shear stresses of the intervertebral discs.³² In our study, we studied 129 patients having chronic low back pain and found PI 48.72 ± 8.90 .

Pelvic tilt PT is an angle that is formed by joining 2 lines.¹¹ One line is formed by joining the hip axis (midpoint of the biconvex femoral heads) and center of the sacrum upper-end plate and the second line is the reference vertical axis.^{19,20} Chaleat-Valayer et al, studied PT in 198 patients having back pain of mean age of 39.4 years with a mean PT of 13.9.¹⁶ In this study, we found PT in chronic low back pain patients of mean age 36.45 $\pm$ 9.54 years having PT 11.21 $\pm$ 5.83.

Sacral horizontal angle SHA is an angle that is formed between the horizontal axis and a line along the cranial end of S1.^{11,23} Sarikaya et al, studied SHA in 39 patients having low back pain with a mean age of 42.6 $\pm$ 3.69 years having SHA 47.05 $\pm$ 10.45.¹⁰ In this study, we measured SHA on 129 patients with chronic low back pain of mean age 36.45 $\pm$ 9.54 years having SHA 52.42 $\pm$ 6.84.

Lumbar lordosis angle LLA is the angle that is formed by joining the lines along the upper-end plate of L1 vertebrae and the lower-end plate of L5 vertebrae.^{7,13,19} Sarikaya et al, studied LLA on 39 patients with a mean age of 42.46 $\pm$ 3.69 years having LLA 45.61 $\pm$ 9.56.¹⁰ Chaleat-Valayer et al, studied PT in 198 patients having low back pain of mean age 39.4 years with a mean LLA of 51.0.¹⁶ In this study, we measured LLA on 129 patients with chronic low back pain of mean age 36.45 $\pm$ 9.54 years having LLA 57.32 $\pm$ 12.45.

Segmental lumbar lordosis SLA L1 – L3 is an angle between the upper-end plate of L1 and the lower-end plate of L3 vertebrae.^{6,30} Nakipoglu et al, studied SLA L1 – L3 in 30 patients of acute low back pain with a mean age of 41.0 $\pm$ 11.63 years with mean SLA L1 – L3 13.52 $\pm$ 4.82.¹⁸ In this study, we measured SLA L1 – L3 in 129 patients of chronic low back pain of mean age 36.45 $\pm$ 9.54 years having a value of 15.31 $\pm$ 3.75. Segmental lumbar lordosis SLA L3 – S1 is an angle between the upper-end plate of L3 and the upper-end plate of S1 vertebrae.^{10,23} Nakipoglu et al, studied SLA L1 – L3 in 30 patients of acute low back pain with a mean age of 41.0 $\pm$ 11.63 years with mean

SLA L3 – S1 34.03 $\pm$ 10.29.¹⁸ In this study, we measured SLA L3 – S1 in 129 patients with chronic low back pain of mean age 36.45 $\pm$ 9.54 years having a value of 42.46 $\pm$ 8.34.

Lumbosacral angle LSA is the angle between the cephalic endplate of the sacrum and the caudal endplate of L5.^{11,18} Evcik and Yucel et al, studied LSA in 30 patients of mean age 40.3 $\pm$ 8.2 years having LSA 17.4 $\pm$ 1.3.¹³ Sarikaya et al, studied LSA in 39 patients having low back pain with a mean age of 42.6 $\pm$ 3.69 years having LSA 14.59 $\pm$ 9.56.¹³ In this study, we measured LSA L3 – S1 in 129 patients of chronic low back pain of mean age 36.45 $\pm$ 9.54 years having a value of 8.94 $\pm$ 4.72.

A sacral inclination angle (SIA) is an angle formed by joining two lines.^{9,10} One line is along the vertical axis and another line is along the posterior border of the S1 vertebrae. Evcik and Yucel et al, studied SIA in 30 patients of mean age 40.3 $\pm$ 8.2 years having a mean SIA of 46.3 $\pm$ 4.7.¹³ In this study, we measured SIA in 129 patients with chronic low back pain of mean age 36.45 $\pm$ 9.54 years having a value of 52.42 $\pm$ 6.84.

As far as the correlation between spinopelvic parameters is concerned, PI correlation has been assessed with other parameters. Multiple research works analyzed the correlation of LLA and PI suggesting a significant positive relationship of $r = 0.40$ to 0.72 ($p < 0.001$).^{4,9,12,27} This showed that as the PI decreases, lumbar lordosis decreases and disc pressure increases and degeneration occurs in the disc leading to low back pain. In this study, we also found a positive significant correlation of $r = 0.492$ having a p -value < 0.001 between PI and LLA. The correlation between PI and SHA, SIA, and PT was positive but between PI and LSA it was negative. A significant correlation of $p < 0.001$ is found between PI and LLA, SHA, and PT. A nonsignificant correlation having p -value > 0.05 was found between PI and LSA and SIA.^{15,20} Correlation between PI and age was assessed in various studies in patients with spondylolisthesis.³³ In our study, we found a

positive correlation of $r = 0.26$ between PI and age and p-value 0.632. Between PI and BMI, the positive correlation $r = 0.319$ was found to have a p-value of 0.072. These results matched with the international literature.

The correlation of LLA and other spinopelvic parameters was assessed. A positive correlation was found between LLA and PI, LSA, SHA, and SIA, and a negative correlation with PI. A significant correlation of p-value < 0.001 is found between PI, SHA, and SIA.^{3,15,24,31} A nonsignificant correlation having a p-value > 0.05 was found between LLA and LSA and PT. The correlation between LLA and age was assessed by Jackson and McManus et al, in patients with chronic low back pain.^{9,12,17} In our study, we found a negative correlation of $r = -0.131$ between LLA and age and p-value 0.319. Between LLA and BMI, the positive correlation $r = 0.084$ was found having p-value 0.713.^{7,16,20,29} These results also matched with the international literature.

LIMITATIONS

One limitation is that sagittal vertical axis SVA was not included in this study because of the unavailability of 36 inches X-ray films. The second limitation is that data of healthy patients' spinopelvic measures were not included and compared with the study patients' spinopelvic measurements having chronic low back pain. The third limitation is that nowadays there is the use of CT scans of the pelvis in DICOM format for the calculation of PI. CT scans were not used and X-rays were taken to determine both femoral heads as a reference point for the hip axis.

CONCLUSION

It is concluded in this study that the most important parameters in spinopelvic measurements are PI and LLA. These parameters have a significant positive correlation with other spinopelvic parameters and harmony among

these play a significant role in maintaining spine balance impairment in any of these has a significant effect on other parameters which leads to chronic low back pain. Further studies will be required to determine the role of aberration of these spinopelvic parameters in the causation of chronic low back pain.

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Additional Information

Disclosures: Authors report no conflict of interest.

Ethical Review Board Approval: The study was conformed to the ethical review board requirements.

Human Subjects: Consent was obtained by all patients/participants in this study.

Conflicts of Interest: In compliance with the ICMJE uniform disclosure form, all authors declare the following:

Financial Relationships: All authors have declared that they have no financial relationships at present or within the previous three years with any organizations that might have an interest in the submitted work.

Other Relationships: All authors have declared that there are no other relationships or activities that could appear to have influenced the submitted work.

Financial Relationships: None.

AUTHORS CONTRIBUTION

Sr. No.	Author Full Name	Intellectual Contribution to Paper in Term of
1	Waqas Noor Chughtai	Study design and methodology.
2	Azhar Rashid	Analysis of data and interpretation of results etc.
3	Muhammad Adeel Razzaque	Data collection and calculations.
4	Manqoosh-ur-Rehman	Paper writing, referencing, data calculations.
5	Tahira Fatima	Analysis of data and quality insurer.
6	Muhammad Asad Ullah	Literature review and manuscript writing.