



RADIOGRAPHIC ASSESSMENT OF SPINO-PELVIC ALIGNMENT OF INDIAN YOUNG AND ELDERLY POPULATION IN COMMON INDIAN SITTING POSTURES AND STANDING: INFLUENCE OF AGE IN THE DIFFERENCE BETWEEN THESE POSITIONS

Dr. Doki Sunil Kumar^{1*}, Dr. Goutam Kumar Satapathy², Dr. Sibasish Patro³, Dr. Golekha Chhatra⁴

^{1*}Assistant Professor, Dept of Orthopaedic, SLN Medical College Koraput.

²Professor, Dept of Orthopaedic, SCB Medical College and Hospital Cuttack.

³Senior Resident, Dept of Orthopaedic, SLN Medical College Koraput Odisha.

⁴Senior Resident, Dept of Orthopaedic, SLN MCH Koraput.

Corresponding Author: Dr. Doki Sunil Kumar

Assistant Professor, Dept of Orthopaedic, SLN Medical College Koraput.

ABSTRACT

Background: Restoring the sagittal spino-pelvic alignment is the key factor in attaining the desirable functional outcomes after spinal deformity correction and degenerative spine surgeries. The existing concepts of sagittal balance are in most cases based on standing radiographic parameters. Though, the Indian population, mainly the one living in rural areas, frequently adopts functional postures like cross-legged sitting and squatting as part of daily life. The impact of these postures and age-related differences on sagittal spino-pelvic alignment has yet to be fully explored.

Objective: To analyze the radiographic alterations in spino-pelvic alignment in standing, erect sitting, cross-legged sitting, and squatting positions in young and elderly Indian populations, and to determine the role of age in these positional changes.

Materials and Methods: In this prospective cross-sectional study we decided to recruit 30 healthy volunteers who were randomly subdivided into 2 groups i.e. young (age is less than 45 years) and elderly (age is more than 45 years) for the convenience of study. Saxual X-rays of lumbosacral spine with both hip joints were taken in standing, erect sitting, cross-legged sitting and squatting positions. Different sagittal spino-pelvic parameters which include Lumbar Lordosis Angle (LLA), Lumbo-sacral Angle (LSA), Sacral Slope (SS), Pelvic Tilt (PT), and Pelvic Incidence (PI) were statistically analyzed and contrasted between different postures and age groups. Statistical tests used were independent sample t-test and multifactor regression analysis, with a significance level of $p < 0.05$.

Results: Sagittal spino-pelvic alignment changed differently and remarkably in different functional postures. On average, lumbar lordosis angle reduced gradually from 45.2 in standing posture to 10.8 in squatting posture, Though pelvic tilt increased from 15.8 to 39.4. Versus erect sitting, cross-legged sitting and squatting resulted in a more noticeable drop in lumbar lordosis and sacral slope. In standing posture, elderly ones had A lot lower lumbar lordosis and sacral slope but higher pelvic tilt versus younger ones. The younger people had a Much greater dynamic postural adaptation as the average change in lumbar lordosis between standing and squatting was 39.1 in young subjects against 27.4 in old subjects ($p < 0.001$). Age was negatively connected to pelvic mobility and compensatory sagittal adjustment.

Conclusion: There are marked differences between the sagittal spino-pelvic alignments in standing posture and Indian sitting postures that are widely practiced. The extent of these variations is largely determined by the degree of flexibility of lumbopelvic region which tends to decrease with age. Apart from standing alignment, if functional sitting postures are also taken into account, it will lead to a deeper insight into physiological sagittal balance. In addition, it will be very helpful for surgical planning and restoring sagittal alignment in the Indian population.

INTRODUCTION

Maintaining and restoring sagittal spino-pelvic alignment is now considered a key principle in the treatment of spinal deformities and degenerative spinal disorders. A correct sagittal balance is a good predictor for an energy-efficient posture, diminishing pain, enhancing function, and achieving a high quality of life after spinal surgery [1]. Today, ideas about spinal alignment and surgical



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intervention to correct the deformities are mainly supported by radiographic parameters taken in the upright position. A number of investigations have set standard values for sagittal spinal and pelvic parameters in the standing posture, and such data are commonly employed for pre-surgical assessment and post-surgical restoration of alignment in spinal deformity surgeries [2].

Though, the standing position may not be the perfect reflection of the functional spinal alignment that a person adopts during the everyday activities, in particular for those populations where alternative sitting postures are often practiced. Sitting is a natural part of our daily life and while chair sitting is the dominant sitting posture in most Western populations, cross-legged sitting and squatting are still the most common postures in India, among the rural population more than the urban one. These postures are so naturally woven into the social cultural occupational, and household activities of the people that each posture brings about its own unique spinal, pelvic, and lower limbs adjustments, resulting in dynamic changes in sagittal alignment and pelvic orientation [3,4].

Previous evidence points to that the parameters of sagittal spine change remarkably between standing and chair sitting postures. Though, the effects of traditional Indian sitting postures like cross-legged sitting and squatting on spino-pelvic alignment have not been studied thoroughly. Besides, changes in spinal flexibility, pelvic mobility, muscle strength, and degenerative changes because of aging may affect the capability of doing these postures and even lead to significant differences between younger and elderly individuals [5]. Even though there is increasing focus on personalized alignment goals in spine surgery, the dynamic changes in sagittal parameters resulting from common Indian postures have not been taken into account during surgical planning [6].

Knowledge of radiographic changes in spino-pelvic alignment during different functional postures can offer a better understanding of physiological adaptations in the Indian population and can also aid in setting more relevant alignment goals for patients who are undergoing correction of spinal deformity and degenerative spine surgeries [7]. So, this study intends to assess and compare the radiographic spino-pelvic parameters in standing, erect sitting, cross-legged sitting, and squatting postures among young and elderly Indians, and to investigate the effect of age on the differences seen between these postures [8].

MATERIAL AND METHODS

Study Design and Ethical Considerations

This forward-looking cross-sectional study was carried out after the departmental level approval and

institutional ethical clearance from the Ethics Committee of SCB Medical College and Hospital, Cuttack were secured. The study's purposes, procedures, and potential risks were thoroughly explained to all volunteers. Written informed consent was acquired from every participant in their most well-understood language Odia before their enrollment in the study.

Study Population

In total, 30 healthy volunteers consisting of both males and females took part in the study. The participants were categorized into two groups as age. Group A comprised 15 younger persons aged below 45 years, whereas Group B comprised 15 older persons aged above 45 years. Participants were only selected after making sure that there was no clinical or radiological abnormality that could change spino-pelvic alignment.

Participation Requirements

The study involved volunteers who had absolutely no history of any spinal disease, spinal operation, or chronic low back pain. Persons with x-ray abnormalities of the spine were not allowed. Besides, to make sure they had no problem with hip, knee, or ankle that could affect posture or pelvic alignment during x-ray evaluation, participants were also checked.

Radiographic Assessment

The radiographic study was carried out at the Department of Radiodiagnosis, SCB Medical College and Hospital. Lateral x-rays of the lower back and sacrum including both hip joints were made in four different positions: standing, erect sitting, cross-legged sitting, and squatting. To reduce the effect of the position and have consistent measurements, all x-rays were performed under uniform conditions.

Measurement of Spino-pelvic Parameters the images taken in different postures have been used for the measurement of various sagittal spino-pelvic parameters. The Lumbar Lordosis Angle measurement was the angle between the superior endplate of the first lumbar vertebra and the superior endplate of the sacrum.

Lumbo-sacral Angle was the angle between the superior border of the sacrum and the inferior border of the fifth lumbar vertebra. Sacral Slope was the angle between a horizontal reference line and the superior endplate of the sacrum. Pelvic Tilt was the angle between a vertical reference line and the line joining the center of the femoral head to the midpoint of the sacral endplate. Lastly, Pelvic Incidence was the angle between the line connecting the center of the femoral head to the midpoint of the S1 endplate and a line perpendicular to the S1 endplate.

Statistical Analysis The gathered data were first inputted into Microsoft Excel software for further

analyses. Percentage was used to describe categorical variables. For quantitative variables that were normally distributed, mean values with standard deviation or confidence intervals were used to describe them.

Comparison of quantitative variables between the two age groups was done by the independent sample t-test. A p-value of less than 0.05 was considered indicative of statistical significance. Besides, Multifactor regression analysis was conducted to evaluate the factors influencing differences in spino-pelvic parameters among the various functional positions.

RESULTS

Among a total of 30 healthy volunteers, there were 15 young individuals in Group A and 15 elderly individuals in Group B. The participants of both Groups were male and female without any history of spinal pathology, previous spinal surgery, or lower limb abnormalities. Radiographic evaluation of

sagittal spino-pelvic parameters was done in standing, erect sitting, cross-legged sitting, and squatting postures in all participants.

The study showed strong evidence that spino-pelvic alignment is different in various functional postures. Lumbar lordosis and sacral slope decreased stepwise from the standing position to sitting and squatting, whereas pelvic tilt increased remarkably in sitting postures. Elderly participants showed relatively less adaptability of pelvic and lumbar parameters to different positions than younger ones.

Comparison of the Spino-pelvic Parameters of the Young and Old Population in Standing Position Table 1 illustrates the comparison of the baseline standing parameters of both age groups. The elderly had lower lumbar lordosis and sacral slope and higher pelvic tilt than the younger. Pelvic incidence was not quite a bit different between the 2 subject groups, signifying the anatomical consistency of the measurement.

Table 1. Comparison of Standing Sagittal Parameters between Young and Elderly Groups

Parameter	Young Group (<45 years) Mean ± SD	Elderly Group (>45 years) Mean ± SD	P value
Lumbar Lordosis Angle (°)	48.6 ± 6.2	41.8 ± 5.9	0.003
Lumbo-sacral Angle (°)	16.2 ± 2.8	13.7 ± 2.4	0.012
Sacral Slope (°)	37.5 ± 5.1	31.9 ± 4.7	0.005
Pelvic Tilt (°)	13.1 ± 3.2	18.6 ± 3.8	0.001
Pelvic Incidence (°)	50.8 ± 7.1	51.4 ± 6.8	0.742

Changes in Sagittal Parameters across Different Functional Postures

Clear changes in posturesilluatoin in sagittal orientation of thewere evident in both groups. Cross-legged sitting and squatting positions caused a

further decrease in lumbar lordosis and sacral slope compared to erect sitting. Pelvic tilt dmaxedly increasedduring the squatting posture, mostly young people who showed a higher degree ofpelvic mobility.

Table 2. Mean Sagittal Parameters in Different Functional Positions

Position	Lumbar Lordosis Angle (°)	Sacral Slope (°)	Pelvic Tilt (°)
Standing	45.2 ± 6.8	34.7 ± 5.2	15.8 ± 4.1
Erect Sitting	28.4 ± 5.9	20.3 ± 4.6	25.1 ± 5.2
Cross-legged Sitting	18.6 ± 5.1	13.4 ± 4.2	32.8 ± 5.8
Squatting	10.8 ± 4.7	8.2 ± 3.9	39.4 ± 6.1

The most significant decrease in lumbar lordosis was found in the squatting position, where the lumbar curvature even turned into kyphosis in some elderly subjects. Then again, young individuals were able to preserve much more of their lumbopelvic flexibility during the changing of postures.

Impact of Age on Dynamic Postural Adaptation

Table 3 illustrates how age influences changes in spino-pelvic dynamic adaptation. Compared to elderly subjects, youngsters showed statistically higher differences in lumbar lordosis and pelvic tilt between standing and squatting positions. Multifactor regression analysis showed that aging alone can reduce the capability of postural adaptability.

Table 3. Age-related Difference in Dynamic Change between Standing and Squatting

Parameter Change	Young Group Mean ± SD	Elderly Group Mean ± SD	P value
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Δ Lumbar Lordosis Angle (°)	39.1 ± 5.6	27.4 ± 5.1	<0.001
Δ Sacral Slope (°)	30.2 ± 4.8	21.7 ± 4.4	<0.001
Δ Pelvic Tilt (°)	28.6 ± 5.1	18.9 ± 4.9	<0.001

These findings indicate that younger individuals possess greater compensatory lumbopelvic motion across functional postures, whereas elderly

individuals exhibit relatively restricted sagittal adjustment capacity.

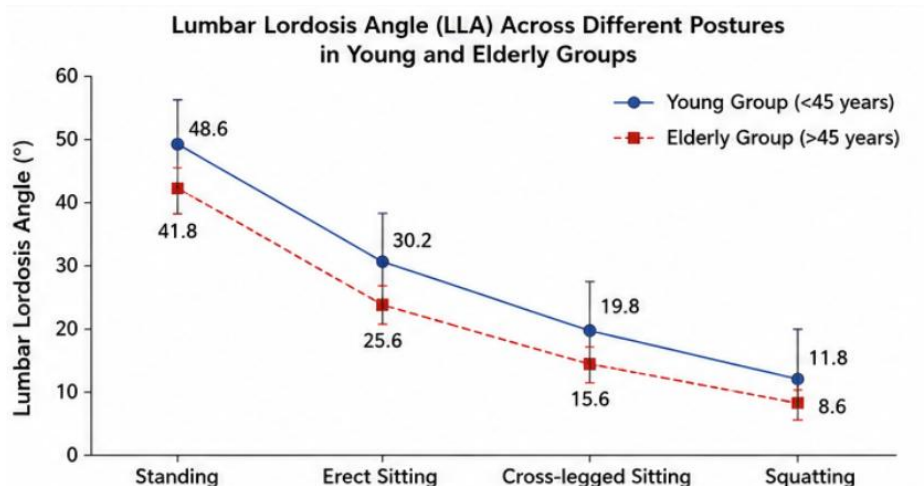


Figure 1. Graphical comparison of lumbar lordosis angle across different postures in young and elderly groups

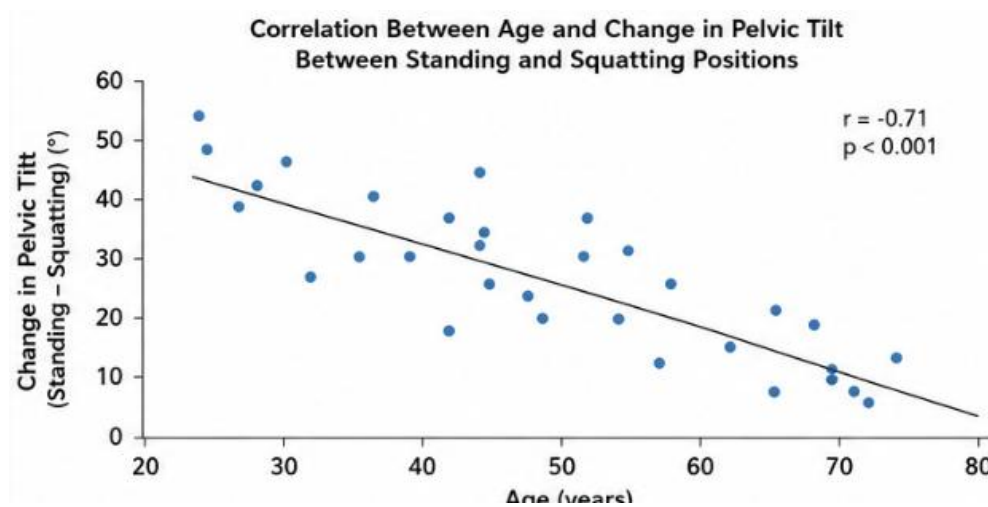


Figure 2. Scatter plot showing correlation between age and change in pelvic tilt between standing and squatting positions

DISCUSSION

This study examined the dynamic changes in sagittal spino-pelvic alignment happening in young and old Indian individuals in the most common functional postures: standing, erect sitting, cross-legged sitting, and squatting. It was revealed that lumbar lordosis, sacral slope, and pelvic tilt were altered really by the different postures while there were notable differences in the compensatory lumbopelvic adaptation due to age. These results emphasize the

need of functional sitting postures, mainly those commonly practiced by the Indian population, in the assessment of sagittal balance and planning of spinal reconstructive surgeries [9].

In this study, lumbar lordosis gradually reduced in the order: standing, erect sitting, cross-legged sitting, and squatting. Average lumbar lordosis fell from 45.2 in standing to 10.8 during squatting. There were similar decreases in sacral slope while pelvic tilt showed marked increase in sitting postures.

These results suggest backward pelvic rotation and lumbar curvature flattening during functional sitting. The largest postural change was seen during the squatting position that required the greatest pelvic retroversion and lumbar flexion [10]. These dynamic variations are very important to clinical cases as typical surgical planning for spinal deformity correction are mainly done using standing radiographs which most of the time do not represent spinal alignment during everyday activities adequately [11].

The present research also uncovered noteworthy differences in postural changes with age. Young participants exhibited more variation in lumbar lordosis and pelvic tilt from standing to squatting positions than older ones. On average, the difference in lumbar lordosis change between standing and squatting was 39.1 in the young group and 27.4 in the elderly group. Same here, younger individuals had a really greater increase in pelvic tilt. Aging leads to loss of flexibility of the lumbopelvic region because of spinal degeneration, lowering of hip mobility, muscle tightness, and also a reduction in compensatory mechanisms. The present study also revealed a negative correlation between age and pelvic mobility which is in line with this notion [12]. Pelvic incidence that is inherently anatomical did not vary appreciably between the two age groups which is also in agreement with the findings of other studies that pelvic incidence is not quite a bit altered by changes in posture or age. Though, changes in the position of pelvic tilt and sacral slope demonstrate that functional orientation of the pelvis differs markedly with sitting postures. This interdependence of pelvic and lumbar parameters has crucial consequences for grasping the concepts of sagittal balance in societies where floor sitting and squatting are prevalent [13].

Firstly, the present research results are highly important for the Indian setting as sitting cross-legged or squatting are not only the most common postures but also deeply rooted in the rural lifestyle of people. So, not achieving a functional sagittal alignment which is compatible with these postures can be one of the reasons for the back pain, surgical complications, poor surgical results and dissatisfaction of the patients after the spinal surgery. So, the rachis dynamic sitting radiographs can be of immense help not only in the study of physiological spinal adaptation but also in the formulation of individualized alignment targets [14].

Still, certain limitations should be kept in mind while interpreting the results of this study. The sample size was small and the volunteers were asymptomatic only. Besides that, functional postures only static radiographs were taken and muscle activity and dynamic motion analysis were

not included in the evaluation. But to an extent, this study reveals the effect based on age and traditional Indian sitting postures on sagittal spino-pelvic alignment as a first step [15].

In general, this study reveals that there are marked changes in sagittal spino-pelvic parameters when engaged in the most common Indian sitting postures and that these changes are influenced by the aging process- which leads to a decrease in lumbar-pelvic flexibility. It is hoped that consideration of functional sitting postures plus standing alignment can shed light on physiological sagittal balance and facilitate appropriate planning of spinal deformity correction and degenerative spine surgeries in the Indian population.

CONCLUSION

The present study shows that there are quite a few differences in sagittal spino-pelvic alignment between standing, erect sitting, cross-legged sitting, and squatting postures among the Indian population, and those changes are largely affected by age. Young people, Mainly during cross-legged sitting and squatting, showed more lumbopelvic flexibility and compensatory movements than the old ones. The data point out that just conventional standing radiographs may not fully show the functional spinal alignment that the Indian population adopts during their everyday activities. So, the traits of spino-pelvic alignment in different sitting and standing positions for different age groups should be a part of consideration when planning surgical reconstruction of sagittal balance, as this might lead to better functional results and more natural physiological alignment after spine surgery.

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