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Asymmetry of hip abductor moments is different between Lenke1 and Lenke3 profiles in the case of patients with scoliosis

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1. Introduction

Idiopathic scoliosis is a common orthopedic disorder. A spine with scoliosis curves looks more like the letter “S” or “C,” rather than a straight “I” (Lenke et al. 2007). Several asymmetries have been presented: on the vestibular level with consequences on dynamic equilibrium (Delpierre et al. 2020), on trunk muscle activities correlated with curvature amplitude (Park et al. 2021), on kinematics and kinetics (Syczewska et al. 2012). Sklensky et al. (2022) and Delpierre & Lemaire (2023) described an asymmetry of hip abductor moments in Lenke profile1 scoliotic patients using a Symmetry Index (SI). However, other Lenke profiles are distinguished according to the presence of thoracic and/or lumbar curvature. Then, Lenke1 is a main thoracic curve; Lenke3 is a double major curve with a thoracic curve and a lumbar curve. The relationship described by Sklensky should therefore be clarified on a wider sample according to Lenke's profiles, for instance in the case of Lenke3 profile.

The aim of the study is to compare SI between patients with Lenke1 and Lenke3 profiles. Therefore, our hypotheses are: (1) patients with Lenke1 profile present significant higher SI on hip than patients with Lenke3 profile; (2) the correlation between the distance separating the center of the thoracic apical vertebra from the vertical axis passing through the center of the sacrum (AVT) and SI is higher in case of the Lenke1 profile compared to the Lenke3 profile; (3)

pelvic mobility is higher in the case of the Lenke3 profile.

2. Methods

2.1 Population

In this retrospective study, a cohort of patients with idiopathic scoliosis was followed (considering patients explored between 01/01/2017 and 31/10/2022). We considered 20 patients per Lenke profile (Table1).

Table 1. Gender (M: Men; W: Women.), age (years), height (m), body mass (kg), AVT (cm) per profile. Data are presented according: mean (standard deviation).

| | Lenke1 | Lenke3 | p |
|-----------|---------------|--------------|-----|
| Gender | 15 W/5 M | 16W/4 M | .70 |
| Age | 17,73 (4,45) | 16,33 (2,83) | .29 |
| Height | 1,61 (0,01) | 1,64 (0,01) | .38 |
| Body mass | 52,30 (11,67) | 53,30 (8,49) | .73 |
| AVT | 5,08 (2,00) | 4,48 (1,70) | .29 |

* significant difference.

All the patients or their families were informed of this study and gave their consent. The Ethics Committee (Angers) approved the study. The inclusion criteria for this study were: patients with idiopathic scoliosis who had undergone quantified gait analysis, had complete radiological images of the spine, were classified as Risser 4 or 5, had no inequalities in the length of the lower limbs and had no surgery on spine, pelvic and lower limbs.

2.2 Protocole

Full spine X-rays were performed in the frontal and sagittal planes in bipedal standing. Then, each patient was classified according to Lenke's methodology. AVT was determined (Sklensky et al. 2022; Delpierre & Lemaire, 2023).

Gait analysis is based on the use of a motion capture system (Vicon, Oxford Metrics, UK, 100 Hz) and 31 spherical retro-reflective markers 14 mm in diameter applied directly to the skin using the Plug in Gait model. Two AMTI force platforms (MCA model; 1000 Hz) synchronized with the motion capture system were placed in the middle of the walking path.

No instructions were given to the patients regarding specific foot placement on these force platforms. The patients walked at spontaneous speed along the 10 m walkway bare footed. At least five strides per subject were averaged. SI was calculated from the joint moments of the hips during the single stance phase (Sklensky et al. 2022):

$$SI = \frac{2 \times (M_r - M_l)}{(M_r + M_l)}$$

with M_r and M_l (Nm) corresponding to the average joint moment of the hip in the frontal plane during single support on the right and left, respectively. These moments are normalized to the patient's mass (Nm kg^{-1}). SI is therefore a real number whose sign reflects the imbalance of the joint moments during unipodal weight-bearing: a positive SI is associated with a moment of the right hip greater than that of the left hip. The greater the SI, the greater the imbalance of hip moments in the frontal plane. Pelvic mobility was considered according to the range of obliquity.

All the statistical analyses were carried out using Statistica (version 13, Statsoft, California, USA). Shapiro-Wilks tests were applied to verify the normality of the distributions. The data is presented in the form: mean (standard deviation). Established according to an unpublished pilot study, the sample size required for the study was based on statistical power (90%) calculated by considering a significantly different SI between the Lenke1 and Lenke3 profiles; at least 19 patients per Lenke profile, provided the conditions for applying a *t* test were met. Pearson correlation tests were applied between SI and AVT for each Lenke profile. Alpha was set at .05.

3. Results and discussion

The results are detailed in Table 2. The Lenke1-group and Lenke3-group presented significant differences on SI ($t=3.54, p=.001$).

Table 2. SI and pelvic mobility ($^{\circ}$).

| | Lenke1 | Lenke3 | <i>p</i> |
|----------|----------------|--------------|----------|
| SI | -31,61 (30,79) | 0,18 (28,96) | .001* |
| Mobility | 8,20 (2,93) | 8,62 (2,89) | .64 |

* significant difference.

Whereas the Lenke1-group presented significant low correlation between AVT and SI ($r=-0.52$; $p<.03$), the Lenke3-group presented no significant correlation ($r=0.04$; $p=.89$). These two correlations were significantly different ($Z=1.80$; $p=.04$). No significant differences on pelvic mobility were noticed between these two profiles (Table 2).

Our results confirm the significant correlation between SI and AVT in Lenke1-group detected previously (Sklenky et al., 2022). Their correlation is close to that calculated in our approach.

Pelvic mobility in the coronal plane was in phase with other studies (Syczewska et al., 2012).

Limitations. Firstly, only two Lenke profiles were considered here. Other Lenke profiles have been described (Lenke 2007). Secondly, only AVT was considered. Other radiological parameters could be explored, such as Cobb angles. Finally, we did not

consider differences in self-selected speed between these two Lenke profiles.

4. Conclusions

What are the implications of the current findings for the scoliosis? SI should be considered according to Lenke profiles.

Conflict of Interest Statement

None.

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