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Accuracy and Reliability of a Surface Topography Approach for Trunk Aesthetic Assessment in Scoliosis: Preliminary Results

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Background

Adolescent Idiopathic Scoliosis (AIS) affects both spinal curvature and trunk aesthetics. Visible trunk asymmetry significantly influences patients' quality of life, body image, and treatment satisfaction. However, current aesthetic assessment methods rely mainly on subjective systems. Therefore, an objective, standardized, and reliable method to quantify trunk asymmetry in AIS is needed.

Study Design

Diagnostic accuracy study

Objective (s)

To evaluate the accuracy and reliability of a surface topography (ST) method for aesthetic assessment in AIS patients.

Methods

ST scans were acquired using a portable depth-sensing device. The method is based on asymmetry analysis, in which individuals without scoliosis present minimal asymmetry, whereas AIS patients show identifiable asymmetric regions. Trunk aesthetics were quantified using root mean square error (RMSE, mm), defined as the mean root squared deviation between the original torso and its reflection around the best plane of sagittal symmetry. Reliability was assessed in AIS patients aged 10 – 18 years undergoing conservative treatment, without prior spinal surgery. Intra-rater reliability was evaluated using two scans performed by the same rater, and inter-rater reliability using scans acquired by two different raters on the same day, with a 5-minute interval. Reliability metrics included two-way mixed-effects intraclass correlation coefficients (ICC), standard error of measurement (SEM), and minimal detectable change (MDC). Accuracy was evaluated using a database. Sensitivity and specificity for overall and regional RMSE thresholds were calculated using receiver operating characteristic (ROC) curve analysis.

Results

Twenty AIS patients (18 females and 2 males) were included in the reliability analysis, with a median TRACE score of 6, mean Cobb angles (CA) of 23° (thoracic) and 28° (lumbar), and mean overall RMSE of 5.9 (±1.9) mm. Intra-rater reliability was excellent for overall RMSE (ICC = 0.91) and ranged from good to excellent across spinal regions (ICC = 0.84 – 0.94). Inter-rater reliability was also good to excellent, with ICC values of 0.86 for overall RMSE and 0.77 – 0.92 for regional measures. SEM ranged from 0.53 to 0.88 mm, and MDC from 1.04 to 1.72 mm.

Accuracy analysis included 786 participants, 602 AIS (mean CA of 27°) and 184 without scoliosis (mean CA 0°). ROC curve analysis demonstrated high accuracy: overall RMSE (cut-off = 4.5 mm) showed 87% sensitivity and 84% specificity (AUC = 0.938, $p < 0.001$). Regional RMSE measures demonstrated sensitivities and specificities ranging from 80% to 85%.

Conclusion(s)

The ST AI-based RMSE demonstrated promising reliability and good accuracy for trunk aesthetic assessment in AIS, supporting its use as an objective quantitative outcome measure. Further studies including a broader spectrum of curve severities and aesthetic presentations are needed to confirm generalizability, as the current sample primarily included patients with moderate curves (mean Cobb angle 20°–30°).

Clinical significance

Preliminary results suggest that an ST-based RMSE can be an alternative approach to support trunk aesthetic assessment in AIS.