

*Review article*

## **Aesthetic Appearance Assessment in Adolescents with Idiopathic Scoliosis**

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### **SUMMARY**

**Introduction.** Aesthetic appearance is one of the major concerns in adolescent idiopathic scoliosis (AIS) patients and its improvement is one of the main treatment's goals. Poor trunk appearance is associated with reduced quality of life in adolescents with idiopathic scoliosis.

**Aim.** To review instruments that have been created to evaluate poor trunk appearance in these children.

**Material and methods.** PubMed database and the Consortium of Libraries of Serbia for Unified Acquisition - KoBSON were searched using the keywords „adolescent scoliosis“, „aesthetic appearance“, „evaluation“ and „questionnaires“.

**Results.** In order to evaluate the aesthetic impairment in these patients, various instruments have been created. They can roughly be classed as instruments that assess subjective perception or objective aesthetic appearance. The first group consists primarily of self-administered quality of life questionnaires that include an aesthetic component, such as the Scoliosis Research Society 22 (SRS-22) questionnaire and the Italian Spinal Youth Quality of Life (ISYQoL) questionnaire, as well as visual scales based on patient-completed trunk drawings, such as the Walter Reed Assessment Scale, the Spinal Appearance Questionnaire, and the Trunk Appearance Perception Scale. Trunk asymmetry scales that use pictures, such as the TRACE (Trunk Aesthetic Clinical Evaluation), the POTSI (Posterior Trunk Symmetry Index) and the ATSI (Anterior Trunk Symmetry Index), 2-dimensional digital photography, and surface topography can all be used to assess the aesthetic profile of subjects, allowing for objective evaluation.

**Conclusion.** Each clinical examination should include a specific assessment of trunk asymmetry. Various instruments were developed with the goal of decreasing x-ray radiation exposure in these patients.

**Keywords:** adolescent idiopathic scoliosis, aesthetic appearance, evaluation, surface topography

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## INTRODUCTION

Scoliosis is a complex three-dimensional (3D) spinal deformity that always includes elements of deformation in the three planes: lateral deviation in the frontal plane, a reduction of kyphosis (hypokyphosis) in the apical thoracic area in the sagittal plane and vertebral axial rotation in the horizontal plane (1). In over 80% of cases, the cause of scoliosis is unknown, which means that scoliosis is not caused by congenital, neuromuscular, neuropathic, or systemic diseases (2).

Adolescent idiopathic scoliosis (AIS) is the most common form of scoliosis with the prevalence of between 0.47% and 5.2% in the general adolescent population of 10 - 17 years of age (2). It occurs more frequently in girls. Small lateral deviations of the spine go unnoticed until puberty when the first clinical signs of scoliosis such as shoulder and scapulae asymmetry, rib hump, waist asymmetry, pelvic obliquity, lateral pelvic prominence, and trunk imbalance occur. If left untreated, scoliosis can progress and lead to severe deformities of the chest and trunk, reducing lung and cardiovascular function, general fitness, working ability and quality of life (3). Besides, it is related to increased back pain, cosmetic concerns and progressive function limitations in adult age (4 - 6). Therefore, the recognition of scoliosis at an early age and adequate treatment is necessary (3).

In 2016, SOSORT (The International Scientific Society for Scoliosis Orthopedic and Rehabilitation Treatment) proposed guidelines in the treatment and evaluation of children with idiopathic scoliosis and other spinal deformities (3). Assessment guidelines are based on the SOSORT consensus paper published in 2009 titled: „Methodology of evaluation of morphology of the spine and the trunk in idiopathic scoliosis and other spinal deformities - 6th SOSORT consensus paper“ (7). It has been emphasized that assessment is essential not only for the management of idiopathic scoliosis in childhood and adolescence, but for the evaluation of treatment outcome as well.

Evaluation of a child with scoliosis consists of patient's history and complete neurological examination to exclude neurological disease, clinical, radiologic and aesthetic appearance assessment, physical capacity and quality of life evaluation (3).

## AESTHETIC APPEARANCE ASSESSMENT

In the treatment of adolescents with idiopathic scoliosis, aesthetic appearance is extremely important, and its improving is one of the key therapy aims. Poor trunk appearance in AIS patients is associated with reduced quality of life (8). Therefore, each clinical examination should include a specific assessment of trunk asymmetry. In order to assess the aesthetic impairment in AIS patients, various instruments have been created. These instruments can roughly be classed as instruments that assess subjective perception or objective trunk appearance. The first group consists primarily of self-administered quality of life questionnaires that include an aesthetic component, such as the Scoliosis Research Society 22 (SRS-22) questionnaire (9) and the Italian Spinal Youth Quality of Life (ISYQoL) questionnaire (10), as well as visual scales based on patient-completed trunk drawings, such as the Walter Reed Visual Assessment Scale (11), the Spinal Appearance Questionnaire (12), and the Trunk Appearance Perception Scale (13). Asymmetrical trunk deformities caused by scoliosis can be objectively evaluated using a clinical tool such as TRACE (14), pictures such are POTSI and ATSI (15, 16), 2-dimensional digital imaging (17), and surface topography (18).

### THE WALTER REED VISUAL ASSESSMENT SCALE (WRVAS)

Sander et al. created the Walter Reed Visual Assessment Scale (WRVAS) in 2003 to allow patients to describe their perception of their deformity (11). It is made up of seven sets of illustrations that depict spinal deformity, rib prominence, lumbar prominence, thoracic deformity, trunk imbalance, shoulder asymmetry, and scapular asymmetry. Each set contains five figures with varying degrees of deformity that are ranked from least to most severe (1 - 5). The total score is calculated by adding the answers to the seven questions. The patient or their parents can fill out the scale. It has been shown that the WRVAS had a strong correlation with the amplitude of the curve and the treatment (11, 19). The scale had excellent internal consistency and it correlated considerably with the self-image scale in the SRS-22 questionnaire (19). However, there was just a sliver of a relationship between the SRS-22 pain, function, and mental

health scores. Bago et al. investigated the WRVAS further and found that individual scores did not differ between the several curve patterns evaluated (thoracic, double major, and thoracolumbar/lumbar) (20). Furthermore, three of the scale's figures (items 3, 5, and 6) did not match the radiological abnormality they were supposed to detect. The authors concluded that WRVAS is a valid questionnaire for assessing patients' subjective perceptions of their deformity, but it is not useful for describing the real deformity a patient has.

### **THE SPINAL APPEARANCE QUESTIONNAIRE (SAQ)**

Based on the WRVAS, Sanders et al. created a questionnaire in 2007 to examine patients' impressions of the look of their spinal deformity (12). This questionnaire has eight sets of illustrations relating to the deformity, the figure related to the scapular asymmetry is excluded and side view is added, as well as twelve questions about how satisfied or dissatisfied patients are with their look. The items are rated on a scale of 1 to 5, with a higher score indicating a poorer patient perception of the abnormality. Individual scale items were assessed to have good to excellent reliability and strong internal scale consistency. The mean scale scores could distinguish between curves larger than 30 degrees and those less than 30 degrees.

The SAQ was modified by Carreon et al. and a new SAQ version 1.1 was established (21). There were 11 drawings and 22 questions on treatment expectations in it. Only 14 elements were selected by the authors: the first ten pictures, known as the Appearance factor, and four questions (12 – 15), known as the Expectations factor. The authors also presented evidence for the SAQ's high reliability and convergent validity in terms of correlations with main curve magnitude, as well as discriminant validity by demonstrating substantial differences between patients undergoing different therapies.

### **THE TRUNK APPEARANCE PERCEPTION SCALE (TAPS)**

Bago et al. developed the Trunk Appearance Perception Scale (TAPS), which included three sets of figures depicting the patient's trunk from three different angles. The first set contains five figures depicting the patient's back in an upright position;

the second set contains five figures depicting the patient bent over towards the examiner; and the third set contains figures depicting the patient's front in an upright position (this third set of drawings includes both female and male versions) (13). Each figure is given a score ranging from 1 (worst deformity) to 5 (smallest deformity). A mean score is calculated by adding the scores for 3 sets of figures and dividing by 3.

This tool was examined for validity and found to have high score distribution, internal consistency, and test-retest reliability (13). TAPS is a valid instrument for assessing patients' perceptions of their trunk deformity, according to the authors (13). It is simple to use in clinical practice, the figures are more natural than the WRVAS, and a frontal figure of the patients is included.

Rigo et al. showed substantial correlations between TAPS and self-image and pain measures in the SRS-22 questionnaire (22). Misterska et al. found high correlations between TAPS and the primary Cobb angle (23). Thielsch et al. evaluated the SAQ version 1.1 and the TAPS for reliability and validity (24). They discovered that both instruments had strong psychometric properties; however, the SAQ Expectations scale's stability appears to be compromised. In comparison to the SAQ, they propose utilizing the TAPS for future clinical investigations because it is much shorter and has slightly greater psychometric quality.

### **THE TRACE (TRUNK AESTHETIC CLINICAL EVALUATION)**

Zaina et al. developed the TRACE (Trunk Aesthetic Clinical Evaluation), a 4-subscale scale based on visual assessment of asymmetry of the shoulders, shoulder blades, waist, and hemithorax (14). Posterior-anterior photographs of AIS patients' trunk were taken and analyzed. Shoulder asymmetry ranged from 0 to 3 (mild, moderate, and pronounced), scapulae asymmetry from 0 to 2 (mild, pronounced), waist asymmetry from 0 to 4 (insignificant, mild, medium, and pronounced), and hemithorax asymmetry from 1 to 2 (mild and pronounced). The final index ranged from 1 to 12. The TRACE showed fair intra-rater and poor inter-rater reliability (14). Further Rasch analysis demonstrated that it can be used to compare the appearance of the trunk in different patient's groups (children and

adolescents) with varying curve magnitudes before and after brace treatment (25).

### **TWO-DIMENSIONAL DIGITAL PHOTOGRAPHY**

With or without the use of external markers, digital photogrammetry can be used to analyze posture. The process of picture registration is easy, rapid, safe, and cost-effective. A semi-automatic image analysis has been developed. Stolinski et al. proposed standardized positions for photogrammetry of children's posture (17). Photos of spontaneous standing frontal and posterior view, sagittal view (left and right side, left and right side actively corrected, left and right side in bending forward), as well as front and back bending forward view are included in the standardized procedure for photographic body posture evaluation. As a result, unintentionally altered posture can be avoided. The authors also created and tested five sagittal plane photographic parameters (sacral slope angle, thoracic kyphosis angle, lumbar lordosis angle, chest inclination angle, and head protraction angle), which showed good repeatability and reproducibility and could become a standard for body posture assessment in children.

### **THE ATSI (ANTERIOR TRUNK SYMMETRY INDEX)**

Stolinski et al. created the ATSI to allow the front of a trunk to be analyzed (15). A digital photography of the front of the trunk was taken, and anatomical landmarks such as the sternal notch, acromion, axillary folds, waist lines, and navel were marked. Three indices of frontal plane asymmetry (one for sternal notch, axillary folds, and waist lines) and three height difference indices made up the ATSI (one for acromion, axillary folds and waist lines). The software was created to calculate this index in a semi-automated manner. For 50 healthy children, the average ATSI value was  $25.3 \pm 10.6$  (15).

### **THE POTSI (POSTERIOR TRUNK SYMMETRY INDEX)**

The POTSI was created in 1999 to assess posterior trunk asymmetry (16). The POTSI provides a thorough indicator of trunk asymmetry with a low measurement error. As a result, it can be used to

assess the cosmetic appearance of scoliosis patients. The POTSI parameter is made up of six indices: three asymmetry indices in the frontal plane (C7, axilla folds, and waist lines) and three frontal plane height difference indices (acromions, axilla folds, and waist lines). In the study of Suzuki et al., the average POTSI in healthy children was 16.5, and 28.1 in children with scoliosis (16).

### **SURFACE TOPOGRAPHY**

Surface topography (ST) was developed with the goal of decreasing x-ray radiation exposure in scoliosis patients. InSpeck, ISIS, Quantec, and Formetric are some of the current systems that measure the surface topography of the trunk. Formetric 3D/4D optical scanning is a cutting-edge diagnostic technique that enables for a static and dynamic scan of the spine without using damaging radiation or topographic markers. For the first time, it is able to assess the patient's posture and spine position while he or she is walking.

The device uses a light projector to project a pattern of parallel stripes onto the patient's back, which is subsequently captured by a camera unit. A software analyzes the line curvature and develops a 3D model of the surface from it, using the photogrammetry approach as well as reconstructing a 3D model of the spine (18).

In the examination of individuals with AIS, the following surface topography parameters can be observed in the frontal plane: trunk length, scoliosis angle, lateral deviation, coronal imbalance, pelvic obliquity, and surface rotation. In the sagittal plane, kyphosis angle, lordosis angle, sagittal imbalance, and vertebral rotation in transverse plane can also be analyzed.

Several researches have examined the Formetric 4D system's validity in AIS patients. Scoliosis angle measures were found to be highly associated with those obtained from routine radiography (18). Although this system does not accurately anticipate curve degree, the primary goal of ST is to detect a change. The clinician will be alerted to the probability of scoliosis progression by this change in ST. The authors concluded that the Formetric 4D can be used to monitor AIS patients with confidence (18). When compared to a standard radiography, the Formetric 4D, however, regularly underestimated the amplitude of curves detected by an average of 8.12 degrees except thoracic kyphosis (18). Thoracic

kyphosis was overestimated by an average of 7.26 degrees (18). In the thoracic curve, the correlation with radiographic data was strong, whereas in the lumbar curve, it was mild (26). The average difference between ST scoliosis angle estimates and radiography Cobb angle was 5.8 degrees in the thoracic spine and 8.8 degrees in the lumbar spine (26). Radiographs and thoracic kyphosis exhibited a high correlation. The differences in coronal vertical axis, sagittal vertical axis, and pelvic obliquity were 1.3, 3.7 and 2.3 degrees, respectively. This shows that direct surface topography measurements have a stronger correlation with radiography than estimated Cobb angles (26).

Data from eleven researches were recently evaluated, demonstrating the relationship between surface topography and X-ray, as well as the reproducibility of surface topography in the sagittal and frontal planes (27). The results of this meta-analysis show that thoracic and lumbar measures in the sagittal plane, as well as thoracic measures in the frontal plane (Cobb), have significant correlations with radiography, while lumbar measures in the frontal plane have modest correlations.

Despite the fact that ST allows for objective evaluation of trunk asymmetries, its usage in clinical

practice is limited due to the high cost of the equipment.

## CONCLUSION

As aesthetic appearance is a major concern among AIS patients, and its improvement is one of the key treatment goals, a variety of tests have been developed to assess bad trunk appearance and monitor its improvement during treatment. The Walter Reed Visual Assessment Scale, The Spinal Appearance Questionnaire, and The Trunk Appearance Perception Scale are examples of visual scales that employ drawings to measure patients' subjective judgments of their deformities. Because it is much shorter and has acceptable psychometric quality, the last one is recommended for clinical investigations. For objective evaluation of a subject's aesthetic profile, trunk asymmetry scales based on images such as TRACE, POTSI, and ATSI, 2-dimensional digital imaging, and surface topography have been proposed. Despite the fact that surface topography enables objective examination of trunk asymmetries in all three planes, its use in daily clinical practice is limited due to the equipment's expensive cost.

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#### Article info

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# Procena estetskog izgleda kod adolescenata sa idiopatskom skoliozom

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## SAŽETAK

**Uvod.** Loš estetski izgled jedna je od glavnih briga pacijenata sa idiopatskom skoliozom u adolescenciji (AIS) i njegovo poboljšanje jedan je od glavnih ciljeva lečenja. Loš izgled trupa dovodi do smanjenog kvaliteta života adolescenata sa idiopatskom skoliozom.

**Cilj.** Analizirati instrumente koji se koriste u proceni lošeg estetskog izgleda trupa ove dece.

**Materijal i metode.** PubMed baza podataka i Konzorcijum biblioteka Srbije za objedinjenu nabavku – KoBSON pretraživani su upotrebom ključnih reči „skolioza u adolescenciji“, „estetski izgled“, „evaluacija“ i „upitnici“.

**Rezultati.** U cilju procene estetskog izgleda ovih pacijenata, kreirani su brojni instrumenti. Oni se mogu klasifikovati kao instrumenti koji procenjuju subjektivnu percepciju ili objektivni estetski izgled. Prvu grupu čine prvenstveno upitnici o kvalitetu života koji uključuju estetsku komponentu, kao što je *Scoliosis Research Society 22 (SRS-22)* upitnik i *Italian Spinal Youth Quality of Life (ISYQoL)* upitnik, kao i vizuelne skale u kojima pacijent, na osnovu crteža trupa, subjektivno procenjuje svoj izgled kao što su *the Walter Reed Assessment Scale*, *the Spinal Appearance Questionnaire* i *the Trunk Appearance Perception Scale*. Fotografije na osnovu kojih se procenjuje asimetrija trupa, kao što su *TRACE (Trunk Aesthetic Clinical Evaluation)*, *POTSI (Posterior Trunk Symmetry Index)* i *ATSI (Anterior Trunk Symmetry Index)*, 2-dimenzionalna digitalna fotografija i površinska topografija mogu se koristiti za objektivnu procenu estetskog izgleda pacijenata sa AIS.

**Zaključak.** Svaki klinički pregled trebalo bi da uključi specifičnu procenu asimetrije trupa. Razvijeni su različiti instrumenti sa ciljem smanjenja izloženosti rendgenskom zračenju ovih pacijenata.

**Ključne reči:** idiopatska skolioza u adolescenciji, estetski izgled, evaluacija, površinska topografija