

Lower Limb Compensation in Adult Spinal Deformity: Can We Identify Different Patterns?

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INTRODUCTION: While the recruitment of compensatory mechanisms in the setting of sagittal malalignment has been extensively described, recruitment of the lower limbs has not been fully elucidated. This study aimed to identify distinct patterns of lower limb compensation and determine which parameters influence the recruitment of these mechanisms.

METHODS: This study was a retrospective analysis of a multicenter prospective ASD database and a normative cohort of asymptomatic subjects. The study included ASD patients aged over 18 years and a normative cohort of healthy subjects, all with full-body X-rays. The amount of lower-limb recruitment in the ASD cohort was defined based on their offset from PI-adjusted normative values. K-means cluster analysis based on sacro-femoral angle (SFA) and knee flexion angle (KA) was performed to classify lower limb compensation patterns in the ASD cohort, followed by a comparison across the established clusters. Statistical analyses included Kruskal-Wallis and ANOVA tests, with post-hoc pairwise comparisons.

RESULTS: 871 ASD patients (66.9% F, 62.3±14.6 years) and 645 healthy volunteers (51% F) were included. Using the normative cohort, PI-adjusted alignment values were established. In the ASD cohort, four distinct compensatory patterns were identified (Figure). Cluster 1 ("No compensators") had minimal lower limb compensation. Cluster 2 ("Recliners") primarily used hip extension, with high SFA and PT values. Cluster 3 ("Squatters") relied on knee flexion, with negative SFA offset and high KA. Cluster 4 ("Mixed compensators") utilized all forms of compensation. Patients in Cluster 3 had the poorest HRQoL, while those in Cluster 1 had the least disability. Significant differences were observed across clusters in age, BMI, and PI-LL mismatch.

DISCUSSION AND CONCLUSION: This study identified four distinct patterns of lower limb compensation in ASD patients, each associated with specific demographic, clinical, and PI-adjusted radiographic parameters. The use of a normative cohort for PI-adjusted alignment provides a deeper understanding of lower limb compensation in sagittal malalignment, potentially guiding treatment strategies in patients with concurrent spine and lower limb joint degeneration.

