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# FOCAL CONCENTRATION OF APICAL VERTEBRAE IN ADOLESCENT IDIOPATHIC SCOLIOSIS: A LARGE OBSERVATIONAL STUDY

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## Background

The etiology of adolescent idiopathic scoliosis (AIS) remains unclear, but recurring features of the deformity point to mechanical factors in its pathogenesis. One such feature is the marked clustering of curve apices at specific vertebral levels, observed in both single and double curves. Traditional descriptions emphasize regional classification (thoracic, thoracolumbar, lumbar) rather than vertebral-level distribution of apices.

## Study Design

Observational study

## Objective (s)

To describe the distribution of curve apices in a large cohort of AIS patients and to explore potential explanations for the marked concentration at particular vertebral levels.

## Methods

We performed a retrospective observational study at a tertiary referral center for conservative scoliosis management. The dataset comprised 7,955 patients with AIS aged 10–18 years, Cobb angle ≥ 10° and no prior treatment. Of these, 4,470 presented with single curves and 3,485 with double curves. For each curve the apical vertebra was recorded; Apices identified at an intervertebral disc (where vertebral rotation could not be measured) were apportioned equally between the adjacent vertebrae (0.5 to the upper and 0.5 to the lower vertebra).Descriptive analyses of apex frequency were performed across vertebral levels and stratified by curve type.

Apex prevalence of single curves

| Vertebrae | Number | Prevalence | % |
|---|---|---|---|
| D4 | 43 | 47 | 1 |
| D5 | 28 | 35 | 0,7 |
| D6 | 62 | 77 | 1,7 |
| D7 | 148 | 159 | 4,4 |
| D8 | 305 | 352 | 7,8 |
| D9 | 348 | 396 | 8,8 |
| D10 | 320 | 369 | 8,2 |
| D11 | 321 | 378 | 8,4 |
| D12 | 912 | 1029 | 23 |
| L1 | 685 | 833 | 18,6 |
| L2 | 548 | 658 | 14,7 |
| L3 | 95 | 135 | 3 |
| L4 | 1 | 2 | |
| | | 4470 | |

Apex prevalence of double curves

| Vertebrae | Number | Prevalence | % |
|---|---|---|---|
| D4 | 118 | 87 | 1,2 |
| D5 | 119 | 108 | 1,5 |
| D6 | 210 | 210 | 3 |
| D7 | 502 | 551 | 8 |
| D8 | 1135 | 1252 | 18 |
| D9 | 1135 | 1237 | 18 |
| D10 | 220 | 268 | 3,8 |
| D11 | 100 | 97 | 1,3 |
| D12 | 392 | 455 | 6,5 |
| L1 | 815 | 982 | 14 |
| L2 | 1178 | 1325 | 19 |
| L3 | 313 | 382 | 5,4 |
| L4 | 27 | 15 | 0,2 |
| | | 6970 | |

## Results

In single curves the apex was markedly concentrated at vertebra T12, with frequency decreasing progressively both cranially and caudally from that level. The Spearman rank correlation between the number of apices per vertebral level and absolute distance from T12 was rho = −0.84 (t = −5.10, df = 11, $p < 0.001$), indicating a strong, highly significant monotonic decrease in apex frequency with increasing distance from T12.

In double curves apex distribution showed two prominent peaks: a thoracic peak at T8–T9 (36%) and a thoracolumbar/upper-lumbar peak at L1–L2 (33%). When distance was measured as the minimal distance to the nearest peak among {T8, T9, L2}, Spearman's rho = −0.81 (t = −4.63, df = 11, $p = 0.0007$), confirming a strong concentration of apices around these levels.

## Conclusion(s)

In single curves the apical vertebra is significantly concentrated at T12 with a clear decrease in frequency as distance from T12 increases. In double curves apices cluster around T8–T9 and L1–L2. These distributions are statistically unlikely to be random. The recurrent localization of apices supports the hypothesis that anatomical and biomechanical factors — including junctional segment properties, rib-cage interactions, sagittal profile alterations, and growth-modulated loading — contribute to AIS development.

## Clinical significance

The findings of this study prompt new considerations of etiological hypotheses implicating mechanical dysfunction. Prospective studies with three-dimensional imaging and biomechanical modelling are required to test causal mechanisms.