

KSSSS 2026

The 43rd International Congress of
Korean Society of Spine Surgery
May 20 (Wed) - 22 (Fri), 2026
Lotte Hotel Seoul (Sogong-dong), Seoul, Korea



Deep Learning-based AI Analysis of the Correlation Between Lumbar Lordosis and Age

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Introduction



- **Lumbar lordosis (LL)** : Fundamental component of sagittal spinal alignment
- Abnormal LL (Hyper/Hypo) ➔ **Spinal imbalance, Degenerative changes, Pain**

Introduction



- **Advances in artificial intelligence (AI)** → Rapid and automated analysis
- Deep learning systems detect abnormalities or provide consistent measurements
- **Few large-scale AI studies on LL-age relationship**
- This study analyzes LL-age association using AI in a **large dataset**

Methods



- Initial dataset: 2,397 standing whole spine lateral radiographs (2019–2021).
- Final Dataset: 904 high-quality radiographs selected

- LL measurement: Angle between the superior endplate of L1 and S1
 - ➔ Automatically measured using a validated deep learning model.
 - ❖ Built on the Detectron2 framework with Keypoint RCNN and ResNeXt-101 backbone

Methods



- Subjects were categorized into **nine age groups**
- To compare differences in mean LL across age groups: one-way ANOVA
- To evaluate the correlation between age and LL: Pearson correlation analysis

Results



Age group	Overall (n=904)	Female (n=548)	Male (n=356)
0-9	56 (6.2%)	41	15
10-19	169 (18.7%)	94	75
20-29	26 (2.9%)	10	16
30-39	49 (5.4%)	20	29
40-49	84 (9.3%)	39	45
50-59	103 (11.4%)	65	38
60-69	203 (22.5%)	130	73
70-79	160 (17.7%)	112	48
≥80	54 (6.0%)	37	17

Table 1. Number of patients by age group in the dataset

- ❖ The 60–69-year group comprised the largest proportion (203 patients, 22.5%)
- ❖ Females (548 patients, 60.6%) > Males (356 patients, 39.4%)

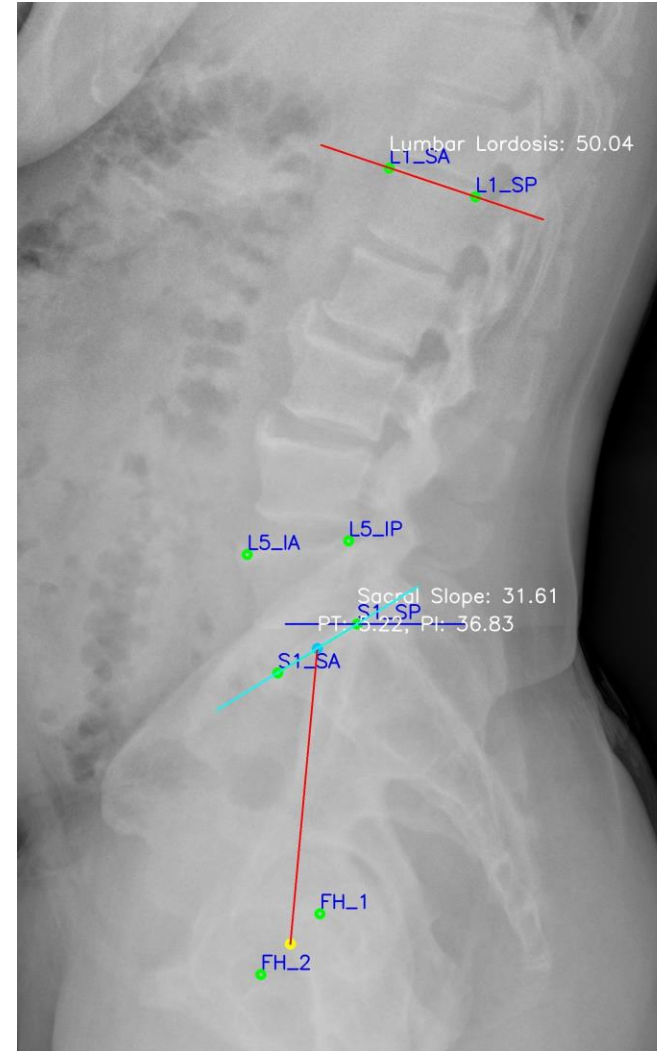


Fig. 1. A representative image measured by the AI-based automated measurement model.

Spinopelvic parameters such as sacral slope, pelvic tilt, and pelvic incidence can also be measured.

Results



Age group	Mean (°)	SD (°)	Min (°)	Q1 (°)	Median (°)	Q3 (°)	Max (°)
0–9	49.7	9.9	23.4	45.2	51.2	54.6	72.7
10–19	52.1	11.2	24.1	45.3	50.7	60.0	79.2
20–29	46.1	12.6	20.7	37.7	46.7	55.1	72.1
30–39	46.8	12.6	16.7	39.5	45.9	53.3	83.7
40–49	45.1	11.4	16.9	36.4	45.7	51.8	72.9
50–59	43.5	13.0	12.2	35.1	43.7	51.6	68.4
60–69	45.0	31.4	2.1	37.0	44.8	54.3	80.2
70–79	43.3	15.0	1.1	35.2	44.0	53.8	77.0
≥80	39.6	15.4	0.0	28.9	41.1	49.6	66.8
Overall	45.9	13.4	0.0	37.9	46.5	54.5	83.7

SD: standard deviation, Min: minimum, Q1: first quartile, Q3: third quartile, Max: maximum.

Table 2. Descriptive statistics of lumbar lordosis across age groups

- ❖ Lumbar lordosis (LL) showed the highest mean value in the 10–19 year group (52.1°), whereas the ≥80-year group demonstrated the lowest mean value (39.6°).
- ❖ Overall, the mean lumbar lordosis was 45.9°±13.4°, with a wide range from 0° to 83.7°.

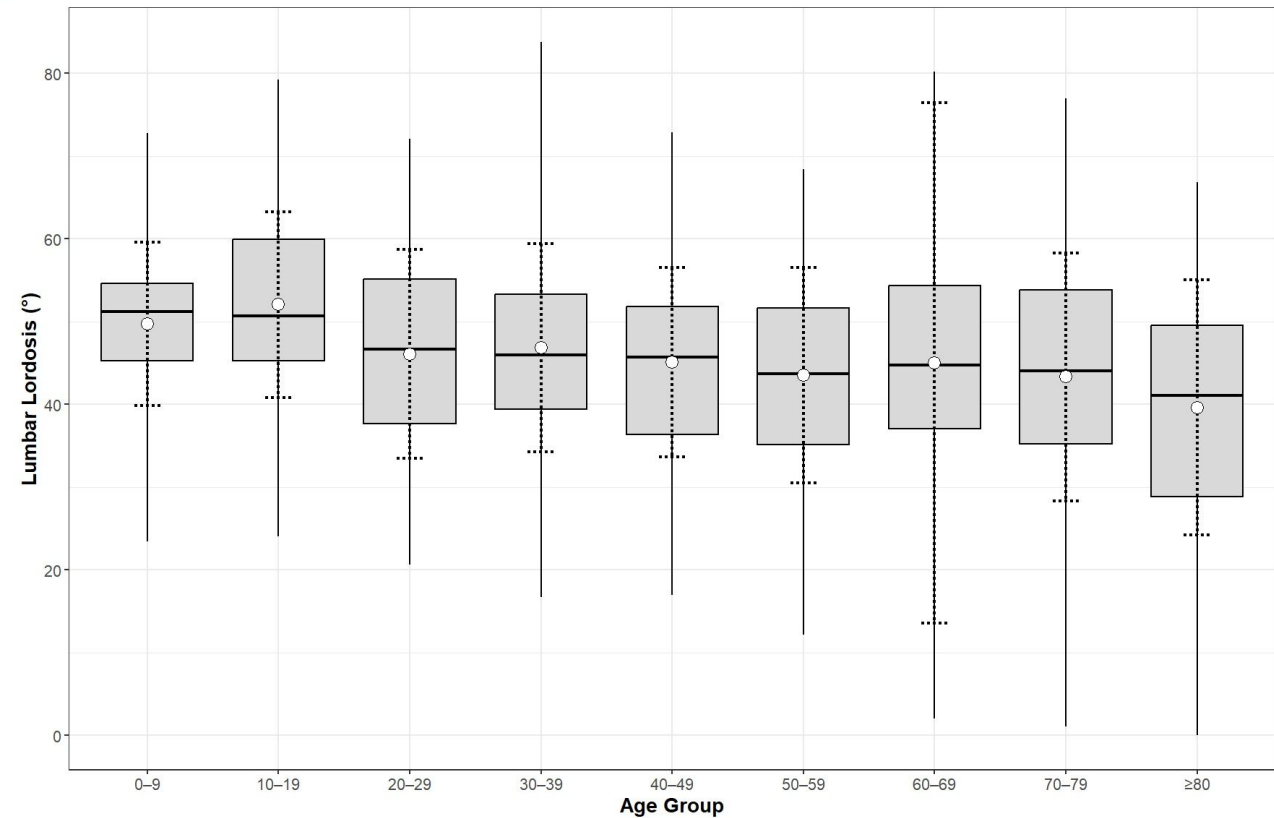


Fig. 2. Lumbar lordosis by age group.

Boxplots represent the distribution of lumbar lordosis for each age group, indicating the minimum, first quartile (Q1), median, third quartile (Q3), and maximum values. Mean values and standard deviation are shown as open circles and dashed lines around the mean.

Results

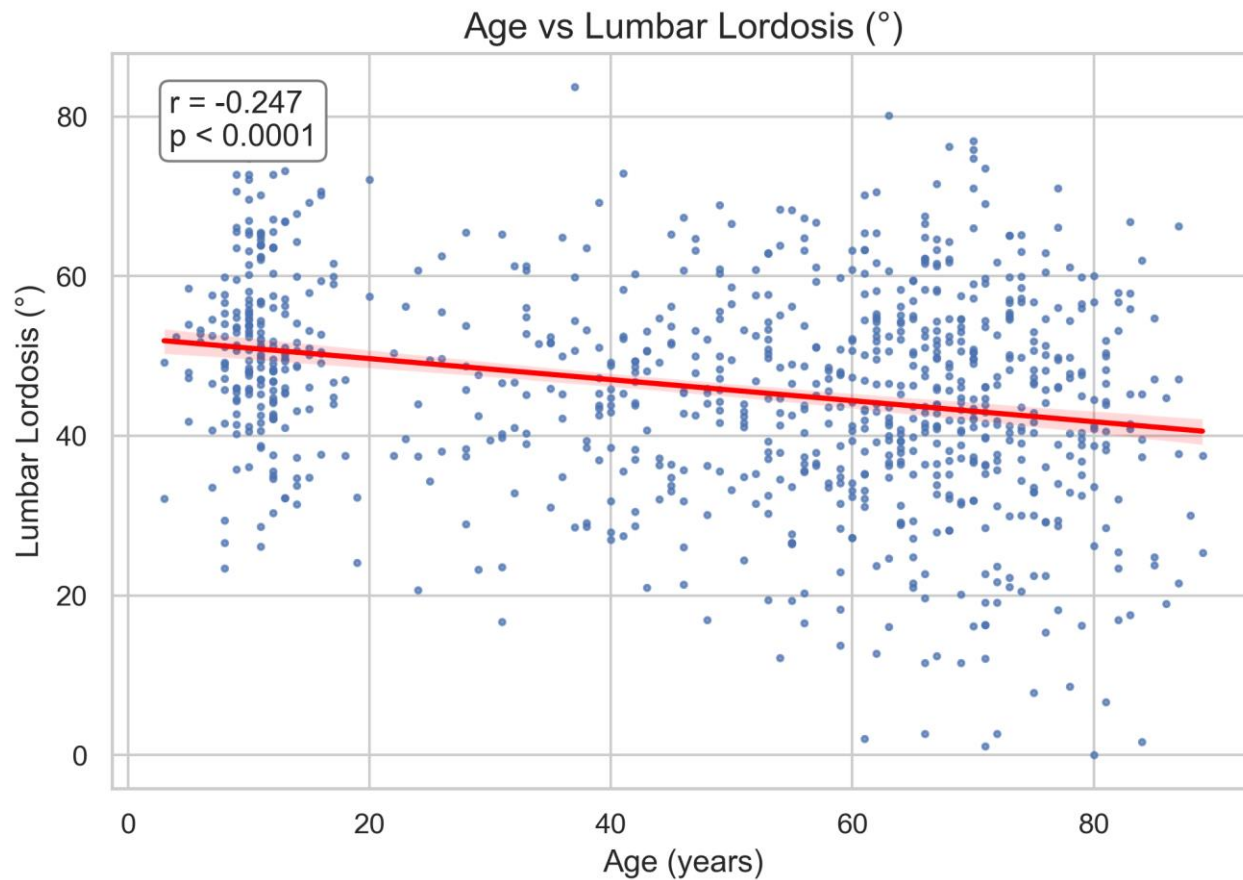


Fig. 3. A scatter plot displaying lumbar lordosis across the full age range was generated, with a linear regression line overlaid based on Pearson correlation analysis.

Pearson correlation analysis between age and lumbar lordosis showed a **significant but weak negative association**, with $r = -0.247$ and $p < 0.0001$
→ **Lumbar lordosis to decrease with increasing age**

❖ The one-way ANOVA performed for lumbar lordosis across age groups :F-statistic 0.811, p-value 0.561

→ **No differences among the 10-year age groups.**

Conclusion



- AI-based analysis showed **wide LL distribution and a weak negative correlation with age**
- **LL tends to decrease as age increases**
- These findings improve understanding of normal spinal alignment and age-related changes
- **Supports future AI-based spinal alignment research using large-scale X-ray data**