



AGREEMENT BETWEEN ADOLESCENTS, PARENTS, AND AN EXPERT IN VISUAL ASSESSMENTS OF ADOLESCENT POSTURE: AN EXPLORATORY PILOT STUDY

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ABSTRACT

Objective: This exploratory pilot study examined agreement among visual classifications of adolescent posture made by adolescents, parents, and an expert using the same standardized reference images. It also explored whether adolescent-expert agreement differed between adolescents with mild-to-moderate adolescent idiopathic scoliosis (AIS) and healthy controls.

Materials and Methods: Forty adolescents aged 10-18 years (20 with AIS and 20 healthy controls) and one parent per adolescent participated. Adolescents, parents, and one expert independently selected one of five standardized images for each of the following regions: head, shoulders, upper-back, and lumbar/waist. Pairwise and three-rater agreement were assessed using Cohen's κ , Fleiss' κ , and Krippendorff's α . Exact agreement proportions were reported with Wilson 95% confidence intervals (CIs). Region-specific adolescent-parent comparisons were performed using exact McNemar tests with Holm-Bonferroni adjustment for the four regional comparisons. AIS-control comparisons were considered exploratory.

Results: Adolescent-expert agreement ranged from $\kappa=0.30$ to $\kappa=0.43$ and was highest for the head ($\kappa=0.43$, 95% CI, 0.24-0.62). Exact adolescent-expert agreement was 62.5% (95% CI, 47.0-75.8) for the head, 60.0% (44.6-73.7) for the shoulders, and 45.0% (30.7-60.2) for both the upper-back and lumbar/waist regions. Parent-expert agreement ranged from $\kappa=-0.01$ to $\kappa=0.26$, with exact-agreement proportions ranging from 25.0% to 40.0%. Adolescents showed greater exact agreement than parents only in the head region (62.5% vs. 37.5%; $p=0.031$), but this difference did not remain significant after Holm-Bonferroni adjustment (adjusted $p=0.124$). No statistically significant AIS-control differences were detected in total adolescent-expert agreement scores ($p=0.151$) or parent-expert agreement scores ($p=0.306$).

Conclusion: Agreement with the expert's visual classification varied across anatomical regions and was generally moderate. No evidence of equivalence between the AIS and control groups can be inferred from this pilot sample. The findings represent expert-referenced agreement rather than objective recognition accuracy and do not establish the visual approach as valid, reliable, or clinically applicable. Larger studies incorporating multiple assessors, repeated measurements, and independent reference methods are required.

Keywords: Postural self-recognition, postural self-recognition accuracy (PSRA), posture awareness, adolescent, scoliosis, body perception

INTRODUCTION

Adolescence is a critical developmental period during which postural control undergoes substantial reorganization due to rapid skeletal growth accompanied by neurodevelopmental changes^(1,2). During this period, the central nervous system continuously updates the body schema to adapt to changes in body segment proportions. However, rapid skeletal growth and maturation of the body schema do not always occur

synchronously⁽³⁾. This temporary mismatch may alter the processing of proprioceptive information, thereby increasing reliance on visual input for postural control⁽⁴⁾. Consequently, postural control during adolescence is more dynamic than in adulthood and is more susceptible to structural and environmental influences^(1,4,5).

One of the principal structural conditions that may affect posture and its perception during adolescence is adolescent idiopathic scoliosis (AIS)^(2,3,5). AIS is a three-dimensional deformity that

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extends beyond lateral curvature of the spine in the coronal plane and involves the frontal, sagittal, and transverse planes⁽⁵⁾. This deformity results in visible asymmetries in postural regions, including head position, shoulder level, scapular symmetry, trunk balance, thoracic-pelvic alignment, and waist triangles, leading to noticeable cosmetic changes⁽³⁾. These visible postural alterations may adversely affect adolescents' perception of their physical appearance, psychosocial well-being, and health-related quality of life^(6,7).

Although the effects of AIS on body image have been extensively investigated, body image does not explain whether an adolescent's perception of their posture corresponds to a clinician's visual assessment. Body image refers primarily to the cognitive, affective, and psychological evaluation of physical appearance, whereas body schema represents the sensorimotor representation of body position and configuration. Body awareness is a broader construct involving conscious attention to internal bodily sensations and perceived body position^(3,6,8). Postural self-recognition, as considered in the present study, is related to but conceptually distinct from these constructs because it concerns an adolescent's ability to select a visual representation of their own postural appearance. Current evidence indicates that disturbances in body schema among adolescents with AIS may lead individuals to perceive their own postural alignment differently from clinically or instrumentally assessed alignment^(1-3,6). Patients may overestimate or underestimate the severity of their spinal curvature and may even misperceive the direction of the deformity. These observations suggest that self-perceived posture and clinically assessed posture may not always correspond. Accordingly, examining the agreement between adolescents' visual self-assessments and clinicians' assessments may provide information that is not captured by conventional measures of body image or postural alignment^(1-3,6,8).

Structural spinal deformity can be characterized using radiographic measurements, particularly the Cobb angle, which remains the standard measure of coronal curve magnitude in AIS^(1,5,9). Other clinical and instrumental methods, including photogrammetry, surface topography systems, scoliometry, and standardized postural analysis, can characterize observable features of head, shoulder, trunk, and pelvic alignment⁽¹⁰⁻¹²⁾. However, these methods evaluate structural or externally observable postural characteristics and do not directly determine whether adolescents identify their own postural appearance in the same way as a clinician. Moreover, a clinician's visual classification should not itself be regarded as an objective gold standard because it may be influenced by observer judgment and measurement error.

Patient-reported instruments used in AIS assess several related but distinct outcomes. Measures of body image and health-related quality of life primarily capture psychological responses, satisfaction, functional impact, and concerns related to appearance. Visual instruments such as the Walter Reed visual assessment scale (WRVAS) and the spinal appearance

questionnaire (SAQ) use standardized drawings to evaluate the perceived type or severity of spinal and trunk deformity^(13,14). The WRVAS focuses on perceived deformity across features such as spinal curvature, rib and flank prominence, trunk imbalance, and shoulder or scapular asymmetry, whereas the SAQ combines visual representations with questions concerning spinal appearance. These established instruments provide valuable information about perceived deformity and appearance but were not designed specifically to quantify exact categorical agreement among an adolescent, a parent, and a clinician using the same region-specific visual categories.

To address this methodological gap, the present study used a standardized visual reference approach in which adolescents, parents, and an expert assessor independently selected the image that they believed best represented the adolescent's posture in each anatomical region. The resulting outcome was interpreted as expert-referenced postural self-recognition agreement rather than objective perceptual accuracy. It represented concordance between the adolescent's self-classification and the expert's visual classification using the same image set and was not interpreted as validation against an independent objective reference standard. Parent-expert and adolescent-parent agreement were examined as separate forms of concordance.

The primary aim of this exploratory pilot study was to provide a preliminary examination of agreement between adolescents' self-selected visual representations of their posture and an expert's classifications using the same standardized visual reference set. The secondary aims were to evaluate parent-expert and adolescent-parent agreement, compare region-specific adolescent-expert and parent-expert exact-agreement proportions, and explore whether adolescent-expert agreement differed between adolescents with mild-to-moderate AIS and healthy controls. We hypothesized that adolescent-expert agreement would be greater than parent-expert agreement in at least one anatomical region and that the magnitude of agreement would vary across anatomical regions. Given the exploratory nature and limited sample size of the study, the comparison between the AIS and control groups was considered hypothesis-generating, and no assumption of equivalence between the groups was made.

MATERIALS AND METHODS

Study Design and Participants

This exploratory cross-sectional methodological pilot study was conducted to provide a preliminary examination of a visual reference-based assessment approach developed for examining agreement between adolescents' self-assessments and an expert's visual classification of their posture. The study was conducted in the Department of Orthopedics and Traumatology at Ege University between March and July 2026. The study was conducted in accordance with the Declaration

of Helsinki, and the study protocol was approved by the Ege University Faculty of Medicine Ethics Committee (approval no: 26-3T/2, date: 05.03.2026). Voluntary assent was obtained from all adolescents, and written informed consent was obtained from their parents.

Adolescents with AIS and healthy controls were recruited consecutively from the Department of Orthopedics and Traumatology at Ege University during the study period. Adolescents with AIS were recruited during their clinical assessments, whereas healthy adolescents without a known diagnosis of scoliosis or another spinal deformity were recruited from the same department during the study period. No individual matching was performed; healthy controls were enrolled within the same predefined age range as the AIS group.

The AIS group included adolescents aged 10-18 years who had been diagnosed with AIS by an orthopedic specialist, whose scoliosis had been confirmed on standing spinal radiographs, who had sufficient cognitive ability to understand the study instructions, and who voluntarily agreed to participate. The ability to understand the study instructions was determined clinically by the researchers during the initial interview, based on each adolescent's ability to understand and appropriately follow the verbal instructions provided for the assessment. The healthy control group consisted of adolescents within the same age range who had no known scoliosis or spinal deformity and no musculoskeletal disorder limiting activities of daily living.

The exclusion criteria for both groups included neurological disorders, congenital spinal anomalies, previous spinal surgery, and the presence of rheumatological, neuromuscular, or systemic diseases that could substantially affect posture. Conditions affecting the ability to understand or complete the visual assessment were also considered exclusion criteria.

Parents were eligible if they were the adolescent's mother or father, were literate, were able to read and understand Turkish, and voluntarily agreed to participate. Parents with cognitive impairment, a history of psychiatric disorders interfering with communication, or visual or reading problems that could prevent completion of the assessment form were excluded. The relationship of the participating parent to the adolescent was recorded as mother or father.

Because this was an exploratory pilot study evaluating a newly developed visual classification approach, no formal a priori power calculation was performed. A pragmatic target of 20 adolescents per group was established based on the feasibility of recruitment during the predefined study period. Accordingly, the study was not powered to demonstrate equivalence between the AIS and healthy control groups.

Development of the Visual Posture Assessment Tool

A region-specific visual assessment tool was developed to enable adolescents to evaluate their own posture using standardized visual references. The development of the visual classification approach was based on regional characteristics

of postural alignment that are readily observable by individuals and are commonly considered during clinical postural assessment. Accordingly, the assessment was structured around four postural regions: head, shoulders, upper-back, and lumbar/waist region. The clinical characteristics to be depicted were determined by researchers with experience in physiotherapy, orthopedics, and postural assessment, and the illustrations were digitally produced and graphically standardized in collaboration with a visual communication design specialist.

For each region, five standardized visual reference images representing different postural appearances were created. The use of five alternatives was intended to represent a sufficiently broad range of visually distinguishable postural configurations while maintaining a manageable number of response options for adolescents. Rather than requiring participants to describe their posture verbally, the assessment was designed to allow them to select the image they believed best represented their own posture. The same standardized visual reference set was used for adolescent, parent, and expert assessments, thereby enabling direct comparison among the three evaluations.

Within each image set, the response alternatives were coded a-e from left to right. In the head set, image a depicted an approximately neutral head position; images b and c depicted left-sided lateral head inclination at different magnitudes; and images d and e depicted right-sided lateral head inclination at different magnitudes. In the shoulder set, image a depicted approximately level shoulders; images b and c represented left-sided shoulder-height asymmetry at different magnitudes; and images d and e represented right-sided shoulder-height asymmetry at different magnitudes. In the upper-back set, images a-e depicted progressively increasing sagittal trunk curvature and thoracic kyphotic appearance, with image a representing the least pronounced and image e the most pronounced configuration. Similarly, in the lumbar/waist set, images a-e depicted progressively increasing lumbar curvature and lordotic appearance, with image a representing the least pronounced and image e the most pronounced configuration.

All illustrations were standardized with respect to body position, viewing perspective, figure dimensions, clothing, background, and graphical style; only the postural characteristic targeted by the relevant image set was systematically varied. Identical visual reference images were incorporated into the adolescent and parent assessment forms, which are provided in Supplementary Files 1 and 2, respectively.

The present visual approach differs from the WRVAS and the SAQ, which primarily assess perceived scoliosis-related trunk deformity and appearance severity^(13,14). The current approach uses the same region-specific images for independent classifications by the adolescent, parent, and expert and evaluates exact concordance among these classifications. It was not designed to assess body-image satisfaction, health-related quality of life, or radiographic deformity severity.

Before implementation, the visual reference images underwent quantitative content evaluation and qualitative review by an

expert panel, as described below. The final visual reference set was established after consideration of the experts' ratings and written feedback.

Content Evaluation by Experts

The content of the developed visual assessment tool was reviewed by a panel of 10 experts with experience in posture and musculoskeletal assessment, including five physiotherapists and five orthopedic and traumatology specialists. Each expert independently evaluated every image for relevance, clarity, and representativeness using a four-point scale: 1, not appropriate; 2, appropriate only after major revision; 3, appropriate with minor revision; and 4, highly appropriate. Ratings of 3 or 4 were considered acceptable. Experts were also invited to provide written comments and revision recommendations for each image.

Content validity was quantified using the item-level content validity index (I-CVI), calculated as the proportion of experts who assigned a rating of 3 or 4 to each image. For a panel of 10 experts, an I-CVI of ≥ 0.78 was considered acceptable⁽¹⁵⁾. Scale-level content validity was evaluated using both the average method (S-CVI/Ave) and universal-agreement method (S-CVI/UA), with an S-CVI/Ave of ≥ 0.90 considered acceptable⁽¹⁵⁾. The S-CVI/Ave was calculated as the mean of the I-CVI values across all 20 images, whereas the S-CVI/UA represented the proportion of images that received acceptable ratings from all experts. All 20 images received acceptable ratings from all 10 experts; consequently, the I-CVI was 1.00 for every image, and both the S-CVI/Ave and S-CVI/UA were 1.00. Thus, unanimous expert agreement was achieved for all images. As the experts did not identify any image requiring modification, no revisions were made following the content evaluation. These indices reflect the experts' judgments of the relevance, clarity, and representativeness of the images; they indicate expert-rated content appropriateness and do not constitute evidence of construct or criterion validity.

Assessment Procedure

Data were collected through face-to-face assessment sessions with the adolescents and their parents. Before data collection, standardized verbal instructions were provided without directing participants toward any particular image. The age and sex of each adolescent were recorded, and, for the AIS group, Cobb-angle data were obtained from standing spinal radiographs available in the medical records. Parent age and education level were also recorded.

The visual assessment tool was administered separately for the four postural regions (head, shoulders, upper-back, and lumbar/waist region). For each region, adolescents were presented with five standardized visual reference images and were asked to select the image they believed best represented their own posture. Parents were asked to use the same standardized visual reference set to select, for each region, the image they believed best represented their adolescent's posture. Adolescents and

parents completed their assessments separately and were not permitted to view or discuss each other's selections. No feedback regarding the selections was provided until all assessments had been completed.

The expert assessment was performed through direct observation of the adolescent's posture using the same standardized visual reference set. The expert assessor was a physiotherapist with 20 years of clinical experience in postural assessment and AIS management. The assessor routinely evaluated adolescents with postural and spinal disorders in clinical practice. Adolescents were assessed barefoot in their habitual standing posture in a well-lit clinical room. Posture was observed from posterior and lateral perspectives corresponding to the perspectives depicted in the visual reference images. The expert independently selected the image that most closely represented the adolescent's posture in each anatomical region. The expert assessor was not involved in the development or content evaluation of the visual reference images.

Adolescent, parent, and expert assessments were conducted independently to prevent the evaluators from being influenced by one another's selections. The expert was blinded to the image selections made by the adolescents and parents. However, the expert was not considered blinded to AIS/control status because visible postural characteristics could indicate the presence of scoliosis. The selected image for each region was recorded as a categorical code.

The expert's visual classification was used as a clinical comparator rather than an objective or independently validated reference standard. Exact correspondence between the adolescent's and expert's selections was defined as adolescent-expert agreement, whereas correspondence between the parent's and expert's selections was defined as parent-expert agreement. Accordingly, these outcomes represent agreement with one clinical observer rather than objective recognition accuracy. Because each participant was assessed once by a single expert, intra-rater and inter-rater reliability of the expert classifications could not be evaluated.

Operational Definition and Assessment of Agreement Outcomes

In the present study, adolescent-expert agreement was operationally defined as the exact correspondence between the image an adolescent believed best represented their own posture and the image selected by the expert based on direct observation. This outcome was interpreted as agreement with the expert's visual classification rather than accuracy against an objective gold standard. Within the visual assessment tool, each postural region was assigned a numerical identifier, while the five visual reference options for each region were coded using the letters a-e (e.g., 1b). Exact agreement was defined as the adolescent and the expert selecting the same image code for a given postural region and was coded as 1; any difference between the selected image codes was coded as 0.

Adolescent-expert agreement was evaluated separately for the head, shoulders, upper-back, and lumbar/waist region. For

each region, the image code selected by the adolescent was compared with the code selected by the expert to determine whether exact agreement was present. The same procedure was applied to the parent assessments by comparing the image code selected by the parent with that selected by the expert; this outcome was evaluated separately as parent-expert agreement. Adolescent-parent agreement was also assessed by comparing their respective image selections for each region. For each adolescent and parent, a total expert-agreement score was calculated by summing the number of anatomical regions in which their selected image corresponded exactly to the expert's selection. The total score ranged from 0 to 4, with higher scores indicating exact agreement with the expert across a greater number of regions. This total score was used as a participant-level summary of regional agreement and was not interpreted as a validated measurement scale.

Statistical Analysis

Analyses were performed using IBM SPSS Statistics version 25.0 (IBM Corp., Armonk, NY, USA). Because Fleiss' κ and Krippendorff's α are not implemented in this version of the software, these two coefficients were calculated directly from the raw rating matrices using their standard formulae for nominal data, and all reported values were verified by independent recomputation. Descriptive statistics are presented as mean and standard deviation for continuous variables, median and range for ordinal variables, and number and percentage for categorical variables. Total expert-agreement scores are presented as median [interquartile range (IQR)] together with mean and standard deviation.

The image codes were analyzed primarily as categorical responses because the principal outcome was exact correspondence between the images selected by different raters. Pairwise agreement between the adolescent and the expert, between the parent and the expert, and between the adolescent and the parent was quantified separately for each postural region using unweighted Cohen's κ . Agreement among the adolescent, parent, and expert was quantified using Fleiss' κ and Krippendorff's α . Ninety-five percent confidence intervals (CIs) for all agreement coefficients were estimated using a non-parametric bootstrap procedure in which participants, each contributing an adolescent, parent, and expert classification, were resampled with replacement (2,000 resamples; percentile method)⁽¹⁶⁾. Interpretation focused primarily on the magnitude of the agreement coefficients rather than their statistical significance.

The head and shoulder image sets included direction-specific configurations combining the side and magnitude of postural deviation and were therefore treated as nominal categories. The upper-back and lumbar/waist image sets depicted progressively changing sagittal postural configurations and had an ordinal structure. Nevertheless, unweighted κ was retained as the primary agreement coefficient because the prespecified outcome required exact selection of the same image, and

any non-identical selection was classified as disagreement regardless of the proximity of the two images. Unweighted κ therefore deliberately treats all disagreements as equivalent: in the upper-back and lumbar/waist sets, a discrepancy between adjacent images (e.g., b vs. c) and a discrepancy between the two extreme images (a vs. e) contribute equally to disagreement. Consequently, the coefficients for these regions quantify exact concordance only and do not reflect the degree of approximate correspondence between raters.

Exact-agreement proportions were defined as the percentages of adolescents or parents whose selected image corresponded exactly to the expert's selection. Given the small sample size, 95% CIs for these proportions were calculated using the Wilson score method rather than the normal approximation.

Region-specific differences between adolescent-expert and parent-expert exact-agreement proportions were examined using paired McNemar tests, with exact binomial p-values reported when appropriate. The four regional observations contributed by each adolescent-parent pair were neither pooled nor treated as statistically independent observations for inferential analysis. Overall exact-agreement frequencies across the four anatomical regions were summarized descriptively only, and no inferential test was applied to the pooled regional observations. This approach preserved the paired structure of the region-specific comparisons and avoided pseudoreplication arising from multiple regional observations contributed by the same participant. Because four region-specific tests were performed for this comparison, the analyses were considered exploratory, and p-values were additionally adjusted for multiplicity using the Holm-Bonferroni procedure⁽¹⁷⁾. Both nominal and adjusted p-values are reported.

Differences between the AIS and control groups were examined using Fisher's exact test for region-specific exact-agreement proportions and the Mann-Whitney U test for total expert-agreement scores. Because the primary outcome was exact categorical agreement and the total agreement score was a bounded ordinal score derived from four dichotomous comparisons, normality was neither assumed nor formally tested; given the small sample size, non-parametric tests were used throughout. The AIS-control analyses were considered exploratory and were not interpreted as tests of group comparability or equivalence. Their nominal p-values are reported without adjustment for multiplicity.

The dataset was complete for all adolescent, parent, and expert image selections, and no imputation was required. All tests were two-tailed, and statistical significance was set at $p < 0.05$.

RESULTS

Participant Characteristics

A total of 40 adolescents (20 with AIS and 20 healthy controls) and one parent for each adolescent were included. The mean adolescent age was 13.6 ± 2.3 years. In the AIS group, the mean

Cobb angle was $24.9 \pm 6.7^\circ$, with values ranging from 10° to 30° . No statistically significant between-group differences were detected in adolescent age, parental age, or parental education level. Although the difference in sex distribution did not reach statistical significance, females predominated in the control group, whereas males predominated in the AIS group (Table 1).

Adolescent-expert Agreement

Adolescent-expert agreement was highest for the head region ($\kappa=0.43$, 95% CI 0.24-0.62) and ranged from $\kappa=0.30$ to $\kappa=0.43$ across the four anatomical regions. The magnitude of these coefficients indicated fair-to-moderate rather than strong agreement, and the wide CIs indicate that these estimates were imprecise (Table 2). The proportion of exact adolescent-expert agreement was 62.5% for the head, 60.0% for the shoulders, and 45.0% for both the upper-back and lumbar/waist regions (Table 3).

Parent-expert Agreement

Parent-expert κ coefficients ranged from -0.01 for the upper-back region to 0.26 for the lumbar/waist region, indicating generally limited agreement with the expert; the 95% CIs for the head, shoulder, and upper-back coefficients included zero (Table 2). Parent-expert exact-agreement proportions ranged from 25.0% for the upper-back region to 40.0% for the lumbar/waist region (Table 3).

Comparison of Expert-referenced Agreement Between Adolescents and Parents

Across the four regions, adolescents selected the same image as the expert in 85 of 160 classifications (53.1%), whereas parents selected the same image as the expert in 56 of 160 classifications (35.0%). These pooled values are presented descriptively only because the four regional classifications contributed by each participant were not statistically independent.

Table 1. Participant characteristics by study group

Variable	Control (n=20)	AIS (n=20)	Total (n=40)
Sample size, n	20	20	40
Age of adolescents, years, mean (SD)	13.5 (2.3)	13.7 (2.3)	13.6 (2.3)
Sex (female/male), n	13/7	7/13	20/20
Cobb angle ($^\circ$), mean (SD)	-	24.9 (6.7)	24.9 (6.7)
Cobb angle, range ($^\circ$)	-	10-30	10-30
Age of parents, years, mean (SD)	45.4 (5.7)	45.7 (4.5)	45.5 (5.1)
Parental education, median (range)	3.5 (1-5)	3 (1-5)	3 (1-5)

Between-group comparisons were performed using the Mann-Whitney U test for adolescent age, parental age, and parental education level, and Fisher's exact test for sex distribution. Parental education was classified as: 1, primary school; 2, secondary school; 3, high school; 4, university; and 5, postgraduate education. -, not applicable. AIS: Adolescent idiopathic scoliosis, SD: Standard deviation

Table 2. Pairwise and multi-rater agreement across anatomical regions

Anatomical region	Adolescent-expert Cohen's κ (95% CI)	Parent-expert Cohen's κ (95% CI)	Adolescent-parent Cohen's κ (95% CI)	Fleiss' κ (95% CI)	Krippendorff's α (95% CI)
Head	0.43 (0.24, 0.62)	0.13 (-0.09, 0.33)	0.14 (-0.09, 0.37)	0.22 (0.07, 0.37)	0.23 (0.08, 0.37)
Shoulders	0.37 (0.13, 0.58)	0.11 (-0.08, 0.30)	-0.05 (-0.19, 0.10)	0.13 (0.00, 0.25)	0.14 (0.01, 0.26)
Upper-back	0.30 (0.11, 0.49)	-0.01 (-0.18, 0.16)	-0.04 (-0.18, 0.12)	0.08 (-0.04, 0.18)	0.08 (-0.03, 0.19)
Lumbar/waist	0.32 (0.15, 0.50)	0.26 (0.09, 0.44)	0.35 (0.13, 0.56)	0.30 (0.13, 0.45)	0.30 (0.14, 0.46)

Pairwise agreement was evaluated using unweighted Cohen's κ , and three-rater agreement was evaluated using Fleiss' κ and Krippendorff's α . Unweighted coefficients represent exact categorical agreement; any selection of different image codes was classified as disagreement. Interpretation focused on the magnitude of the coefficients rather than statistical significance alone. 95% confidence intervals (CIs) were obtained by non-parametric bootstrap resampling of participants (2,000 resamples, percentile method). κ : Kappa coefficient

Table 3. Exact agreement with the expert according to anatomical region

Anatomical region	Adolescent-expert exact agreement, n (%)	Wilson 95% CI	Parent-expert exact agreement, n (%)	Wilson 95% CI
Head	25 (62.5)	47.0-75.8	15 (37.5)	24.2-53.0
Shoulders	24 (60.0)	44.6-73.7	15 (37.5)	24.2-53.0
Upper-back	18 (45.0)	30.7-60.2	10 (25.0)	14.2-40.2
Lumbar/waist	18 (45.0)	30.7-60.2	16 (40.0)	26.3-55.4

Exact agreement was defined as selection of the same visual category as the expert. Confidence intervals (CIs) were calculated using the Wilson score method

In the region-specific paired analyses, adolescent-expert exact agreement was more frequent than parent-expert exact agreement for the head region at the nominal level (62.5% vs. 37.5%; exact McNemar $p=0.031$); however, this difference was not statistically significant after Holm-Bonferroni adjustment for the four regional comparisons (adjusted $p=0.124$). No statistically significant differences were detected for the shoulders ($p=0.078$; adjusted $p=0.234$), upper-back ($p=0.115$; adjusted $p=0.234$), or lumbar/waist region ($p=0.727$; adjusted $p=0.727$) (Table 4).

Multi-rater Agreement Among Adolescents, Parents, and the Expert

Three-rater agreement varied across anatomical regions. Fleiss' κ was highest for the lumbar/waist region ($\kappa=0.30$) and lowest for the upper-back region ($\kappa=0.08$). Krippendorff's α demonstrated a similar pattern, ranging from 0.08 for the upper-back to 0.30 for the lumbar/waist region (Table 2). Overall, the magnitudes of the coefficients indicated limited multi-rater agreement.

Exploratory Comparison Between the AIS and Control Groups

The total adolescent-expert agreement score was median 3 (IQR 1-4) (mean 2.45 ± 1.39) in the control group and median

2 (IQR 0.25-3) (mean 1.80 ± 1.44) in the AIS group. However, no statistically significant between-group difference was detected in this pilot sample ($U=148$, $p=0.151$). The corresponding parent-expert agreement scores were median 1 (IQR 1-2) (mean 1.25 ± 0.79) and median 2 (IQR 1-2) (mean 1.55 ± 1.05), respectively, with no statistically significant difference ($U=164$, $p=0.306$). Region-specific analyses similarly detected no statistically significant differences between the AIS and control groups (Table 5). These findings should not be interpreted as demonstrating equivalence between the groups.

DISCUSSION

This exploratory pilot study provided an initial evaluation of agreement among adolescents', parents', and one expert's visual classifications of adolescent posture using the same standardized reference images. Adolescent-expert agreement was greatest for the head region and ranged from fair to moderate across the four anatomical regions. Parent-expert and adolescent-parent agreement was generally limited, although the magnitude of agreement varied by region. The proportion of classifications corresponding exactly to the expert's selection was numerically higher for adolescents than

Table 4. Region-specific comparison of exact agreement with the expert between adolescents and parents

Anatomical region	Adolescent only in agreement, n	Parent only in agreement, n	McNemar χ^2	Exact p-value	Holm-adjusted p-value
Head	14	4	4.500	0.031	0.124
Shoulders	15	6	3.048	0.078	0.234
Upper-back	14	6	2.450	0.115	0.234
Lumbar/waist	5	3	0.125	0.727	0.727

Values represent discordant adolescent-parent pairs within each anatomical region. McNemar χ^2 values are continuity-corrected; p-values are exact (binomial). Holm-Bonferroni adjustment was applied across the four regional comparisons, and these analyses were exploratory. No overall McNemar test was conducted by pooling regional observations because this would violate the assumption of independent paired observations

Table 5. Exploratory comparison of expert-referenced agreement between the AIS and control groups

Anatomical region	Rater	Control, n (%)	AIS, n (%)	p-value
Head	Adolescent	15 (75.0)	10 (50.0)	0.191
Shoulders	Adolescent	14 (70.0)	10 (50.0)	0.333
Upper-back	Adolescent	11 (55.0)	7 (35.0)	0.341
Lumbar/waist	Adolescent	9 (45.0)	9 (45.0)	1.000
Head	Parent	9 (45.0)	6 (30.0)	0.514
Shoulders	Parent	7 (35.0)	8 (40.0)	1.000
Upper-back	Parent	3 (15.0)	7 (35.0)	0.273
Lumbar/waist	Parent	6 (30.0)	10 (50.0)	0.333
Overall [†]	Adolescent	3 (1-4) 2.45 (1.39)	2 (0.25-3) 1.80 (1.44)	$U=148$; 0.151
Overall [†]	Parent	1 (1-2) 1.25 (0.79)	2 (1-2) 1.55 (1.05)	$U=164$; 0.306

Regional values represent the number and percentage of participants whose selected image corresponded exactly to the expert's selection. Region-specific comparisons were performed using two-sided Fisher's exact tests. [†]: Overall values represent the total expert-agreement score (range 0-4), presented as median (interquartile range) and mean (standard deviation), and were compared using the Mann-Whitney U test. These exploratory analyses were not interpreted as tests of group equivalence, AIS: Adolescent idiopathic scoliosis

for parents in each of the four regions; however, a nominally significant region-specific difference was observed only for the head, and this difference did not remain statistically significant after adjustment for multiple comparisons. Accordingly, the hypothesis that adolescent-expert agreement would exceed parent-expert agreement in at least one anatomical region was not supported after correction for multiplicity. Because the pooled regional observations were not subjected to inferential analysis, no conclusion was drawn regarding an overall difference between adolescents and parents. Furthermore, no statistically significant difference in expert-referenced agreement was detected between adolescents with mild-to-moderate AIS and healthy controls in this pilot sample. These findings should be regarded as preliminary and hypothesis-generating rather than evidence that the visual approach is a validated clinical measurement instrument.

Recognition of one's own posture is a complex perceptual process involving the integration of visual, proprioceptive, and somatosensory information within the central nervous system^(2,6,8,18). Related aspects of body perception have traditionally been conceptualized through body awareness, body schema, and body image^(3,6,8,19). Body image primarily concerns the cognitive, emotional, and psychological evaluation of physical appearance, whereas body schema refers to the sensorimotor representation of body position and configuration. Body awareness encompasses conscious attention to bodily sensations and perceived body position. The outcome examined in the present study differs from these constructs because it represents exact agreement between an adolescent's visual self-classification and one expert's visual classification using the same image set. It should therefore be interpreted as expert-referenced postural self-recognition agreement, not as an objective measure of perceptual accuracy. The magnitude of adolescent-expert agreement varied across anatomical regions, with the highest coefficient observed for the head and lower coefficients for the upper-back and lumbar/waist regions. One possible explanation is that the head and shoulders are encountered more frequently through mirrors, photographs, and interpersonal interactions and may therefore provide more accessible visual cues^(6,8,20,21). In contrast, the upper-back and lumbar/waist regions are not directly visible during routine activities, and their perception may depend more strongly on proprioceptive and somatosensory information^(6,7,18,20). Previous research suggests that body representation may be facilitated when visual and proprioceptive information can be integrated^(6,8,19,20). Nevertheless, the present study did not directly measure visual exposure, proprioception, or the mechanisms underlying regional differences. Consequently, these explanations remain hypotheses and should not be interpreted as mechanisms demonstrated by the current findings.

Parent-expert agreement was generally limited, ranging from $\kappa=-0.01$ for the upper-back region to $\kappa=0.26$ for the lumbar/waist region. Previous studies have mainly compared parental

perceptions of adolescents' appearance or spinal deformity with adolescents' self-perceptions and have sometimes reported similarities between these perspectives^(6,13,22). However, parent-adolescent agreement does not necessarily imply correspondence with a clinician's visual classification. In the present study, adolescents demonstrated numerically higher exact-agreement proportions than parents, but the region-specific difference reached nominal significance only for the head and did not persist after multiplicity adjustment. Therefore, the findings do not support a broad conclusion that adolescents consistently classify their posture better than their parents. Rather, they suggest that adolescent, parent, and expert classifications may provide different perspectives and that the magnitude of concordance depends on the anatomical region being evaluated.

The three-rater coefficients also indicated region-dependent variation. Fleiss' κ and Krippendorff's α were highest for the lumbar/waist region and lowest for the upper-back region, although their overall magnitudes remained limited. These coefficients reflect simultaneous classification by the adolescent, parent, and expert and therefore address a different question from pairwise agreement. The findings illustrate the potential value of reporting both pairwise and multi-rater coefficients; however, statistical significance should not be interpreted as evidence of clinically strong agreement, particularly in a small pilot sample⁽²³⁾.

No statistically significant difference in adolescent-expert agreement was detected between the AIS and healthy control groups. Previous research found no differences in the perception of vertical and horizontal orientation between adolescents with idiopathic scoliosis and healthy controls⁽²⁴⁾, whereas other studies suggested that discrepancies in perceived trunk appearance may become more apparent with increasing curve magnitude and may be less evident in milder deformities^(1,3). Similarly, body image may be affected in adolescents with mild AIS even when subjective trunk appearance is not strongly associated with radiographic or photogrammetric measurements⁽²⁵⁾. The adolescents with AIS in the present study had Cobb angles ranging from 10° to 30°, and the restricted severity range may have limited the ability to detect group differences. Moreover, the small sample provided limited statistical power. Thus, the findings indicate only that no statistically significant between-group difference was detected; they do not demonstrate that adolescents with AIS and healthy adolescents have equivalent postural self-recognition.

The sex distribution should also be considered when interpreting the exploratory group comparison. Females predominated in the control group, whereas males predominated in the AIS group. Although this difference was not statistically significant, the distributions were notably different in direction, and sex-related differences in attention to appearance or body perception could have influenced the findings. Because of the small sample, sex-adjusted or sex-stratified analyses were not feasible. The AIS-control results should therefore be interpreted

cautiously and examined in larger samples with more balanced sex distributions.

Existing AIS-related patient-reported measures primarily address body image, perceived deformity, trunk appearance, psychosocial effects, and health-related quality of life^(3,6,26-28). Instruments such as the WRVAS and the SAQ use visual representations to assess perceived scoliosis-related deformity and appearance^(13,14). These measures provide clinically important information but do not specifically quantify exact agreement among adolescents, parents, and a clinician using the same set of region-specific visual alternatives. The approach examined in the present study addresses this narrower question of cross-observer concordance. It is not intended to replace existing measures of body image, perceived deformity, trunk aesthetics, body awareness, or health-related quality of life. At this stage, it should be considered a preliminary visual classification approach whose potential clinical value remains to be established.

Study Limitations

Several limitations should be considered. First, this exploratory pilot study included only 40 adolescent-parent pairs, and no formal a priori power calculation was performed. The study may therefore have been insufficiently powered to detect meaningful differences, particularly between the AIS and control groups. The small sample also resulted in wide CIs for the agreement coefficients, so the regional estimates should be regarded as imprecise. Furthermore, the overall adolescent-parent frequencies were summarized descriptively because pooling the four regional observations for inferential analysis would have violated the independence assumption. Consequently, no inferential conclusion regarding an overall adolescent-parent difference can be drawn from this study. Second, the AIS sample was restricted to mild-to-moderate deformities with Cobb angles of 10°-30°, limiting generalizability to adolescents with more severe curves. Third, the expert's visual classification was used as the comparator, but it was not independently validated against radiography, photogrammetry, surface topography, or another objective postural reference. The expert assessment may itself have contained classification error. Fourth, each participant was assessed once by a single expert; consequently, intra-rater and inter-rater reliability could not be determined. Fifth, the expert-based content evaluation established the content appropriateness of the images only; the reliability, construct validity, criterion validity, responsiveness, and clinically meaningful interpretation of the visual approach have not yet been established. In addition, because unweighted κ was used for the ordinal upper-back and lumbar/waist image sets, near-miss classifications were counted as full disagreements; the reported coefficients may therefore understate approximate correspondence in these regions. Sixth, the imbalance in sex distribution may have confounded the AIS-control comparison. Seventh, current or previous brace treatment, physiotherapy, and scoliosis-specific exercise may influence postural awareness;

the small sample did not permit these potential effects to be examined adequately. Finally, the cross-sectional design precluded assessment of temporal stability or responsiveness to postural education and rehabilitation. Future studies should include larger and more diverse samples, multiple blinded assessors, repeated assessments, independent instrumental reference measures, and prospective evaluation of reliability, validity, and responsiveness before clinical application is considered.

CONCLUSION

This exploratory pilot study demonstrated that adolescents', parents', and an expert's visual classifications of adolescent posture can be compared using the same standardized reference image set. Adolescent-expert agreement varied across anatomical regions and was greatest for the head, whereas parent-expert agreement was generally limited. Although exact-agreement proportions were numerically higher for adolescents than for parents in all four regions, the only nominally significant difference, observed for the head, did not remain significant after adjustment for multiple comparisons and should be interpreted with caution. No statistically significant difference in adolescent-expert agreement was detected between adolescents with mild-to-moderate AIS and healthy controls; however, this finding should not be interpreted as evidence of equivalence. The present findings provide preliminary evidence regarding expert-referenced visual agreement and do not establish the approach as a valid, reliable, or clinically applicable measurement instrument. Larger studies incorporating multiple assessors, repeated assessments, and independent objective reference measures are required to determine its reliability, validity, responsiveness, and potential clinical utility.

Ethics

Ethics Committee Approval: The study protocol was approved by the Ege University Faculty of Medicine Ethics Committee (approval no: 26-3T/2, date: 05.03.2026).

Informed Consent: Voluntary assent was obtained from all adolescents, and written informed consent was obtained from their parents.

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Footnotes

During the preparation of this manuscript, the authors used ChatGPT (OpenAI) to assist with English translation, language editing, and improvement of the clarity and readability of the manuscript. The tool was not used for data collection, statistical

analysis, generation of study results, or independent scientific interpretation. All AI-assisted text was critically reviewed, revised, and approved by the authors, who take full responsibility for the scientific content and integrity of the manuscript.

Authorship Contributions

Surgical and Medical Practices: D.B., Concept: D.B., Ö.B.Ç., E.E., T.O.B., A.M.Ö., Design: D.B., Ö.B.Ç., E.E., T.O.B., A.M.Ö., Data Collection or Processing: D.B., Ö.B.Ç., E.E., A.M.Ö., Analysis or Interpretation: T.O.B., Literature Search: D.B., Writing: D.B., Ö.B.Ç., E.E., T.O.B., A.M.Ö.

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