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Original article

Influence of posture on relationships between pelvic parameters and lumbar lordosis: Comparison of the standing, seated, and supine positions. A preliminary study

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ABSTRACT

Background: Pelvic incidence (PI) is an anatomical parameter that is considered invariable in a given individual. Although changes in posture influence the mobile lumbar spine, lumbar lordosis (LL) and the pelvis are typically evaluated only in the standing position. Thus, whether other positions commonly used during daily activities influence the relationship between LL and PI is unknown. The objective of this study was to determine whether LL and sacral slope (SS) correlated with PI, using two standardised positions, seated and supine, different from the standing position that is generally used.
Hypothesis: We are supposing that lumbar lordosis and sacral sloop are correlated to pelvic incidence whatever the posture. The goal of this study was to confirm or deny this hypothesis, using two standardize positions (sitting and lying) different that the usual standing position. LL and SS correlate with PI in the standing, seated, and supine positions.
Method: Lumbar and pelvic parameters were measured on radiographs obtained in the standing, seated, and supine positions in 15 asymptomatic adult volunteers younger than 50 years of age. Mean values with their standard deviations were computed and compared across the three positions using ANOVA. Spearman's test was applied to assess correlations.
Results: PI had the same value in all three positions. The L1-S1 LL angle was $54.8 \pm 9.8^\circ$ in the standing position, $15.9 \pm 14.6^\circ$ in the seated position, and $50.2 \pm 9.6^\circ$ in the supine position. Pelvic tilt (PT) in the same three positions was $12.1 \pm 6.3^\circ$, $37.7 \pm 10.4^\circ$, and $9.5 \pm 5.1^\circ$, respectively; and SS was $37.1 \pm 6.3^\circ$, $11.3 \pm 10.8^\circ$, and $41 \pm 7.2^\circ$, respectively. Correlations were strongest in the supine position between PI and LL ($r = 0.72$), LL and SS ($r = 0.9$), and PI and SS ($r = 0.84$).
Conclusion: Whereas PI remains unchanged in a given individual, lumbar lordosis and sacral orientation show significant changes across positions used in daily life, with the greatest changes seen in the seated position. During spinal fusion surgery, adjusting LL based on IP is crucial even in patients who have limited physical activity.
Level of evidence: IV.

1. Introduction

Pelvic incidence (PI), first described by Duval-Beaupère [1], is an angle that defines the position of the sacrum within the pelvis in the sagittal plane. The angle is formed by the line connecting the centre of the femoral heads to the midpoint of the sacral endplate (bicoxo-femoral axis) and the line perpendicular to the midpoint of the sacral endplate (sacral axis). In a given individual, important anatomical characteristics are invariable (iliac bone morphology, intra- and inter-coxo-femoral diameter, and minimal mobility of the sacro-iliac joint) and, consequently, PI is believed to remain unchanged regardless of the position of the body. The spinal curves are determined by this anatomical concept [2–5]. A wide PI angle in an individual with good sagittal spinal balance results in wide LL and SS angles and in a narrow PT angle [6]. PT and SS vary in a given individual, and their relationships with LL also vary. However, studies of the values of these parameters relied solely on radiographs obtained in the erect position. The time spent in different positions varies across individuals and depend chiefly on socio-economic status and age [7]. Older individuals spend less than 10% of their

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waking hours in the standing position. In addition, comorbidities may leave sitting and lying down as the only options. Nevertheless, relationships between the pelvis and lumbar spine have been investigated only in the standing position. When moving from the standing to the seated position, maintaining spino-pelvic balance requires decreases in LL and SS combined with an increase in PT [8,9]. Whether PI and LL correlate with each other in other positions commonly used in daily life is unknown. PI is accepted as a relevant parameter for planning surgery. Lumbar or lumbo-sacral fusion should correct or prevent spinal deformities by using simplified formulas [1,10–13]. Thus, determining LL based on PI improves the outcomes of fusion procedures. The various postures play a role in the development of spinal disease.

In this study, we focussed on three positions: standing, seated, and supine. The objective of this study was to determine whether LL and sacral slope (SS) correlated with PI, using two standardised positions, seated and supine, different from the standing position that is generally used. The working hypothesis was that LL and SS correlated with PI in the standing, seated, and supine positions.

2. Material and methods

The study included 15 asymptomatic adult volunteers aged 18 to 50 years. None of the participants had a history of surgery, infection, deformity, or tumour of the pelvis and/or spine. A physical examination was performed to rule out spinal deformities. The study was approved by the institutional review board and the appropriate ethics committee (Comité de protection des personnes du Sud-Ouest et d'Outre-Mer).

There were 10 males and 5 females with a mean age of 42.9 years and a mean body mass index of 24.4 kg·m^2 (range, 17–34.7 kg·m^2). All 15 volunteers were Caucasian.

2.1. Radiographic measurements

The standard lateral radiographs obtained in all three positions included T12 proximally and the femoral heads distally. During image acquisition, the distance between the X-ray source and the patient was 1.15 m in all three positions. The standing radiograph was taken with the participant standing straight, gazing straight ahead horizontally, and placing each hand on the ipsilateral clavicle. For the seated radiograph, the participant sat comfortably on an adjustable height stool, with the thighs horizontal and perpendicular to the torso, the knees flexed at 90°, and the hands crossed and resting on the thighs to ensure good visibility of the lumbo-sacral spine. The supine radiograph was obtained with the participant lying flat on the back on a horizontal radiography table, the hands crossed and resting on the chest and the knees extended; no pad was used to induce hip flexion.

2.2. Data analysis

The pelvic parameters and the L1-S1 LL angle were computed using Surgimap 2.1.1 software (Nemaris Inc., New York, NY, USA). On the supine radiograph, SS was measured relative to a vertical axis and PT relative to a horizontal axis.

Statistical tests were run using IBM SPSS Statistics version 22.0 (IBM, Armonk, NY, USA). Each parameter was described as the mean ± SD. Distribution normality was checked by applying the Shapiro-Wilk test. Spearman's test was used to assess correlations.

3. Results

Table 1 reports the mean values of the spino-pelvic parameters. In a given participant, PI showed no change across three positions: 49.3 ± 8.1° standing, 48.7 ± 7.9° seated, and 50.4 ± 6.7° supine. LL was 54.8 ± 9.8° standing, 15.9 ± 14.6° seated, and 50.2 ± 9.6° supine; PT was 12.1 ± 6.3° standing, 37.7 ± 10.4° seated, and 9.5 ± 5.1° supine; and SS was 37.1 ± 6.3° standing, 11.3 ± 10.8° seated, and 41 ± 7.2° supine.

Table 2 shows the correlations between each pelvic parameter and LL (Figs. 1–3).

Table 1
Mean ± SD values of the lumbo-pelvic parameters, in degrees.

	PI (°)	PT (°)	SS (°)	LL (°)
Standing	49.3 ± 8.1	12.1 ± 6.3	37.1 ± 6.3	54.8 ± 9.8
Seated	48.7 ± 7.9	37.7 ± 10.4	11.3 ± 10.8	15.9 ± 14.6
Supine	50.4 ± 6.7	9.5 ± 5.1	41 ± 7.2	50.2 ± 9.6

PI: pelvic incidence; PT: pelvic tilt; SS: sacral slope; LL: lumbar lordosis.

Table 2
Spearman's correlation coefficients between the pelvic parameters and lumbar lordosis.

	LL/PI	LL/SS	PI/SS	PI/PT
Standing	0.57*	0.67**	0.63*	0.54*
Seated	0.68*	0.80**	0.23	0.43
Supine	0.72**	0.9**	0.84**	0.72*

PI: pelvic incidence; PT: pelvic tilt; SS: sacral slope; LL: lumbar lordosis.
* Statistically significant correlation with $p < 0.05$.
** Statistically significant correlation with $p < 0.01$.

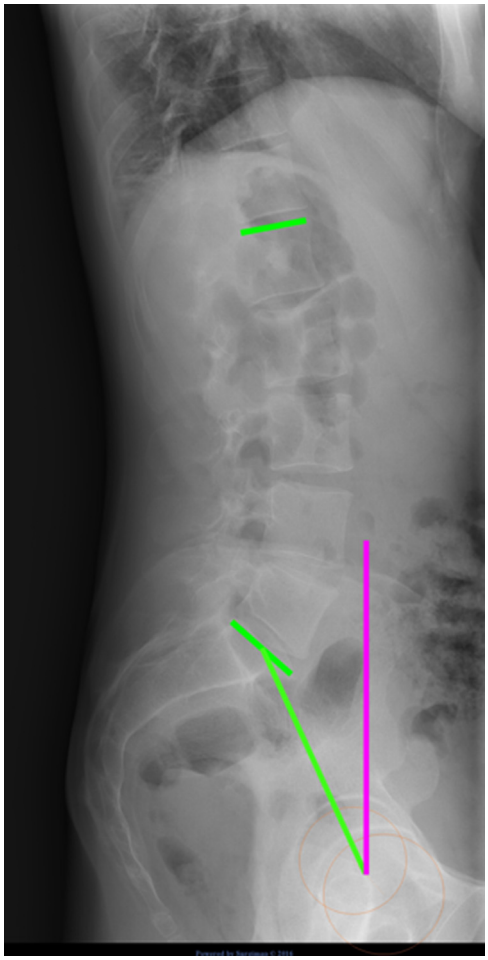

Fig. 1. Thirty-six-year-old participant in the standing position: PI = 68°, PT = 24°, SS = 44°, and LL = 54°.

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