Spino-pelvic radiological parameters in normal Indian population

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Abstract – Introduction: There is increasing emphasis on the sagittal spino-pelvic alignment and its interpretation is of critical importance in the management of spinal disorders. A cross-sectional study of several spino-pelvic radiographic parameters was conducted to determine the physiological values of these parameters, to calculate the variations of these parameters according to epidemiological data, and to study the relationships among these parameters.

Material and method: Fifty normal healthy volunteers (29 males and 21 females) with no history of back pain were selected and were subjected to standing sagittal spino-pelvic radiographs. All the measurements of various radiographic parameters were performed with use of a software program. A statistical analysis was done to study the relationships among them.

Results: The mean values of pelvic incidence (PI) and lumbar Lordosis Angle (LLA) were 48.52 ± 8.99 and 58.78 ± 9.51, respectively. There was statistical difference between male and female parameters in LLA, lumbo-sacral angle (LSA), sacral horizontal angle (SHA), sacral inclination angle (SIA), sacropelvic angle (PRS1), pelvisacral angle (PSA), and PI. A majority of parameters had higher values for female subjects when compared to male subjects. PI was positively correlated with LLA, pelvic angle (PA), pelvic overhang (PO), pelvic tilt (PT), sacrofemoral distance (SFD), SHA, and sacropelvic translation (SPT), which were highly significant, whereas LLA was positively correlated with SHA and SIA only. PI and LLA were both negatively correlated with PSA, pelvic thickness (PTH), and PRS1.

Conclusions: This study presents the various spino-pelvic radiographic parameter values of a sample of the normal asymptomatic Indian population. There was significant difference in radiographic parameters between males and females in about half of the parameters studied in the sample. The values obtained are comparable with the values presented as normal in the literature. A comparison of the study results with data published about other populations revealed no differences in any of the pelvic parameters between the Indian, Brazilian, and Korean populations.

Key words: Spino-pelvic alignment, Radiologic parameters, Pelvic incidence, Lumbar lordosis angle.

Introduction

The sagittal spino-pelvic alignment pattern varies from one individual to another and is specific to each person. The vertebral column plays an important role in the support and locomotion of the human body. An understanding of the elements that compose it is essential for learning about its role in body balance and alignment. Many investigators have reported the importance of the sagittal plane contour in the normal function of the spine and in various diseased states [1, 2].

To analyze the consequences of changes in sagittal balance in each individual, we need to understand the normal parameters for the population. The judgment of normality can be made possible by analyzing the normal patterns of sagittal curvature and characteristics of each pattern of sagittal curves. If sagittal alignment is abnormal, more expenditure of energy and high demand on the dynamic and static stabilizer are required to compensate the abnormal sagittal alignment for balance [3, 4].

Several studies have evaluated the relationship between the position of the pelvis and spinal alignment [4–16]. However, it is important to know the values of these radiographic parameters in healthy individuals, without spinal disease. Although some studies address these parameters, it is interesting to evaluate them in a specific population as there are structural

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differences between different population groups. Various studies have been conducted with evaluations of individuals from the European, Caucasian, Brazilian, and Korean populations [1–3, 10–12, 17]. However, a similar study has not yet been conducted for the Indian population.

The objective of this study is to observe the parameters of sagittal and spino-pelvic balance in a sample of the Indian population consisting of volunteer asymptomatic individuals, in order to establish the relationship between these parameters, age, and sex and to compare the results with those of other studies that cover other population groups.

**Materials and methods**

The present study was conducted from May 2012 to November 2014 in a tertiary care center. Fifty subjects agreed to participate in the study. All were volunteers and met the following inclusion criteria: an age between 18 and 50 years, no history of a spinal disorder or spinal surgery, and no radiographic abnormality detected prior to or during the study. Hip, knee, and ankle abnormalities were ruled out by clinical examination. All volunteers provided informed consent. The study population consisted of 50 volunteers (29 men and 21 women), with a mean age of 31.14 ± 9.62 years. The epidemiological and morphological characteristics of this cohort were obtained from the following data: age, gender, weight, and height. The body mass index was calculated as the weight in kilograms divided by the square of the height in meters.

Informed written consent was obtained from all the subjects participating in the study. The institutional review board cleared the study and ethical clearance was taken.

Each volunteer was thoroughly examined clinically to rule out any obvious spinal pathology and was subjected to sagittal spino-pelvic radiographs.

**Sagittal spino-pelvic radiographs**

Lateral radiographs of the lumbo-pelvic region were taken using Philips digital radiography system. The participants were instructed to stand straight and relaxed, with their knees fully extended. The elbows were flexed, with both hands resting on a horizontal bar at the level of their shoulders. The film-to-focus distance was 2 m.

The following angles (Figure 1) were measured on the sagittal spino-pelvic radiographs using open source software.
OsiriX (version 3.8.1, Pixmeo, Geneva, Switzerland) downloaded from http://www.osirix-viewer.com/.

(a) Lumbar Lordosis Angle (LLA) – The angle between the cephalad endplate of the first lumbar vertebra and the cephalad endplate of sacrum.
(b) Segmental Lordosis Angle (SLA) L1-L3 – The angle between the cephalad endplate of the first lumbar vertebra and the cephalad endplate of third lumbar vertebra.
(c) SLA L3-S1 – The angle between the cephalad endplate of the third lumbar vertebra and the cephalad endplate of sacrum.
(d) Lumbo-sacral angle (LSA) – The angle between the line along the upper border of sacrum and lower border of L5 vertebra.
(e) Sacral Horizontal Angle (SHA) – The angle between a horizontal line and a line drawn tangentially to the upper surface of sacrum.
(f) Sacral Inclination Angle (SIA) – The angle between the line along the posterior border of S1 body and the reference vertical line.
(g) Pelvic tilt (PT) – The angle between the line joining the hip axis (midpoint of bicoxofemoral axis) and the center of the S1 endplate and the reference vertical line.
(h) Pelvic angle (PA) – The angle between the line joining the hip axis and the posterior corner of the S1 endplate and the reference vertical line.
(i) Pelvic incidence (PI) – The angle between the line joining the hip axis and the center of S1 endplate and the line orthogonal to the S1 endplate.
(j) Pelvisacral Angle (PSA) – The angle between the line joining the hip axis and the center of S1 endplate and the line along the S1 endplate.
(k) Sacropelvic angle (PRS1) – The angle between the line joining the hip axis and the posterior corner of the S1 endplate and the line along the S1 endplate.
(l) Sacrofemoral distance (SFD) – The horizontal distance between the reference vertical line through the hip axis and the reference vertical line through the anterior corner of the S1 endplate.
(m) Pelvic overhang (PO) – The horizontal distance between the reference vertical line through the hip axis and the reference vertical line through the center of the S1 endplate.
(n) Sacrofemoral translation (SPT) – The horizontal distance between the reference vertical line through the hip axis and the reference vertical line through the posterior corner of the S1 endplate.
(o) Pelvic Radius (PR) – The distance of the line joining the hip axis and the posterior corner of the S1 endplate.
(p) Pelvic thickness (PTH) – The distance of the line joining the hip axis and the center of S1 endplate.
(q) Lordosis Tilt Angle (LTA) – The angle between the anterior superior edge of S1 and the anterior superior edge of L1 with the reference vertical line is defined as the lordosis tilt angle. By convention, this angle is expressed as a negative value if the limit of the lumbar lordosis is posterior to the anterior aspect of S1, and positive if it is anterior to S1.

Table 1. Demographic data study population.

| Parameter                  | Mean ± SD, n = 50 |
|---------------------------|-----------------|
| Age (years)               | 31.14 ± 9.62    |
| Sex                       | Male 29         |
|                           | Female 21       |
| Height (m)                | 1.64 ± 0.064    |
| Weight (kg)               | 66.34 ± 5.33    |
| BMI (kg/m²)               | 24.72 ± 2.36    |

Table 2. Findings on sagittal spino-pelvic radiographs among study group.

| Radiographic parameter             | Mean ± SD (range) |
|------------------------------------|------------------|
| Lumbar Lordosis Angle (LLA) (°)    | 58.78 ± 9.51 (37 to 79) |
| Lumbo-sacral angle (LSA) (°)       | 10.56 ± 3.58 (5 to 20)  |
| Pelvic angle (PA) (°)              | 13.86 ± 6.76 (2 to 39)  |
| Pelvic incidence (PI) (°)          | 49.52 ± 8.99 (33 to 69) |
| Pelvic overhang (PO) (mm)          | 18.22 ± 12.78 (−9 to 61) |
| Pelvic radius (PR) (mm)            | 128.90 ± 8.86 (111 to 157) |
| Pelvisacral Angle (PSA) (°)        | 41.36 ± 9.11 (21 to 57)  |
| Pelvic tilt (PT) (°)               | 9.30 ± 7.16 (−5 to 37)  |
| Pelvic thickness (PTH) (mm)        | 116.94 ± 9.41 (99 to 147) |
| Sacrofemoral distance (SFD) (mm)   | 4.52 ± 12.51 (−23 to 44) |
| Sacral Horizontal Angle (SHA) (°)  | 39.14 ± 7.05 (22 to 55)  |
| Sacral Inclination Angle (SIA) (°) | 48.62 ± 6.62 (35 to 62)  |
| Segmental Lordosis Angle (SLA) L1-L3 (°) | 17.54 ± 3.81 (9 to 25)  |
| Segmental Lordosis Angle (SLA) L3-S1 (°) | 43.46 ± 8.15 (28 to 64) |
| Sacropelvic angle (PRS1) (°)       | 37.02 ± 8.05 (18 to 52)  |
| Sacrofemoral translation (SPT) (mm)| 30.82 ± 13.82 (4 to 75)  |
| Lordosis Tilt Angle (LTA) (°)      | −2.48 ± 4.98 (−16 to 10) |

Statistical analysis

Collected data were entered in the MS Excel spreadsheet, coded appropriately, and later cleaned for any possible errors in SPSS (Statistical Package for Social Studies) for Windows version 20. Categorical data were presented as percentage (%). Normally distributed data were presented as means and standard deviation, or 95% confidence intervals (CIs). For comparing two groups containing quantitative variables, independent sample t-test was used. In case of violation of normality, Mann-Whitney test was used. Pearson’s correlation was used for measuring correlation coefficient between two quantitative variables. In case of qualitative variables, Spearman’s correlation coefficient was applied. All tests were performed at a 5% level significance, thus a difference was significant if the value was less than 0.05 (p value < 0.05).

Results

Table 1 shows the demographic data of study population. Of the 50 volunteers analyzed, 29 were males and 21 were females with a mean body mass index (BMI) of 24.72 ± 2.36 kg/m².

Table 2 shows values of various radiological parameters of the study group. The mean values of PI and LLA were 48.52 ± 8.99 and 58.78 ± 9.51, respectively.
Table 3 shows the statistical comparison of various radiographic parameters according to gender. There was statistical difference between male and female parameters in LLA, LSA, SHA, SIA, PRS1, PSA, and PI. A majority of parameters had higher values for female subjects when compared to male subjects.

Table 4 shows Correlation of Pelvic Incidence and Lumbar Lordosis Angle with other radiographic parameters, age, gender, and BMI. PI was positively correlated with LLA, PA, PO, PT, SFD, SHA, and SPT, which were highly significant, whereas LLA was positively correlated with SHA and SIA only. PI and LLA were both negatively correlated with PSA, PTH, and PRS1.

Table 5 shows variations in radiographic parameters overall and in males and females in different populations. The parameters among European population were comparatively higher than other studied populations.

Table 6 summarizes the findings of the studies done so far and the findings of the present study.

**Discussion**

The current study yields a physiological standard for several angular pelvic and spinal parameters that describe spinal balance, measured in a cohort of 50 asymptomatic adult volunteers of Indian resident population.

In the past three decades, increasing emphasis is being placed on quantitative evaluation of the parameters of sagittal spino-pelvic alignment as it is useful for clinical application and treatment of spino-pelvic pathologies. The harmony among spino-pelvic parameters is therefore of significant importance [4–19]. However, for us to correctly understand the effects of the loss of sagittal balance on the quality of life of each individual, we must know the normal values of the parameters used to evaluate sagittal and spinopelvic balance in the population.

A statistically significant difference was found between PI and gender in the present study with higher values of PI in
Jackson et al. found significant negative correlation between PI and PRS1 \( (r = -0.80 \text{ to } -0.62, p < 0.001) \) between PRS1 and LLA [6, 18]. In the present study, we also found significant negative correlation with \( r = -0.59 \) (\( p < 0.001 \)). Legaye reported significant positive correlation between PRS1 and PR \((r = 0.38 - 0.73, p < 0.001) \). In the present study, we also found significant correlation between these two spino-pelvic parameters \( (r = 0.46; p = 0.01) \).

In the present study, a significant correlation was found between LLA and other spino-pelvic parameters i.e. SHA \((r = 0.82; p < 0.001) \) and SIA \((r = 0.57; p < 0.001) \). There was no significant correlation regarding SFD, PO, and SPT. Similar significant correlation was found between PI and other spino-pelvic parameters i.e. PA \((r = 0.57), SFD \text{,} \text{PO}, \text{and SPT} \).

The mean values of PI \((48.52 \pm 8.99, n = 50) \) in the present study in the control group were found similar to the data reported in the literature for Korean \((47.8 \pm 9.5, n = 86) \) and Brazilian \((48.7 \pm 9.6, n = 50) \) populations and somewhat different from data of European population \((54.7 \pm 10.6, n = 300) \) [1-3] for the total sample and in the comparison between the Indian, Brazilian, and Korean populations, we can see that there were no differences for any of the pelvic parameters when compared by sex of the individuals evaluated. A majority of parameters had higher values for female when compared to male subjects. When we compare the average values and standard deviations obtained in this study with those published in the literature for European, Brazilian, and Korean populations, we can see that there were no differences for any of the pelvic parameters between the Indian, Brazilian, and Korean populations, even when compared by sex. The values of pelvic incidence of the European population were higher than those of the Indian population sample. Both for the total sample and for the female group, the pelvic tilt values of the European population were similar to those obtained for the sample population studied. These data show

| Population | Brazilian [3] \((n = 50)\) | European [1] \((n = 300)\) | Korean [2] \((n = 86)\) | Indian \((n = 50)\) |
|------------|----------------|----------------|----------------|----------------|
| Mean | SD | Mean | SD | Mean | SD | Mean | SD |
| PI Total | 48.7 | 9.6 | 54.7 | 10.6 | 47.8 | 9.5 | 48.5 | 9.0 |
| Male | 49.1 | 6.4 | 53 | 10.6 | 48.8 | 7.3 | 46.31 | 9.28 |
| Female | 48.3 | 9.6 | 56 | 10 | 46.1 | 9.5 | 51.57 | 7.79 |
| SS Total | 38 | 8.4 | 41.2 | 8.5 | 36.3 | 8.6 | 39.1 | 7.0 |
| Male | 38.2 | 6.9 | 41 | 8.5 | 37.3 | 7.1 | 37.00 | 6.26 |
| Female | 37.8 | 8.4 | 43.2 | 8.4 | 34.4 | 8.6 | 42.09 | 7.16 |
| PT Total | 12.15 | 6.2 | 13.2 | 6 | 11.5 | 5.4 | 9.3 | 7.2 |
| Male | 12.1 | 6.2 | 13 | 6 | 11.4 | 5.4 | 9.17 | 8.40 |
| Female | 12.2 | 5.3 | 13.6 | 6 | 11.6 | 5.1 | 9.47 | 5.19 |
Table 6. Existing studies and reported values.

| Study                                           | N   | Age (years) | PR (mm) | Description |
|------------------------------------------------|-----|-------------|---------|-------------|
| Jackson et al. (1998) [5]                      | 50  | 39.4 ± 9.5  | 135 ± 8.6| Normal      |
| Jackson et al. (2003) [6]                      | 75  | 39          | 136.8 ± 8.9| Normal      |
| Present study                                  | 50  | 31.14 ± 9.62| 128.9 ± 8.86| Normal males|
|                                                | 29  | 130.62 ± 8.75|        | Normal males|
|                                                | 21  | 126.52 ± 8.65|        | Normal females|
| Study                                          | N   | Age (years) | PTH (mm) | Description |
| Duval-Beaupere et al. (1992) [7]               | 17  | 29.4 ± 11.0 | 120 ± 7.5| Normal      |
| Rajnics et al. (2001) [8]                      | 25  | 35.1 ± 3.0  | 155.5 ± 19.3| Normal females|
|                                                | 15  | 33.5 ± 2.9  | 133.1 ± 15.3| Normal males|
| Present study                                  | 50  | 31.14 ± 9.62| 116.94 ± 9.41| Normal males|
|                                                | 29  | 119.03 ± 9.74|        | Normal males|
|                                                | 21  | 114.04 ± 8.30|        | Normal females|
| Study                                          | N   | Age (years) | PSA (C176) | Description |
| During et al. (1985) [9]                       | 52  |             | 41.3 ± 10.0| Normal      |
| Itio (1991) [10]                               | 18  | 72          | 33.2 ± 13.2| Normal      |
| Present study                                  | 50  | 31.14 ± 9.62| 41.36 ± 9.11| Normal males|
|                                                | 29  |             | 43.72 ± 9.32| Normal males|
|                                                | 21  |             | 38.10 ± 7.91| Normal females|
| Study                                          | N   | Age (years) | PI (C176) | Description |
| Duval-Beaupere et al. (1992) [7]               | 17  | 29.4 ± 11.0 | 51.8 ± 9.4 | Normal      |
| Rajnics et al. (2001) [8]                      | 15  | 33.5 ± 2.9  | 53.6 ± 8.9 | Normal males|
|                                                | 15  | 35.1 ± 3.0  | 55.1 ± 8.4 | Normal females|
| Vialle et al. (2005) [1]                       | 300 | 35.4 ± 12.0 | 54.7 ± 10.6| Normal      |
|                                                | 190 |             | 53.0 ± 10.6| Normal males|
|                                                | 110 |             | 56.0 ± 10.0| Normal females|
| Roussouly et al. (2005) [12]                   | 160 | 27          | 51.9 ± 10.7| Normal      |
| Boulay et al. (2006) [13]                      | 149 | 30.8 ± 6.0  | 53.1 ± 9.0 | Normal      |
| Legaye (2007) [14]                             | 145 | 40.7 ± 18.7 | 50.2 ± 10.6| Normal      |
| Janssen et al. (2009) [15]                     | 30  | 27          | 53 ± 10   | Normal males|
|                                                | 30  | 26          | 50 ± 10   | Normal females|
| Mac-Thiong et al. (2010) [16]                  | 354 | 37.9 ± 14.7 | 52.7 ± 10.0| Normal males|
|                                                | 355 | 37.7 ± 13.9 | 52.4 ± 10.8| Normal females|
| Lee et al. (2011) [2]                          | 86  | 28.19       | 47.8 ± 9.3 | Normal      |
|                                                | 54  |             | 48.8 ± 7.3 | Normal males|
|                                                | 32  |             | 46.1 ± 9.5 | Normal females|
| Pratali et al. (2014) [3]                      | 50  | 34.85       | 48.7 ± 9.6 | Normal      |
|                                                | 25  | 32.3        | 49.1 ± 6.4 | Normal males|
|                                                | 25  | 37.4        | 48.3 ± 9.6 | Normal females|
| Present study                                  | 50  | 31.14 ± 9.62| 48.52 ± 8.99| Normal     |
|                                                | 29  |             | 46.31 ± 9.28| Normal males|
|                                                | 21  |             | 51.57 ± 7.79| Normal females|
| Study                                          | N   | Age (years) | PRS1 (C176) | Description |
| Jackson et al. (1998) [5]                      | 50  | 39.4 ± 9.5  | 31.2 ± 7.9 | Normal      |
| Jackson et al. (2000) [18]                     | 20  | 46          | 31 ± 8.7  | Normal      |
| Jackson et al. (2003) [6]                      | 75  | 39          | 30.9 ± 9.8 | Normal      |
| Legaye (2007) [14]                             | 145 | 40.7 ± 18.7 | 35.2 ± 9.6 | Normal      |
| Present study                                  | 50  | 31.14 ± 9.62| 37.02 ± 8.05| Normal males|
|                                                | 29  |             | 38.93 ± 8.61| Normal males|
|                                                | 21  |             | 34.38 ± 6.50| Normal females|
| Study                                          | N   | Age (years) | PT (C176) | Description |
| Legaye et al. (1998) [19]                      | 28  | 24 ± 5.8    | 11.9 ± 6.6| Normal males|
|                                                | 21  |             | 10.3 ± 4.8| Normal females|
| Roussouly et al. (2005) [12]                   | 160 | 27          | 11.99 ± 6.46| Normal     |

(continued on next page)
| Study                        | N  | Age (years) | PT (°)    | Description       |
|-----------------------------|----|-------------|-----------|-------------------|
| Vialle et al. (2005) [1]    | 300| 35.4 ± 12.0 | 13.2 ± 6  | Normal            |
|                             | 190| 13 ± 6      |           | Normal males      |
|                             | 110| 13.6 ± 6    |           | Normal females    |
| Boulay et al. (2006) [13]   | 149| 30.8 ± 6.0  | 11.96 ± 6.44 | Normal           |
| Janssen et al. (2009) [15]  | 30 | 27          | 12 ± 5.7  | Normal males      |
| Mac-Thiong et al. (2010) [16]| 354| 37.9 ± 14.7 | 13.4 ± 6.7 | Normal males     |
|                             | 355| 37.7 ± 13.9 | 12.7 ± 7.0 | Normal females    |
| Lee et al. (2011) [2]       | 86 | 28.19       | 11.5 ± 5.3 | Normal            |
|                             | 54 | 11.4 ± 5.4  |           | Normal males      |
|                             | 32 | 11.6 ± 5.1  |           | Normal females    |
| Pratali et al. (2014) [3]   | 50 | 34.85       | 12.15 ± 6.2 | Normal          |
|                             | 25 | 32.3        | 12.1 ± 6.2 | Normal males      |
|                             | 25 | 37.4        | 12.2 ± 5.3 | Normal females    |
| Present study               | 50 | 31.14 ± 9.62| 9.30 ± 7.16 | Normal          |
|                             | 29 | 9.17 ± 8.40 |           | Normal males      |
|                             | 21 | 9.47 ± 5.19 |           | Normal females    |

| Study                        | N  | Age (years) | SHA (°)  | Description       |
|-----------------------------|----|-------------|----------|-------------------|
| Legaye et al. (1998) [19]   | 28 | 24 ± 5.8    | 41.9 ± 8.7 | Normal males      |
|                             | 21 |             | 38.2 ± 7.8 | Normal females    |
| Roussouly et al. (2005) [12]| 160| 27          | 39.9 ± 8.2 | Normal            |
| Vialle et al. (2005) [1]    | 300| 35.4 ± 12.0 | 41.2 ± 8.5 | Normal            |
|                             | 190| 41 ± 8.5    |           | Normal males      |
|                             | 110| 43.2 ± 8.4  |           | Normal females    |
| Boulay et al. (2006) [13]   | 149| 30.8 ± 6.0  | 41.18 ± 6.96 | Normal       |
| Janssen et al. (2009) [15]  | 30 | 27          | 41 ± 8.6  | Normal males      |
| Mac-Thiong et al. (2010) [16]| 354| 37.9 ± 14.7 | 39.3 ± 8.0 | Normal males      |
|                             | 355| 37.7 ± 13.9 | 39.8 ± 7.9 | Normal females    |
| Lee et al. (2011) [2]       | 86 | 28.19       | 36.3 ± 7.8 | Normal            |
|                             | 54 | 37.3 ± 7.1  |           | Normal males      |
|                             | 32 | 34.4 ± 8.6  |           | Normal females    |
| Pratali et al. (2014) [3]   | 50 | 34.85       | 38 ± 8.4  | Normal            |
|                             | 25 | 32.3        | 38.2 ± 6.9 | Normal males      |
|                             | 25 | 37.4        | 37.8 ± 8.4 | Normal females    |
| Present study               | 50 | 31.14 ± 9.62| 39.14 ± 7.05 | Normal       |
|                             | 29 | 37.0 ± 6.26 |           | Normal males      |
|                             | 21 | 42.10 ± 7.16|           | Normal females    |

| Study                        | N  | Age (years) | PO (mm)  | Description       |
|-----------------------------|----|-------------|----------|-------------------|
| Legaye et al. (1998) [19]   | 28 | 24 ± 5.8    | 22.6 ± 12.5 | Normal males      |
|                             | 21 |             | 19.2 ± 7.9 | Normal females    |
| Present study               | 50 | 31.14 ± 9.62| 18.22 ± 12.78 | Normal       |
|                             | 29 | 17.83 ± 14.85| 18.76 ± 9.55 | Normal males    |
|                             | 21 |             | 18.76 ± 9.55 | Normal females    |

| Study                        | N  | Age (years) | LLA (°)   | Description       |
|-----------------------------|----|-------------|-----------|-------------------|
| Legaye et al. (1998) [19]   | 28 | 24 ± 5.8    | 61.4 ± 10.2 | Normal males      |
|                             | 21 |             | 58.1 ± 10.8 | Normal females    |
| Present study               | 50 | 31.14 ± 9.62| 66.36 ± 9.47 | Normal        |
|                             | 29 |             | 58.78 ± 9.51 | Normal males     |
|                             | 21 |             | 62.33 ± 8.46 | Normal females    |

| Study                        | N  | Age (years) | SLA L1-L3 (°) | Description       |
|-----------------------------|----|-------------|----------------|-------------------|
| Present study               | 50 | 31.14 ± 9.62| 17.54 ± 3.81  | Normal            |
|                             | 29 | 17.0 ± 4.01 |               | Normal males      |
|                             | 21 | 18.28 ± 3.46|               | Normal females    |
the importance of studies in this format, aimed at adjusting
the radiographic parameters for different populations [1–3].
Furthermore, the normative values derived from the present
data can be utilized clinically to evaluate spinal deformities
and in deformity corrective measures (surgical/conservative)
targeting to achieve normal spino-pelvic balance in the Indian
population.

Conclusion

This study presents the various spino-pelvic radiographic
parameter values of a sample of the normal asymptomatic Indian
population. There was significant difference in radiographic parameters between males and females in about half of the
parameters studied in the sample. The values obtained are com-
parable with the values presented as normal in the literature.
A comparison of the study results with data published about
other populations revealed no differences in any of the pelvic
parameters between the Indian, Brazilian, and Korean populations. There were differences in pelvic incidence between the Indian and European populations both in the total sample and
in the male and female groups. There were differences in sacral
slope between the Indian and European populations in relation to
the total sample and the female group. More extensive studies
are needed to further validate the findings of the present study.

Conflict of interest

The authors declare no conflict of interest.

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