



Kinetic-functional assessment of the adolescent idiopathic scoliosis: a cohort study

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ABSTRACT

Introduction: It is estimated that 1 to 3% of the world's population is diagnosed with idiopathic scoliosis, with a higher prevalence in females and a higher index of curves in the right thoracic region. Diagnosis and clinical follow-up are based on radiographic analysis and measurement of the Cobb angle, which is considered the gold standard for classifying scoliotic severity.

Objective: This study investigated the applicability and feasibility of the kinetic-functional examination in patients with adolescent idiopathic scoliosis, considering the main functional tests described in the literature.

Methods: It was a cross-sectional, quantitative cohort study (CAAE xxxxxxxxxxxxxxxxx) involving individuals of both sexes, aged between 10 and 14 years, who had a diagnosis of idiopathic scoliosis of the adolescent confirmed by radiographic examination (Cobb angle between 10° and 50°). Statistical significance was set $p < 0.05$.

Results: A total of 157 individuals participated in the study, 77.7% were female and 57.9% were considered underweight according to body mass index. Regarding the degree of severity of the curve, 61.8% of the adolescents had a moderate scoliotic curve. A trend towards a reduction in spine flexibility was observed as the severity of the curvature increased, especially in mild and moderate curves, while the strength tests showed negative values, with no marked differences between the severity groups.

Conclusion: The standardized application of functional tests ensures reliability and reproducibility of the results, and ensures the patient's performance, reducing biases, favoring clinical validity and assisting in the accurate identification of functional deficits.

1. Introduction

Adolescent idiopathic scoliosis (AIS) is a three-dimensional deformity of the spinal column, characterized by the presence of one or more curvatures in the frontal plane accompanied by rotation of the vertebrae in the transverse plane, predominantly affecting adolescents in the growth phase (Negrini et al., 2018; Associação et al., 2025). It is estimated that 1 to 3% of the world's population is affected by this condition (Negrini et al., 2018; Associação et al., 2025; Espírito et al., 2011) with a higher prevalence in females compared to males, and a higher rate of curves in

the thoracic region on the right (Associação et al., 2025). Diagnosis and clinical follow-up have traditionally been based on radiographic analysis and measurement of the Cobb angle, which is considered the gold standard for classifying scoliotic severity (Negrini et al., 2018).

Factors such as multiple curvatures, Cobb angle greater than 25°, and delayed bone maturation indicate greater potential for curve progression. The progress of AIS can have an impact on important clinical and psychosocial repercussions (Negrini et al., 2018; Fernandes et al., 2012; Almahmoud et al., 2024) and may later lead to implications such as reduced functional exercise capacity associated with pulmonary function

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(Fernandes et al., 2012), low back pain (Negrini et al., 2018; Espírito et al., 2011; Fernandes et al., 2012), decline in physical function (Li et al., 2021), gait alteration due to fatigability and stiffness (Delpierre and Armand, 2024; Mahaudens et al., 2009a, 2009b) and other deformities (Negrini et al., 2018; Associação et al., 2025; Espírito et al., 2011), involving a significant impact on the quality of life of patients.

In this context, kinetic-functional tests emerge as essential complementary tools, enabling the evaluation of parameters such as strength, resistance, flexibility, and mobility, in a non-invasive and safe way. Kinetic-functional examinations constitute an integrated approach to assess human functionality, focusing on the analysis of mobility, strength, flexibility and endurance. These examinations include the application of functional and physical tests, specific scales, and questionnaires, enabling an interpretation of musculoskeletal conditions, movement limitations, and potential restrictions on participation in social activities (Classificação Brasileira de Diagnósticos Fisioterapêuticos; Ferreira et al., 2010; Martins et al., 2017; Barbosa et al., 2010) aimed at spinal dysfunctions.

Among the most used tests for scoliosis are Adams test (Negrini et al., 2018; Mahaudens et al., 2009a) associated with the scoliometer, the Stibor index (Mahaudens et al., 2009b), the Schober test (Mahaudens et al., 2009b), the Sorensen test (Classificação Brasileira de Diagnósticos Fisioterapêuticos) and the abdominal strength test (Ferreira et al., 2010). The standardized application of functional tests is essential to ensure reliability and reproducibility of results, allowing consistent comparisons between different evaluations. In addition, it ensures that the patient's performance is analyzed under the same conditions, reducing biases, favoring clinical validity, helping in the accurate identification of functional deficits. Thus, the objective of this cohort study was to demonstrate the applicability and feasibility of the kinetic-functional examination in patients with AIS, considering the main functional tests described in the literature. Such factors support the hypothesis that a greater severity of adolescent idiopathic scoliosis, measured by the Cobb angle, would be associated with changes in the results of kinetic-functional tests used in physiotherapeutic evaluation.

2. Material and methods

2.1. Ethical issues

This study was prepared according to the guidelines established by the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) reporting guideline and approved by the Research Ethics Committee of the xxxxxxxxxxxxxxxxx, in accordance with Resolution 466/2012, registered at CAAE xxxxxxxxxxxxxxxxx. The selection of participants respected the principles of justice and equity, without distinction of race, creed, educational level or family income. Anonymity and data protection of the participants were guaranteed through the Informed Consent Form (ICF), and they were previously informed about the objective and benefits of the research. They were also informed that the results of this study will be disclosed exclusively for academic-scientific purposes, preserving the confidentiality of the identities of those involved. All individuals who signed up for the ICF agreed with their participation.

2.2. Population

This is a cross-sectional quantitative cohort study composed of patients of both sexes and aged between 10 and 14 years. Adolescents with a diagnosis of AIS confirmed by radiographic examination, with a Cobb angle between 10° and 50°, were included. The exclusion criteria adopted were adolescents with a history of spine or lower limb surgery, neurological alterations, lack of adequate completion of the medical record, and patients who were already using the brace before the initial evaluation.

Data were obtained through the online medical records platform

of the *Escoliose Brasil* clinic, and values of radiographic examinations and results of kinetic-functional examinations obtained in the evaluation were collected for analysis. Data collection was carried out at one of the headquarters of Scoliosis Brazil, located in the city of Salvador. The analyses were carried out between August and September 2025.

The researchers constructed a standardized data matrix for data collection, which included sociodemographic (gender, age), anthropometric (weight and height) and clinical (Cobb angle measurement and scoliotic curve severity) information, as well as records of kinetic-functional exams: Schober test (Martins et al., 2017), Stibor test (Martins et al., 2017), Sorensen test.

2.3. Kinetic-functional tests for AIS

In the Schober test, which focuses on lumbar mobility, the evaluator marks one point on the lumbar spine and another 10 cm above. During anterior flexion of the trunk, the distance between these points increases proportionally to the flexibility of the spine. Values below 05 cm in flexion indicate low flexibility (Mahaudens et al., 2009b). The Stibor test evaluates the thoracolumbar region, where the evaluator measures the distance between the spinous processes of C7 and S1 before and after flexion, increases of less than 10 cm after flexion indicate low mobility (Martins et al., 2017).

The Sorensen test is used to assess the muscular endurance of the lumbar extensors. To perform it, the patient is positioned in the prone position on a stretcher, with the pelvis and legs fixed, so that the trunk is suspended on the edge of the stretcher, in line with the iliac spines. The patient should keep the trunk extended horizontally, parallel to the ground, with the arms crossed on the chest, without support. The evaluator measures the time in which the patient can maintain this position without giving in, the result being a measure of the resistance of the lumbar extensor muscles. The longer the support time, the better the muscular endurance (Barbosa et al., 2010).

The Abdominal Strength Test is performed with the patient in the recumbent position where he performs an isometric abdominal for a period of 1 min. The patient must remain at an angle where the core is activated for the entire test period, the time of 1 min is timed (Marchese et al., 2024).

This current study followed the methodological recommendations for the application of the tests (Amjad et al., 2022; Martínez-Romero et al., 2020; Dederig et al., 2000), which are intended to be performed only once. This leads us to infer that the repeatability and reproducibility of the measurements may generate variation between analyses.

In the Schober test (Amjad et al., 2022), the most relevant aspect is not the segmental evaluation of isolated vertebrae, but rather the measurement of the overall lumbar spine mobility. Therefore, the variation in patients' height, and consequently, trunk size, does not represent a significant bias, since the outcome to be analyzed is based on the difference obtained between the measurements in flexion and extension, without the influence of the exact location of the reference points in relation to the vertebral levels.

2.4. Statistical analysis

Sociodemographic variables included information on participants' gender (male/female), age (in complete years), and anthropometric data (height and weight). The clinical and functional variables were listed in divisions by groups based on the degrees of scoliotic curves based on the measurement at the Cobb angle, with light curves being those that between 10 and 24°, moderate curves from 25 to 44°, is a moderate curve, severe curves between 45 and 50°. Functional parameters were analyzed based on the results obtained from the Schober and Stibor tests, evaluating mobility and flexibility. To measure strength, the Sorensen test and the Dynamic/Static Abdominal Strength Test were analyzed.

In the descriptive analysis, the meaning with standard deviation will be applied for continuous variables, while categorical variables will be

expressed in proportions. The Shapiro-Wilk test was used to verify the normality of the data (normal distribution). Statistical significance was set $p < 0.05$.

To explore correlations, Pearson's Correlation Coefficient was applied to continuous variables to identify potential associations between the degree of curvature and specific findings. For categorical variables, the chi-square test was used to evaluate associations, such as between gender and degree of scoliosis severity.

For the descriptive and analytical analysis of the data, the Statistical Package for Social Sciences (SPSS) software, version 17.0 for Windows, was used (see Fig. 1).

3. Results

A total of 255 medical records from the database of the *Portal Escoliose Brasil* were analyzed, referring to the care provided at the clinic in Salvador-BA. After excluding incomplete records, postoperative patients, or patients with spinal deviations less than 10° (Cobb angle), the final sample consisted of 157 individuals, aged between 10 and 14 years. Fig. 2 shows the flow chart of the population recruited and selected for this study.

As shown in Table 1, 77.7% of the study population is female. Regarding body mass index (BMI), 57.9% of the participants are underweight, and regarding the degree of severity of the curve, 61.8% of the adolescents have a moderate scoliotic curve.

54 adolescents (34.39%) reported not engaging in physical activities. Among the others, physical activity is performed between 1 and 3 times per week, with various types of activities.

Table 2 shows weak correlations between Stibor's test and the mild ($r = 0.196$; $p = 0.232$) and severe ($r = 0.126$; $p = 0.427$) curves, as well as practically no correlation with moderate ($r = 0.008$; $p = 0.941$). As with the results mentioned above, it was also possible to find a moderate but not significant correlation between the Schober test and mild scoliotic curves ($r = 0.045$; $p = 0.786$), and very weak correlations for moderate ($r = -0.013$; $p = 0.902$) and severe ($r = 0.104$; $p = 0.513$) curves.

As shown in Table 3, the Sorensen test, as well as the abdominal muscle strength test, showed a negative correlation with all degrees of severity of the curve.

Non-significant correlations found in this study may suggest that the clinical tests applied are not correlated with the severity of spinal deformities. Given the population examined in this study, whose vertebral changes may result from various idiopathic factors, subsequent research should focus on comparing clinical test outcomes between patients with scoliosis and asymptomatic control groups.

4. Discussion

In AIS, functional limitations varied according to the type of capacity assessed, with different repercussions on flexibility and muscle strength tests. A trend towards a reduction in spine flexibility was observed as the severity of the curvature increased, especially in mild and moderate curves, while the strength tests showed negative values, with no marked differences between the severity groups.

In line with the literature, this study showed a predominance of females (77.7%) among patients with AIS (Negrini et al., 2018; Liang et al., 2021). To date, there is no single causal factor that explains this higher incidence in women, and the etiology of AIS is widely recognized as multifactorial. Studies, such as the one by Peng et al., indicate that genetic factors, endocrine alterations, may be associated with this predominance (Liang et al., 2021; Peng et al., 2020).

About 67.9% of the study population had a low BMI, a characteristic also found in previous studies. A cross-sectional study conducted in China com about 1,6412 adolescents showed that girls with a low body mass index are 4 times more likely to have scoliosis (Kim et al., 2020). However, the study by Liang et al. (2021), had a sample of 196 compo-

nents, with 12.2% of adolescents with obesity diagnosed with scoliosis. Some hypotheses can be raised for the controversies in the literature between BMI and curve severity, such as food culture and difference in the population of the sample analyzed (Catanzariti et al., 2023).

In the functional analyses of flexibility, the results did not show a statistically significant correlation. Similarly, the Schober test showed little correlations in the mild and severe curves, while the moderate curves showed practically no negative correlation, with no statistical significance being identified in any of the degrees of severity.

The study by Eyvazov et al. (2017), conducted at the University of Hong Kong with 96 adolescents (86 girls and 10 boys) diagnosed with idiopathic scoliosis, investigated the relationship between Cobb's angle and lumbar range of motion by means of flexion and extension radiographs. The results revealed weak and non-significant correlations; however, the authors emphasize that, even in the face of this weak association, flexibility can be affected by the severity of the curvature, due to structural changes and biomechanical imbalances that compromise lumbar mobility in different planes of motion. In addition, it is possible that the different objectives of these measurements explain the weak relationship found, since clinical tests evaluate functional limitations, while the Cobb angle quantifies the structural deformity of the spine (Luo et al., 2023; Balint et al., 2024).

Similarly, the muscle strength tests (Sorensen and abdominal strength) did not show statistically significant correlations with the degree of curvature. Although some negative values indicate a possible tendency to reduce the force in steeper curves, this relationship was not consistently confirmed between the different degrees of severity. Although they do not present statistical significance, these findings suggest that individuals with steeper curves may have lower performance in these tests, indicating a possible influence of the deformity on the bearing capacity and stability of the trunk. Previous studies indicate that idiopathic scoliosis can significantly impact muscle function and physical capacity. Czuprowski et al. (2012) showed a decrease in abdominal FM in patients with moderate scoliosis.

Similarly, Martínez-Llorrens et al. (Martínez-Llorens et al., 2010) found that patients with severe spinal deformity had respiratory muscle and limb function, as well as exercise capacity, below normal limits, compared to healthy individuals. These findings reinforce the idea that the severity of the scoliotic curve can influence muscle and functional performance, even if the statistical correlations are not always significant. Kim (2016) showed that factors such as muscle weakness and postural changes can affect strength tests, even without showing the severity of the curve. In the study by Kuru et al. (2016), they highlight that strengthening the Core muscles can help control the progression of the curve.

This study has limitations, with a cross-sectional design, which makes it difficult to determine the causal relationship. The lack of research on bone maturity and the practice of physical activities may have influenced the results. Another factor to be appreciated is that the data are from only one clinic. However, despite the absence of statistical significance, the indices of flexibility and muscle strength should be linked to postural and functional analysis, resulting from radiological imaging exams for a good clinical evaluation. Thus, it is suggested that future studies be conducted with larger samples and in a longitudinal manner.

This study did not specify the age at which scoliosis was detected, nor the Lenke profile of the patients investigated. Although this is considered a potential limitation of this study, the classification regarding the curvature was not considered, since our main objective was to direct the functional kinetic analysis considering the degree of curvature angulation, whose impact is more significant on mobility limitation than the type of curvature. The stages of Risser were also not highlighted in this study. Even understanding that this information is relevant in comparative clinical studies, for the specific purpose of this observational cohort study, the classification of the Risser stage was not determined as a variable for analysis, so it would not impact the expected outcomes.

Future perspectives from this observational study future research will



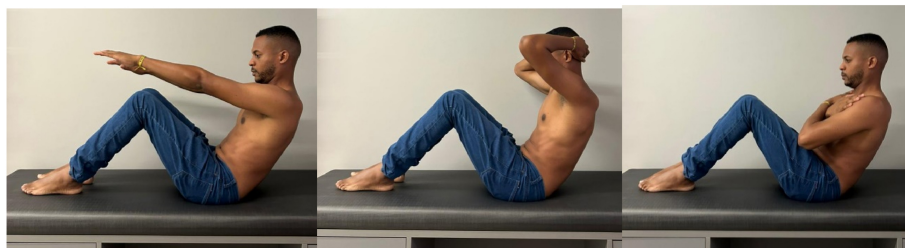
A- Lumbar spine - Schober test



B-Spine - Stibor test.



C- Lumbar extension - Sorensen test



D - Abdominal strength test

Fig. 1. Standardized kinetic-functional tests to assess AIS. A- Lumbar spine - Schober test. B-Spine - Stibor test. C - Lumbar extension - Sorensen test. D - Abdominal strength test.

be developed by this study group to consider the normality index of this population (Healthy adolescents) and enable clinical studies with the inclusion of a control group.

5. Conclusion

The findings of the present study indicate that, although no statistically significant correlations were observed between the groups of

severity of adolescent idiopathic scoliosis and the results of the kinetic-functional tests, there is a clinical trend that associates increased curvature with less flexibility and possible reduction in muscle strength. This lack of significance does not invalidate the importance of the tests, since they allow the identification of functional patterns and compensatory alterations observed, in addition to the radiographic examination, allowing a broader understanding of the biomechanical and postural repercussions of scoliosis, favoring the development and evolution of

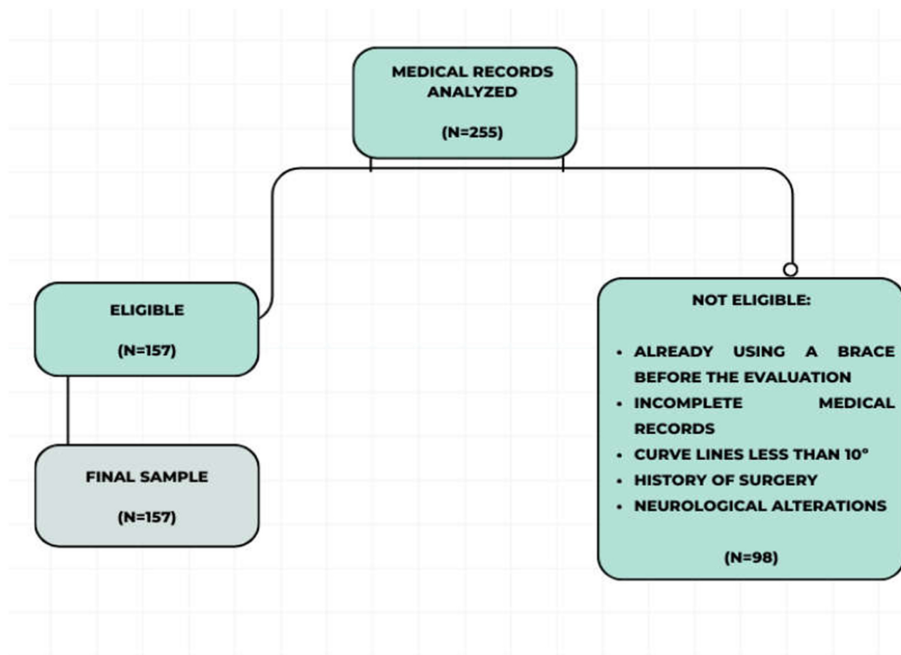


Fig. 2. – Flowchart of the study.

Table 1

Sociodemographic characteristics of patients with adolescent idiopathic scoliosis treated at the specialized clinic “Escoliose Brasil Salvador”, Salvador, Bahia, Brazil, 2025.

Sociodemographic characteristics	N	%
Gender		
Women	122	77,7
Male	35	22,3
BMI		
Underweight	91	57,9
Suitable weight	60	38,2
Overweight	5	3,2
Obesity	1	0,6
Degree of scoliosis		
Lightweight	36	22,9
Moderate	97	61,8
Grave	24	15,3

BMI = Body mass index. % = percentage.

Table 2

Correlation between scoliotic curve severity and spinal flexibility in patients with adolescent idiopathic scoliosis, Salvador, Bahia, Brazil, 2025.

Flexibility Testing	Curve Degree	r (Pearson)	p-value
Stibor	Lightweight	0,196	0,232
	Moderate	0,008	0,941
	Grave	0,126	0,427
Shobber	Lightweight	0,045	0,786
	Moderate	-0,013	0,902
	Grave	0,104	0,513

individualized physical therapy plans. It is recommended that future studies be developed with larger samples and longitudinal designs to deepen the understanding of the relationships between curve progression and functional performance, strengthening evidence on the clinical applicability of these assessment instruments.

Data availability statement

Data from this study are stored with the authors, and data sharing is not available.

Table 3

Correlation between scoliotic curve severity and spine muscle strength in patients with adolescent idiopathic scoliosis, Salvador, Bahia, Brazil, 2025.

Muscle Strength Tests	Curve Degree	r (Pearson)	p-value
Sorensen	Lightweight	-0,007	0,967
	Moderate	-0,009	0,931
	Grave	0,126	0,427
Abdominal Muscle Strength	Lightweight	-0,050	0,769
	Moderate	-0,010	0,922
	Grave	-0,118	0,445

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CRediT authorship contribution statement

Darlan Gonzaga da Silva: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Validation, Writing – original draft. **Lara Galvão Nascimento:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Validation, Writing – original draft. **Beatriz Cerqueira da Silva:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Visualization, Writing – original draft. **Rodrigo Mantelatto Andrade:** Conceptualization, Project administration, Resources, Software, Supervision, Validation, Writing – review & editing. **Laisa Liane Paineiras-Domingos:** Project administration, Supervision, Validation, Visualization, Writing – review & editing. **Paulo Itamar Ferraz Lessa:** Conceptualization, Methodology, Project administration, Resources, Software, Supervision, Validation, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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