“OVIDIUS” UNIVERSITY OF CONSTANTA

DOCTORAL SCHOOL OF MEDICINE

FIELD: MEDICINE

ACADEMIC YEAR 2024 – 2025

DOCTORAL THESIS

MEDICAL REHABILITATION IN PERIPHERAL VESTIBULAR DISORDERS AND IDIOPATHIC SCOLIOSIS IN CHILDREN

ABSTRACT

Doctoral Supervisor: **Prof. Dr. Habil. Elena Danteș**

Advisory Committee: **Prof. Univ. Dr. Habil. Irina Tica**

Prof. Univ. Dr. Habil. Fildan Ariadna Petronela

Assoc. Prof. Univ. Dr. Habil. Irsay Laszlo

Doctoral Candidate: **Liliana Latori (Vlădăreanu)**

INTRODUCTION

Idiopathic scoliosis in children accounts for over 80% of scoliosis cases, with a global incidence of 2–3%. Treatment consists of conservative methods (physical exercises, rigid bracing) or surgical options (spinal fusion, vertebral body tethering), both involving significant economic and psychological costs. In Romania, limited access to treatment outside urban centers and the discontinuation of screening programs since 2017 exacerbate this issue. The doctoral thesis is structured into two parts: a review of the specialized literature, with emphasis on neurodevelopmental etiology and conservative methods, and the personal contribution, which includes three studies: the association of vestibular disorder history with Cobb angle, the relationship between persistent primitive reflexes and scoliosis, and the validation of the SRS-22r questionnaire translation for evaluating patients' quality of life. The conclusions propose the development of a free, validated, and easy-to-apply early screening protocol with national and international applicability.

CURRENT STATE OF KNOWLEDGE

Chapter 1. Idiopathic Scoliosis in Children

1.1.Definition – Scoliosis is a three-dimensional deformation of the spine, regardless of the location of the pathological curve, provided the Cobb angle exceeds 10°. Thus, it is defined by the appearance of a pathological curve in the frontal plane, rotation of the vertebrae within the pathological curve in the transverse plane, and either accentuation or flattening of the physiological curves in the sagittal plane [1–3]. Idiopathic scoliosis (IS), as the name suggests, does not yet have a well-determined cause, and there are currently several etiopathogenic theories, still not fully proven. The most common form of scoliosis is adolescent idiopathic scoliosis, with a global incidence ranging from approximately 2–3% up to 5.2% [4–8]. The average age of onset for adolescent idiopathic scoliosis (AIS) is around 8–9 years for girls and 10–12 years for boys, due to the different timing of puberty onset between the sexes, although forms with earlier onset also exist [4–8].

1.2. Current Etiopathogenic and Morphological Theories

Currently, various theories attempt to explain the pathogenesis of idiopathic scoliosis (IS), including the factors responsible for its onset and progression [9-12]. To better understand the multifactorial pathogenesis of IS, these theories can be classified as follows: the genetic theory, the mesenchymal stem cell theory, the tissue theory, the biomechanical theory of spinal development, the neurological theory, the hormonal theory, the biochemical theory, the environmental and lifestyle theory, and the integrative theory – a more recent approach that attempts to link the aforementioned factors [9-12].1.2.4. Biomechanical Theory of Spinal DevelopmentThe biomechanical hypothesis of idiopathic scoliosis (IS), one of the most accepted and intensively researched, supports the existence of a growth imbalance between the two vertebral columns: the anterior column (formed of spongy bone) and the posterior column (formed of compact bone), with a faster development of the anterior column (RASO – Relative Anterior Spinal Overgrowth). Experimental studies (Murray, Shi, Crijins) have demonstrated that this asymmetric growth can induce spinal curves similar to those in IS, though there were differences regarding whether RASO is a primary or secondary condition [13-15]. Other research (Guo, Will, Brink) has highlighted the differential contribution of ossification types and intervertebral discs in the onset and progression of spinal curves [16-18]. Additionally, complex biomechanical relationships have been explored, such as the influence of rib length differences, muscle asymmetries determined by laterality (Yang), or growth discrepancies between the sternum and the thoracic spine (Chen), all suggesting a multifactorial mechanism in the etiopathogenesis of idiopathic scoliosis [19,20]**.**

***1.2.5. Neurological Theory* -** This hypothesis of secondary adaptation is also supported by functional studies that analyzed brain connectivity, suggesting alterations in neural networks involved in proprioceptive processing and postural balance.

Central Nervous System – The study by Schlösser et al., using functional magnetic resonance imaging (fMRI), identified reduced connectivity between the cerebellum and the posterior parietal cortex, a region involved in integrating sensory information for postural control [21]. Furthermore, multisensory integration dysfunctions in the vestibulo-cerebellar areas were also suggested by research from Chen et al., who demonstrated decreased activity in the nodulus-uvula region in adolescents with IS, correlated with chronic postural imbalance [22]. Along this line of research, the hypothesis of dysfunction in the cerebello-thalamo-cortical axis is gaining increasing clarity, as inadequate functioning of this fine motor control loop may influence the asymmetric neuromuscular development of the trunk during the rapid growth period. Although rare, post-mortem histological studies have shown alterations in the density and organization of Purkinje cells in the medial cerebellar cortex, supporting the neurodevelopmental etiopathogenesis hypothesis [23]. Nevertheless, the lack of robust longitudinal studies and the difficulty in establishing a causal relationship between neuroanatomical abnormalities and the onset of scoliosis warrant cautious interpretation. The question remains open as to whether cerebellar changes are causal, adaptive, or coexistent, with the etiology of idiopathic scoliosis likely being multifactorial, with a complex neuromuscular substrate.

Vestibular System – The distinction between peripheral and central origins of vestibular dysfunction is essential for understanding the etiopathogenesis of idiopathic scoliosis. Supporting a central mechanism, functional neuroimaging studies have shown changes in cortical activity associated with vestibular information processing. For instance, Iwasaki et al. demonstrated through fMRI an atypical activation of the insula and posterior parietal cortex in adolescents with IS during galvanic vestibular stimulation, suggesting altered multisensory integration [24]. Meanwhile, electrophysiological research has revealed increased latency and reduced amplitudes of vestibular evoked myogenic potentials (VEMP) among IS patients, suggesting decreased excitability of the vestibulo-spinal pathway [25]. These findings converge on the hypothesis of a sensory integration defect that could affect postural tone and axial alignment in the long term, particularly during the growth spurt. An important aspect highlighted by several studies is the unilateral or asymmetric nature of these deficits, which may explain the dominant direction of the scoliotic curve (e.g., left or right concavity), depending on the predominant vestibular hypofunction. In this regard, Bohr et al. showed that vestibular system functional abnormalities were significantly correlated with the direction and severity of the Cobb angle, raising the issue of a possible causal relationship [26]. In conclusion, although evidence of the vestibular system's involvement in IS pathogenesis remains contradictory, there are sufficient indications of functional impairment (peripheral, central, or combined) that may contribute to the development and progression of spinal curves. Clarifying this relationship could significantly impact diagnostic and treatment strategies, including the development of early vestibular rehabilitation interventions for preventive purposes.

1.3. Diagnosis of Idiopathic Scoliosis

Patients with idiopathic scoliosis (IS) typically present for specialist evaluation after a postural spinal deformity is noticed by family members or identified during school screening or by a family physician. According to the SOSORT guidelines, the diagnosis is one of exclusion, meaning that neurological and congenital causes must first be ruled out. Once these are excluded, clinical and/or imaging investigations are tailored to the patient's age and the presence of specific clinical signs.

1.3.1. Clinical Diagnosis of Idiopathic Scoliosis

The clinical assessment of idiopathic scoliosis focuses, in the frontal plane, on identifying asymmetries in the shoulders, scapulae, iliac crests, gluteal fold, kneecaps, and other pelvic or lower limb landmarks. In the sagittal plane, the examiner evaluates the physiological curvatures of the spine, head alignment, pelvic positioning, and knee extension. In addition, the symmetry of the paravertebral muscles is examined, along with the presence of a rib hump during the Adam's forward bend test and any spinal axis deviation. These findings help determine the type of scoliosis and whether imaging studies are necessary

The Adam's forward bend test is performed with the patient standing upright and bending forward at the waist. During this maneuver, the examiner inspects the ribcage for the presence of a rib hump, noting its position—whether it appears on the right or left side, and whether it is located in the upper thoracic, thoracolumbar, or lower regions. From the same position, the examiner also observes any lumbar prominence and detects any lateral shift of the pelvis to the right or left [3].

Special Clinical Tests - *The Fukuda stepping test* (also known as the Unterberger test) is the preferred method for evaluating the presence of peripheral vestibular disorders. It can be performed in three different ways:The patient marches in place with eyes closed and arms crossed at the shoulders.The patient marches in place with eyes closed and arms extended at 90° to the trunk.The patient marches in place with eyes closed, forearms flexed, and performs alternating anteroposterior swinging motions with the legs.In all versions, the patient counts silently up to 100 steps. The examiner then measures the anteroposterior displacement and any rotational deviation to the right or left. The test is considered positive if the patient moves more than 50 cm forward or backward and rotates more than 20° laterally [27].

Stabilometry tests are performed by having the patient stand on one foot, both with the entire foot (plantigrade) and on the toes (digitigrade), on each leg. These tests assess the patient's ability to maintain a stable position without using their arms for support. For children older than six, the normal duration for the plantigrade test is 20–30 seconds. The digitigrade duration is expected to be about half of that achieved in the plantigrade position [3].

Testing of residual primitive reflexes is limited to those reflexes related to the motor skills required for trunk control, sitting, crawling, and walking. This testing applies only to older children who have already acquired these motor milestones and who do not present with any neurological symptoms. The results are scored using the Ayres scale, ranging from 0 to 4. A score of 0 indicates full age-appropriate integration of the reflex. A score of 1 means that only one automatic response element is present. A score of 2 reflects two elements, 3 indicates three motor components, and a score of 4 shows a fully present typical reflex response. The reflexes tested include the Moro reflex, the Symmetric Tonic Neck Reflex (STNR), the Asymmetric Tonic Neck Reflex (ATNR), and the Galant Spinal Reflex (GSR) [28, 29].

Instrumental Clinical Tests

The Scoliometer **-** is a standardized instrument, graded from 0° to 20°, used to determine the lateral tilt of a rib hump. However, it is not a device that can replace the standard radiological examination, as the results are not directly comparable. It serves to guide the examiner regarding the clinical progression of the patient and the need for repeating an X-ray.For the examination, the patient is placed in the Adam's forward-bending position, and the goniometer is positioned with its central zone (cut-out) on the spine at the highest point of the rib hump, and the indicated value is read. An angle greater than 5° is considered positive and defines the Adam's test in both standing and seated positions. It evaluates the transverse plane of the spine. A positive progression, meaning an increase in the scoliometric tilt angle, requires the examiner to perform a new X-ray [3].

Platforms for Instrumental Evaluation of Proprioceptive/Vestibular/Gait DeficitsThe Framinal Multi-Equilibre platform is an evaluation and re-education system developed in France in the mid-2000s at the University of Marseille. It uses a suspended platform with motion sensors, connected to software that analyzes the spontaneous motor response for balance after exposure to visual stimuli and/or during cranial box movement.Along with posturographic evaluation, a videonystagmographic assessment is also performed, which records the spontaneous oculomotor response caused by the movement of the otoliths when the patient is seated in a rotating chair. The calculated indices include those previously mentioned, specifically the Romberg index, for all tested situations: eyes open – eyes closed in a fixed and free (unstable) position, with and without concurrent visual stimulus, and eyes open – eyes closed with lateral head movements.The suspended platform does not generate any movements of its own; all recorded movements are those of the tested patient. After the software analyzes the collected patient data, it can generate, in addition to a precise diagnosis—such as hyporeflexia in the left or right ear, areflexia in the left/right ear, etc.—a specific training program designed to reduce the risk of worsening the specific vestibular disorder [30].If the patient wears corrective lenses, the test can be performed with or without glasses.

1.3.2. Imaging Diagnosis of Idiopathic Scoliosis

Imaging currently represents the gold standard for establishing a definitive diagnosis of spinal alignment disorders. It is the evaluation method for which there is universal professional consensus, regardless of the medical specialty to which the patient is referred. At present, the guideline used for imaging analysis of the scoliotic spine is the Radiographic Measurement Manual, developed in 2016 through a consensus by the Scoliosis Research Society (SRS), the Harms Study Group for Scoliosis (HSGS), and the International Society on Scoliosis Orthopedic and Rehabilitation Treatment (SOSORT). The radiographs of the patients in this doctoral study were performed according to the model presented in this manual (https://www.srs.org/Files/Research/Manuals-and-Publications/sdsg-radiographic-measuremnt-manual.pdf).

The Cobb-Webb method - is the reference standard for evaluating spinal deviations in the frontal plane. It determines the Cobb angle, a radiological technique that allows objective quantification of scoliotic curves and is regarded as the gold standard for diagnosing and monitoring scoliosis. The orientation of the curvature, or the scoliosis, is determined by the convexity. According to the Cobb angle value, scoliosis is classified using the Lippman-Cobb system, which is the most commonly used in clinical practice. Scoliosis is classified as Grade I for angles between 10 and 20 degrees, Grade II for angles between 21 and 30 degrees, Grade III for angles between 31 and 50 degrees, Grade IV for angles between 51 and 75 degrees, Grade V for angles between 76 and 100 degrees, Grade VI for angles between 101 and 125 degrees, and Grade VII for angles over 125 degrees.

Musculoskeletal ultrasound - has limited clinical value in scoliosis assessment and is typically used only when there is suspicion of associated acute or subacute muscle injury. The only ultrasound system that evaluates the spine as a whole is Scolioscan, which uses imaging ultrasound. However, this method is not yet considered a complete substitute for standard radiography. It is instead regarded as an intermediate assessment method, used to reduce excessive radiation exposure in scoliotic patients.

1.4. Treatment of Idiopathic Scoliosis

The therapeutic decision in idiopathic scoliosis depends greatly on factors such as the age of onset, the Cobb angle value, the number of pathological curves, the degree of bone maturity as indicated by the Risser index, the location of the main curve, and the rate of progression.There are two main types of treatment.

The *conservative treatment* - which includes scoliosis-specific physical exercises (known in the literature as Physiotherapeutic Scoliosis-Specific Exercise or PSSE) and rigid bracing, referring to the use of rigid cervico-thoraco-lumbo-sacral orthoses.

The surgical treatment - which involves the surgical correction of pathological curves using osteosynthesis materials. The objectives of each type of treatment are described in detail within the body of the thesis.

SPECIAL PART (PERSONAL CONTRIBUTIONS)

Chapter 1. Purpose, Objectives, and Working Hypothesis

1.1. Thesis Motivation - The main motivation of the thesis lies in the need to identify early, accessible, and reproducible functional tools capable of anticipating the risk of developing adolescent idiopathic scoliosis (AIS) before the formation of structural deformity. In the context of a lack of clear etiological markers and the frequent late diagnosis, the work proposes integrating tests for persistent primitive reflexes and peripheral vestibular dysfunctions into the screening protocol. This supports a preventive, multidisciplinary approach that complements classical morphological evaluation and allows for early interventions with potential impact on functional prognosis and therapeutic costs.

***1.2. Thesis Objectives* -** This thesis aims to use two of the previously presented etiopathogenic theories: the biomechanical theory of spinal development and the neurological theory. The latter involves the vestibular system and the theory of automatic motor acquisition (persistent primitive reflexes). The goal is to integrate these two theories—developmental and neurological—into the creation of a more effective treatment plan with better patient adherence in the medium and long term. The thesis also proposes the potential inclusion in the AIS evaluation and monitoring protocols of the following elements:Sensorimotor assessment of peripheral vestibular disorders in static and dynamic vertebral disorders (using clinical tests such as the Fukuda test and/or instrumental assessments on vestibular evaluation platforms like Framiral or standardized stabilometric platforms);Evaluation and integration of sensory-proprioceptive deficiencies in patients with AIS;Assessment of pathologically persistent primitive reflexes and their integration into efficient motor patterns;Evaluation of the quality of life of AIS patients using an internationally validated questionnaire endorsed by professional societies involved in scoliosis diagnosis and treatment.

***1.3. Significance of the Study* -** The study critically analyzes the current limitations of conservative treatment for idiopathic scoliosis (AIS), highlighting its predominantly biomechanical nature, lack of international standardization, and low long-term effectiveness. Internationally recognized methods such as Schroth, SEAS, Rigo, or Dobomed—although validated by guidelines like those of SOSORT or SRS—are based exclusively on biomechanical principles (derotation, elongation, active posturing) without incorporating neurological dimensions or sensory evaluations. The thesis introduces an emerging neurological theory suggesting that peripheral vestibular dysfunctions may play a role in the etiopathogenesis of AIS. In this context, it explores the hypothesis that scoliosis patients are more prone to vestibular dysfunctions than the general population. The vestibular system, involved in vertical perception and spatial orientation, if deficient from early childhood, could negatively influence the axial development of the spine during rapid growth periods. Motion sickness (kinetosis), often present in children with vestibular dysfunctions, is proposed as a potential early predictor of scoliosis risk. Supporting this hypothesis, the use of the Fukuda Step Test (FST)—a simple clinical tool for evaluating vestibular function—is analyzed, with a proposal to correlate its results with motion sickness history and Cobb angle values obtained radiologically.

Chapter 2. Methodology

The data of patients evaluated within the Pediatric Neuropsychomotor Recovery Department of the Techirghiol Balneary and Rehabilitation Sanatorium and at the FizioZone Clinic in Constanța were analyzed in three retrospective observational studies conducted between March 1, 2022, and December 31, 2024. Out of a total of 723 patients examined, only 179 met the inclusion criteria, and among them, 135 consented to standard radiological evaluation, thus being included in the first two studies. The third study was conducted on the entire group of 179 patients with postural spinal disorders.The methodology described below was used for all three studies included in the doctoral thesis.

2.1. Inclusion Criteria - Patients under the age of 19, with a primary diagnosis of spinal disorders, who were able to walk independently and provided written consent for the use of their personal data for scientific purposes were included.

2.2. Exclusion Criteria - Patients over the age of 19, with a history of neurological, genetic, or orthopedic diseases, with assisted walking, or who did not provide written consent for data analysis were excluded.

2.3. Standard Clinical Evaluation - Included the Adam's Forward Bend Test, the finger-to-floor index (IDS), finger-to-finger index (IDD), Fukuda Stepping Test (FST) for vestibular dysfunction, evaluation of primitive reflexes (STNR, ATNR, Galant, Moro) using the Ayres scale (0–4), and single-leg stabilometric testing.
2.4. Standardized Anamnestic Evaluation - Information was collected regarding: personal data, history of motion sickness based on Bárány Society criteria [34], optical corrections, history of crawling, and other relevant pathologies.
2.5. Imaging Evaluation - Standard upright (posteroanterior and lateral) X-rays were performed according to SOSORT guidelines [3], with measurements of the Cobb angle (scoliosis >10°), vertebral rotation (Nash-Moe), bone maturity (Risser), iliac crest asymmetry, and any congenital spinal malformations.
2***.6. Computerized Evaluation on the Framinal Multi-Equilibre Platform*** - Used for vestibular and proprioceptive analysis by calculating the Romberg index (sway area, mm²) under four sensory conditions (OIS, ODS, OII, ODI), and for vestibular diagnosis using videonystagmography, identifying involved canals and sides (uni-/bi-/tricanal).
2.7. Statistical Data Analysis - Performed with IBM SPSS Statistics 25 and Microsoft Excel/Word 2024. Quantitative variables were analyzed using Shapiro-Wilk, Mann-Whitney U, Kruskal-Wallis H, Wilcoxon tests, and Spearman correlations. Qualitative variables were analyzed using Fisher's test. The statistical significance threshold was set at $\alpha = 0.05$

Chapter 3: Study 1 – Peripheral Vestibular Disorders in Idiopathic Scoliosis

3.1. Introduction

Adolescent idiopathic scoliosis (AIS) is a spinal deformity in the frontal plane characterized by a Cobb angle greater than 10°, with no known cause. It typically begins around the ages of 9–10 in girls and 11–12 in boys, and it is the most common form of scoliosis, with a prevalence of 2 to 5.2 percent. Classification is based on the Cobb angle, the location and orientation of the spinal curve, and the age of onset. Treatment options include conservative and surgical approaches, with most mild to moderate cases requiring only conservative management, such as physical therapy and bracing. The most widely accepted physical therapy methods are those following the EFSS model (e.g., Schroth, SEAS), which are based solely on biomechanical principles. These approaches do not incorporate stimulation of antigravity postural reflexes or assessment of oculo-vestibular function, both of which are essential for diagnosing peripheral vestibular syndromes.

3.2. Working Hypothesis / Objectives

A recently proposed but not yet proven neurological hypothesis suggests that peripheral vestibular dysfunctions may be associated with the onset of scoliosis. Patients with AIS may be more predisposed to such dysfunctions compared to the general population. The vestibular system influences spatial orientation, and an inaccurate perception of verticality—if present during early motor development—may contribute to spinal deviations during periods of rapid growth. Motion sickness (kinetosis), often appearing as early as one year of age in the form of dizziness or nausea, is already correlated with vestibular hypersensitivity. This raises the question of whether this symptom could serve as an early predictor of scoliosis and its severity, particularly regarding high Cobb angle values. The Fukuda stepping test (FST), a clinical tool for evaluating vestibular dysfunction, is considered positive if the patient rotates more than 45° during the test. The extent of rotation is correlated with the severity of the dysfunction. Since there is currently no formal link between scoliosis screening and vestibular symptoms, this study aims to investigate whether AIS patients frequently have a history of motion sickness and positive Fukuda test results, and whether there is a relationship between Cobb angle values, history of kinetosis, and FST results.The specific aims of the study are to identify a possible correlation between the Cobb angle and peripheral vestibular dysfunction, to analyze the link between a history of kinetosis and vestibular disorders, to explore the relationships between vestibular test results (such as Romberg and videonystagmography) and the clinical and imaging characteristics of scoliosis, and to statistically assess the demographic and biometric features of the studied group.

3.3. Methodology

3.3.1. Informed Consent - All participants provided informed consent for the scientific use of their medical data. For patients under the age of 16, consent was also signed by their parents or legal guardians. The study was approved by the Ethics Committee under approval number 3739/15.03.2022. Out of 723 patients evaluated between March 2022 and December 2024, a total of 177 minors (106 girls and 61 boys), aged between 7 and 19 years, were selected. These patients were followed in the clinic over an 18-month period for assessment and treatment of spinal disorders.Patients under 19 years old, with a primary diagnosis of a vertebral static disorder, who could walk independently and who provided written consent for the scientific use of their data, were included in the study. Patients over 19, those with neurological, genetic, or orthopedic conditions, those requiring assisted walking, or those who did not provide written consent were excluded.

3.3.2. Clinical assessment - included the Fukuda stepping test, Adam's test, and the finger-to-floor index. The Fukuda test was conducted under controlled conditions with clear instructions given to the patients. It was considered positive if the rotation exceeded 45° or if there was a forward displacement greater than 50 cm. In these cases, patients were referred for instrumental vestibular testing using the Framiral platform, which allowed for the identification of peripheral vestibular syndrome and localization of the affected area.

3.3.4. Medical history - The standard medical history included questions regarding the presence of motion sickness, the need for optical correction, and the patient's past medical history, particularly in relation to the exclusion criteria.

3.3.5. Imaging - was performed using cervico-dorso-lumbar "stitching" radiographs in a standing position, following SOSORT guidelines. The Cobb angle, vertebral rotation (Nash-Moe), bone maturation level (Risser), iliac crest asymmetry, and any bone malformations were evaluated, with only clinically insignificant spina bifida occulta being accepted.

3.3.6. Statistical analysis was performed using IBM SPSS Statistics 25 and Microsoft Excel/Word 2024. Quantitative variables were expressed as means or medians, and their distribution was assessed with the Shapiro-Wilk test. Group differences were analyzed using Fisher's Exact Test, and non-parametric quantitative variables were assessed with the Mann-Whitney U and Kruskal-Wallis H tests. Correlations were measured using Spearman's coefficient, and paired measurements were compared using the Wilcoxon test. To evaluate the predictive value of the Cobb angle in diagnosing peripheral vestibular syndrome, a ROC curve was used. Predictive performance was expressed through the AUC, and the optimal threshold was identified based on Youden's index. The significance level used for the analysis was set at $\alpha = 0.05$.

3.4. Results

The general statistical data of the study group shows that most of the analyzed patients were girls (63%), with a mean age of 13.42 ± 2.83 years and a median age of 13 years. Out of the 177 patients enrolled in this retrospective study, 135 consented to undergo a standard cervico-thoraco-lumbar X-ray, following SOSORT guidelines, to assess the Cobb angle, Nash-Moe classification, and Risser score. The average Cobb angle was 16.14 ± 11.31 degrees, with a median of 12 degrees (range: 10–17). According to the SI classification based on the Cobb angle, 76.27% (135 patients) had scoliosis, with most of them (69.6%) presenting with grade I scoliosis.

The study titled "Peripheral Vestibular Disorders in Idiopathic Scoliosis" explores potential links between adolescent idiopathic scoliosis (AIS) and peripheral vestibular dysfunction (PVD). The working hypothesis suggests that patients with AIS may have a higher likelihood of exhibiting peripheral vestibular dysfunctions, which could point to a partially neurosensory origin for the condition. The study cohort consisted of 177 patients aged between 7 and 19, with a predominance of females (63%). Out of these, 135 underwent imaging to determine the Cobb angle.

The initial mean Cobb angle was 16.14° ± 11.31°, while the final mean angle was 15.31° ± 9.81°, and the difference between them was statistically significant ($p = 0.007$, Wilcoxon test).The comparison of Cobb angle values based on the results of the Fukuda Stepping Test (FST) revealed significant differences. The median initial Cobb angle was 27.5° (interquartile range: 14–34.25) in patients with a positive FST, compared to 12° (interquartile range: 10–15) in those with a negative FST, with a p-value of less than 0.001. The final median Cobb angle was 23.5° (IQR: 10.75–30) in the FST-positive group and 12° (IQR: 10–15) in the FST-negative group, also with a p-value below 0.001.

Regarding the presence of peripheral vestibular syndrome (PVS), the analysis indicated that patients with right-side PVS had a median initial Cobb angle of 18.5° (IQR: 12–31.5), while those with left-side PVS had a median angle of 20° (IQR: 13.5–32.5). In contrast, patients without PVS had a significantly lower median initial Cobb angle of 11.5° (IQR: 9.75–14), with a p-value below 0.001.

The final Cobb angle values were 16° (IQR: 10–25) for right-side PVS, 20° (IQR: 13.5–26) for left-side PVS, and 11° (IQR: 10–14) for those without PVS, again with statistically significant differences ($p < 0.001$).

3.5. Discussion

This section analyzes and interprets the results concerning the relationship between adolescent idiopathic scoliosis (AIS) and peripheral vestibular dysfunctions (PVD). The findings suggest a significant correlation between vestibular dysfunction and scoliosis severity, as measured by the Cobb angle. Patients with a positive Fukuda test displayed significantly higher Cobb angle values both at the beginning and during the evolution of the condition, which may indicate a potential influence of vestibular dysfunction on the development or progression of the scoliotic curve.

Additionally, there was a higher prevalence of motion sickness among patients with severe scoliosis, supporting the hypothesis that a sensitized vestibular system from early childhood might contribute to postural imbalances that, in turn, affect spinal alignment. These findings are reinforced by the positive correlations observed between Romberg test scores and Cobb angle values. The presence of PVD, confirmed by instrumental assessments such as videonystagmography and posturography tests, was associated with higher Cobb angles and more advanced scores in the Nash-Moe and Risser classifications. This suggests a possible influence of vestibular function on vertebral rotation and bone maturation during growth.

Among the limitations of the study are its retrospective nature, the absence of a control group without spinal disorders, and the heterogeneity of patient ages within the sample. Nevertheless, the statistical consistency and the multiple correlations between relevant variables support the validity of the proposed hypotheses.

3.6. Conclusions

The study supports the hypothesis of a significant correlation between peripheral vestibular dysfunction and the severity of scoliosis, observed both during the initial evaluation and at the end of treatment. The integration of vestibular tests such as the Fukuda test, videonystagmography, and the Romberg test into the screening of AIS patients may help identify early those cases with a high risk of severe progression. The conclusions also emphasize the necessity of incorporating vestibular evaluation into the screening and treatment protocols for idiopathic scoliosis. Moreover, the study provides a strong argument in favor of therapeutic approaches that include vestibular reflex stimulation and postural balance training as part of physical therapy.

Chapter 4: Study 2 – Unintegrated Primitive Reflexes – A Possible Predictor for the Onset and Progression of Idiopathic Scoliosis

4.1. Introduction

Idiopathic scoliosis (IS) is defined as a spinal curvature in the frontal plane >10° Cobb angle, associated with vertebral rotation, in the absence of an identifiable structural, neurological, or syndromic cause [1–3]. The most common form is adolescent idiopathic scoliosis (AIS), with a global estimated incidence of 2–5.2% in the 10–19 age group [4–8]. Treatment is conservative for curvatures <45°, including specific scoliosis exercises (SSEs) for curves under 25°, and for angles >30°, flexible or rigid bracing. Curves >45° are eligible for surgical treatment [3].Recent etiopathogenic hypotheses include genetic and neurodevelopmental components, but genetic testing remains limited to specialized centers [9–12]. Primitive reflexes—ATNR, STNR, and GSR—are innate motor responses involved in early motor development [46–49]. Their integration typically occurs by 12 months of age. Persistence in the absence of neurological pathology may suggest neuromotor immaturity, potentially relevant for IS.

4.2. Working Hypothesis

Starting from the observed difficulty of patients with idiopathic scoliosis in maintaining correct derotated postures, this study investigated whether the persistence of primitive reflexes (Moro, ATNR, STNR, GSR) affects active correction capacity. The incidence of unintegrated reflexes, their correlation with Cobb angle and vertebral rotation, and their impact on curve progression were analyzed. The results could support the development of accessible and effective early screening tools.

4.3. Materials and Methods

This prospective observational study was conducted between June 2022 and December 2024, with ethics approval (decisions no. 3739/11.03.2022 and no. 19377/08.12.2022). Written informed consent was obtained from all participants, age-appropriately.Out of 723 patients with vertebral pathology evaluated, 179 (106 girls, 73 boys; aged 7–19) met the inclusion criteria: diagnosed with idiopathic scoliosis, under 19 years of age, and written consent for data use.

Evaluations included clinical examination (Adam's test, IDS, IDD), primitive reflex testing (Moro, ATNR, STNR, GSR) using the Ayres scale [28, 29, 46–49], and stabilometric testing.

Anamnesis focused on motor milestones in the first year of life and optical correction needs.

Imaging included standard radiographs (PA and LL), with analysis of Cobb angle, vertebral rotation (Nash-Moe), bone maturity (Risser), iliac crest asymmetry, and presence of congenital malformations (only spina bifida occulta accepted).

Statistical analysis was performed with SPSS 25 and Excel 2024. Variable distribution was evaluated using the Shapiro-Wilk test. Mann-Whitney, Kruskal-Wallis, and Wilcoxon tests were used for non-parametric quantitative variables; Spearman was used for correlations. Qualitative data were compared using Fisher's Exact Test. Cobb angle's predictive value for vestibular syndrome was evaluated via ROC analysis, with AUC and threshold determined by the Youden Index. The significance threshold was $\alpha = 0.05$.

4.4. Results

All variables analyzed were found to be non-parametric ($p<0.05$, Shapiro-Wilk test). Spearman correlation was used for relationships between primitive reflex scores and radiological scoliosis parameters (Cobb angle, Nash-Moe score).

Initial Cobb angle showed a significant, moderate positive correlation with the Moro reflex score ($R=0.353$, $p<0.001$). This remained significant at final evaluation, though weaker ($R=0.205$, $p=0.017$).

ATNR showed no significant correlation initially ($R=0.139$, $p=0.109$), but a moderate significant correlation with Cobb angle at final evaluation ($R=0.422$, $p<0.001$).

STNR had a weak but significant correlation with Cobb angle both initially ($R=0.202$, $p=0.019$) and at final evaluation ($R=0.213$, $p=0.013$).

GSR had consistent, significant, moderate correlations with Cobb angle initially (R=0.347, p<0.001) and at final evaluation (R=0.375, p<0.001).
Primitive reflex scores also significantly correlated with Nash-Moe scores. Moro reflex correlated positively and significantly with initial (R=0.319, p<0.001) and final Nash-Moe scores (R=0.275, p=0.001). ATNR showed significant positive correlation with Nash-Moe score, initially weak (R=0.211, p=0.014), and moderately strong at final evaluation (R=0.491, p<0.001). STNR had weak but significant correlations both initially (R=0.293, p=0.001) and at final evaluation (R=0.307, p<0.001). GSR had moderate, significant correlations with Nash-Moe score initially (R=0.369, p<0.001) and at final evaluation (R=0.396, p<0.001).
Comparisons of Cobb angle based on crawling acquisition showed no significant differences (initial p=0.351; final p=0.434).
Similarly, Nash-Moe score comparisons related to crawling were not statistically significant (initial p=0.055; final p=0.159).
Cobb angle did not differ significantly based on foot type (initial p=0.393; final p=0.150), although mean Cobb angles were higher in patients with altered foot posture.
Plantar stabilometric testing showed significant differences. Cobb angles were higher in patients with abnormal results, both initially (p<0.001) and at final evaluation (p=0.002).
Digitigrade stabilometry showed similar trends (initial p=0.004; final p=0.040).In Jack's test, initial Cobb angle was higher in patients with a negative result (p=0.048). At final evaluation, the difference approached but did not reach significance (p=0.052).
No significant differences were found in Cobb angle based on curve location (p=0.221) or side (p=1.000) related to Jack's test.

4.5. Discussion

Conservative treatment of idiopathic scoliosis involves specific scoliosis exercises (SSEs) and individualized spinal bracing, following SRS and SOSORT guidelines [3, 50–61]. The 2016 and 2018 guidelines recommend that interventions be initiated by physiotherapists trained in recognized methods under supervision of experienced physicians. In practice, trained specialists are unequally distributed, mostly in large urban centers. Physiotherapist expertise varies significantly by experience, employer, and access to continuing education [62–65].
Adolescent patient compliance poses an additional challenge, particularly due to the discomfort of rigid bracing and the demanding exercise regimens [59–61]. Early identification of scoliosis progression risk is crucial. In this context, primitive reflexes could serve as accessible, non-invasive tools for use in primary care. These are already part of neuromotor assessments in infants and toddlers [28, 29, 46–49, 66–68]. While no studies to date establish a direct link between idiopathic scoliosis and persistent primitive reflexes, literature supports their association with motor coordination disorders and poor postural control [66–68].
The reflexes analyzed in this study – Moro, ATNR, STNR, and GSR – are considered functional developmental markers mediated subcortically and reflect persistence of primary motor patterns. Reflex scores were evaluated with the Ayres scale at baseline and again 12 months later.
Initial hypotheses predicted significant correlations between GSR and ATNR reflexes and scoliotic curves (given their role in frontal and transverse planes). Results showed significant reductions in all four reflex scores, suggesting a favorable therapeutic response. However, Cobb angle progression did not significantly differ between groups based on reflex scores, indicating that while reflex integration improved, it did not directly affect measurable scoliosis progression.
Initial Ayres scores significantly correlated with Cobb angles for Moro (R=0.353, p<0.001), STNR (R=0.202, p=0.019), and GSR (R=0.347, p<0.001), but not ATNR (R=0.139, p=0.109). At final evaluation, all four reflexes showed significant positive correlations with Cobb angle: Moro (R=0.205, p=0.017), STNR (R=0.213, p=0.013), GSR (R=0.375, p<0.001), ATNR (R=0.422, p<0.001).

These findings suggest that persistence of primitive reflexes is associated with higher Cobb angles both at diagnosis and at follow-up. Notably, STNR and Moro—predominantly sagittal reflexes—show similar correlations to those seen with GSR and ATNR, supporting a multiplanar role in postural control.

Crawling was assessed via anamnesis. Children who had gone through a crawling phase had lower ATNR, STNR, and GSR scores, consistent with previous findings (Vlădăreanu et al., Medicina, 2025). However, no significant statistical correlations were observed between crawling and initial/final Cobb or Nash-Moe scores ($p>0.05$).

Reflex testing methods aligned with existing literature. Moro, STNR, ATNR, and GSR assessments followed age-adapted, validated protocols [28, 29, 46–49]. Each reflex's biomechanical characteristics—based on the movement plane involved—highlight their functional utility in assessing scoliosis progression risk.

Overall, these observations support the idea that primitive reflex assessment can provide additional, relevant insights for managing idiopathic scoliosis, without replacing existing diagnostic or monitoring methods. Further studies are needed to determine their predictive value and practical applicability.

4.6. Conclusions

Positive Ayres scores for Moro, ATNR, STNR, and GSR reflexes indicated neuromotor immaturity associated with higher Cobb angles. This suggests that early integration of these reflexes—by age 5 through targeted motor interventions—could offer an opportunity for preventing the development of non-structural spinal curvatures.

Chapter 5: Study 3 – Quality of Life – Using the Validated SRS-22 Questionnaire for Patients with Idiopathic Scoliosis in Romania

5.1 Introduction

Idiopathic scoliosis requires sustained monitoring. For spinal curves greater than 25°, conservative treatment includes SEAS exercises, active posture correction, and rigid bracing for at least 12 hours per day. Psychosocial factors often reduce compliance, which justifies the use of standardized questionnaires like the SRS-22r, recommended by SOSORT and the Scoliosis Research Society (SRS) for assessing quality of life.

5.2 Working Hypothesis / Objectives

Despite Romania's active participation in international societies like SOSORT and EuroSpine, the SRS-22r questionnaire does not yet have an official Romanian translation. To address this gap, the validated English version available on the SRS website was used as a basis for translation and cultural adaptation, following current guideline recommendations. The primary goal of this study was to develop a Romanian version of the SRS-22r that is clinically applicable and facilitates the evaluation of quality of life in patients with idiopathic scoliosis. Additionally, the study explored correlations between questionnaire scores and clinical parameters such as Cobb angle, sex, and age, to support the questionnaire's integration into routine clinical practice in Romania.

5.3 Materials and Methods

All participants gave informed consent for medical procedures and scientific data use. For patients under 16 years old, consent was provided both by the patient and their parent or legal guardian. The study was approved by the ethics committee under approval form no. 3739/15.03.2022.Between March 2022 and December 2024, 723 patients were assessed. Out of these, 179 minors (106 girls and 63 boys, aged between 7 and 19), diagnosed with developmental spinal disorders and capable of independent ambulation, were included in this retrospective observational study.

Inclusion criteria were age under 19, a primary diagnosis of a spinal postural disorder, and written consent.

Clinical evaluation included the Fukuda stepping test, Adam's forward bend test, the fingertip-to-floor index, and the administration of the SRS-22r questionnaire. Medical history data included motion sickness (based on Bárány criteria), type of optical correction, and any exclusionary comorbidities.
Radiographic evaluation was conducted using a cervico-thoraco-lumbar full-spine "stitching" X-ray in standing position, both posteroanterior and lateral views, according to SOSORT guidelines. Measurements included the Cobb angle (considered significant if greater than 10°), vertebral rotation (Nash-Moe scale, grades 0–4), skeletal maturity (Risser scale 0–5), iliac crest asymmetry (in millimeters), and the presence of spinal malformations. Only spina bifida occulta without clinical significance was accepted.
The SRS-22r questionnaire was downloaded from the official SRS website. It was translated into Romanian using a combination of manual translation and automated translation via a licensed large language model (LLM). The two versions were reviewed and compared by three bilingual evaluators experienced in idiopathic scoliosis rehabilitation. The manually translated version was validated, and then back-translated into English using the same software to check fidelity.
The questionnaire consists of 22 items, distributed across five domains: function, pain, self-image, mental health, and treatment satisfaction. Responses are scored from 1 to 5. Although the questions are presented to patients in random order, they are later grouped by the evaluator for domain scoring.
Statistical analysis was conducted using IBM SPSS 25 and Microsoft Excel/Word 2024. The distribution of quantitative variables was tested with the Shapiro-Wilk test. Quantitative variables were reported as means with standard deviations or medians with interquartile ranges. Qualitative variables were presented as frequencies and percentages. Group comparisons were made using Fisher's Exact Test.For non-parametric data, the Mann-Whitney U test, Kruskal-Wallis H test, and Dunn-Bonferroni post-hoc analysis were used. Correlations were assessed using Spearman's rho, and paired comparisons were analyzed using the Wilcoxon signed-rank test. The significance threshold was set at $\alpha = 0.05$.

5.4 Results

5.4.1 Correlation Between Cobb Angle and SRS-22r Scores

The analysis examined the relationship between scoliosis severity and perceived quality of life in adolescents, using initial and final Cobb angle values correlated with scores in each SRS-22r domain. Both variables had non-parametric distributions.
In the Function domain, both initial and final Cobb angles showed strong and statistically significant negative correlations ($R = -0.530$ and $R = -0.539$, $p < 0.001$), indicating that better functional outcomes were associated with less spinal deviation.
For Pain, the relationship was also negative and moderately strong ($R = -0.473$ initially and $R = -0.515$ finally, $p < 0.001$), suggesting that patients with lower Cobb angles reported less pain.
The Self-image domain showed one of the clearest inverse correlations, with $R = -0.608$ initially and $R = -0.607$ finally ($p < 0.001$), indicating that body image perception was particularly sensitive to scoliosis severity.
In the Mental Health domain, correlations were significant but slightly weaker ($R = -0.512$ initially and $R = -0.475$ finally, $p < 0.001$), reflecting a likely psychological impact of spinal deformity.
Treatment Satisfaction scores had moderate negative correlations with Cobb angle ($R = -0.332$ initially and $R = -0.339$ finally, $p < 0.001$).
The total SRS-22r score also showed a significant negative correlation with Cobb angle both at baseline ($R = -0.635$) and follow-up ($R = -0.629$), highlighting a consistent relationship between scoliosis severity and overall patient-reported quality of life.

5.4.2 Gender-Based Differences in SRS-22r Scores

Differences by sex were examined using non-parametric tests. Function domain scores showed a trend toward better results in boys (median 4.8) compared to girls (median 4.4), though not statistically

significant ($p = 0.199$). Pain scores had identical medians (5) in both groups, with no significant differences in means or ranks ($p = 0.364$).
In the Self-image domain, boys had significantly higher scores than girls (median 5 vs. 4.8, $p = 0.024$).
In the Mental Health domain, boys again scored higher (median 5 vs. 4.6, $p < 0.001$).
For Treatment Satisfaction, there were no statistically significant differences between the sexes ($p = 0.243$).
The total SRS-22r score was significantly higher in boys (median 4.77) than in girls (median 4.55), with $p = 0.009$.

5.4.3 Correlation Between Age and SRS-22r Scores

Correlations were calculated using Spearman's rho. Function scores were moderately and negatively correlated with age ($R = -0.426$, $p < 0.001$), indicating that younger patients tended to report better functionality.
Pain scores followed a similar pattern ($R = -0.317$, $p < 0.001$).
Self-image also had a moderate negative correlation with age ($R = -0.337$, $p < 0.001$).
Mental Health scores showed a weak, statistically insignificant correlation with age ($R = -0.128$, $p = 0.138$).
Treatment Satisfaction had a weak but statistically significant negative correlation ($R = -0.218$, $p = 0.011$).
The total SRS-22r score had a moderate negative correlation with age ($R = -0.389$, $p < 0.001$), suggesting that younger patients tended to report better overall quality of life.

5.5 Discussion

The consistent and statistically significant negative correlations between Cobb angle and SRS-22r scores across all domains reflect findings in existing literature that supports early intervention and conservative treatment for idiopathic scoliosis. Lower Cobb angles were associated with better outcomes in function, pain, self-image, mental health, treatment satisfaction, and overall quality of life, regardless of the timing of assessment.
Sex had no significant impact on function or pain perception, which aligns with international data suggesting no consistent association between spinal pain in children and variables such as biological sex, school furniture, or backpack weight. However, boys had significantly better self-image and mental health scores. This is supported by psychological studies indicating that adolescent girls are more affected by body image concerns and social pressures, especially when using visible treatments like braces.
Though satisfaction with treatment did not differ significantly between sexes, boys had higher total SRS-22r scores, which aligns with findings from psychological research indicating that male adolescents tend to report better perceived quality of life across cultures.
The study's urban–rural imbalance limited conclusions about environmental influences, although higher Cobb angles were observed in rural patients.
Age-related findings showed significant negative correlations for function, pain, and self-image, but not for mental health or treatment satisfaction. These results reflect age-related changes in body image perception and the role of social media in reinforcing idealized beauty standards.
The total score also showed a statistically significant negative correlation with age, consistent with the observation that younger patients often had smaller Cobb angles.
A final methodological observation concerns the need for an official Romanian version of the SRS-22r. Although validated in many languages, including Arabic, Chinese, Danish, Japanese, Dutch, Slovenian, and Turkish—and used unofficially in Greek, Hindi, and Thai—there is still no published Romanian version. This gap limits access to standardized assessment tools in national clinical practice.

5.6 Conclusions

The SRS-22r is a globally validated instrument that requires an official Romanian translation to ensure standardized use in assessing quality of life among Romanian patients with idiopathic scoliosis

Chapter 6: General Discussions

Screening programs for adolescent idiopathic scoliosis (AIS) were initiated in Europe at the beginning of the 20th century and later extended to North America. Their goal was early detection and prevention of surgical treatment through early conservative interventions such as physical exercise and bracing [94–99]. After a period of active support, the effectiveness of these programs was questioned between 1990 and 2004, sparking debates within relevant professional societies [94–99]. Starting in the late 2000s, within the broader shift of healthcare systems toward patient-centered models, AIS screening was reappraised as a means of supporting informed choice and minimally invasive treatment [94–99].

In Romania, a national AIS screening program was launched in 2010 through Ministry of Health Order no. 1591/1110/2010, as a partnership between pediatric orthopedic centers and the network of family physicians. Although active until 2014 and administratively maintained until 2017, the program has not been updated since, and Romania currently lacks centralized epidemiological data on AIS. Clinical estimates suggest that 8–9% of newly diagnosed patients already present with Cobb angles >40°.

Access to conservative treatment remains significantly limited due to unequal distribution of specialized personnel, insufficient public funding (20 reimbursed sessions/year), and logistical and psychosocial pressures on patients and families. These barriers often contribute to treatment dropout and curve progression.

In the absence of a validated biomarker, Adam's forward bending test using a scoliometer remains the evaluation standard, though its accuracy is influenced by the examiner's experience. Restarting the screening program, along with the implementation of uniform reporting standards, remains a pressing need, tailored to the current demographic and systemic context.

Study 1 investigated the association between peripheral vestibular dysfunction and the severity of AIS by correlating Cobb angle values with vestibular clinical tests and motion sickness history. Patients with a positive vestibular syndrome (identified via the FST test) had significantly higher Cobb angles both initially and at follow-up compared to those without vestibular involvement, consistent with published literature [58–67]. Higher values in the instrumental Romberg test were also associated with more severe scoliotic curves. The results suggest these parameters may serve as auxiliary tools for early evaluation and personalized conservative treatment, particularly within the EFSS (exercise-based scoliosis treatment) framework.

Study 2 explored the hypothesis of a neurological implication in the pathogenesis of AIS by analyzing the correlation between retained primitive reflexes and Cobb angle values. Retention of the Moro, STNR, and GSR reflexes was significantly associated with scoliosis severity, except for the relationship between ATNR and initial Cobb value. These findings are relevant to a patient's ability to understand and apply EFSS derotation techniques, especially in the context of reduced spontaneous motor activity in adolescents.

Study 3 highlighted the absence of an official Romanian version of the SRS-22r questionnaire, even though the WHO has recommended since 2006 that treatment focus on patient quality of life, not solely the disease itself [100]. The lack of this standardized tool, along with the interruption of the national screening program, contributes to late diagnosis and reduces the ability to integrate the patient's perspective into the treatment plan.

Chapter 7: Conclusions

In the analyzed cohort, patients with a positive history of motion sickness and a positive Fukuda test exhibited higher Cobb angle values. This supports the hypothesis of a correlation between peripheral vestibular disorders and AIS severity. Given that motion sickness typically begins between the ages of 1–2, while scoliosis is usually diagnosed clinically around 9–12 years, early identification of these vestibular symptoms could help in detecting children at risk of axial deviation.

Examination of unintegrated primitive reflexes revealed a positive correlation between initial Ayres scores for the Moro, STNR, and GSR reflexes and the Cobb angle at diagnosis, suggesting a possible neuromotor vulnerability associated with curve severity. In contrast, ATNR did not show such a correlation, possibly indicating a lesser role in scoliosis pathogenesis or limitations in assessment at this age. Practicing quadrupedal locomotion in early childhood was associated with significantly lower Ayres scores, suggesting a protective effect of early motor development. A general decrease in Ayres scores during conservative therapy points to a potential positive influence of reflex integration interventions. Patients with low adherence to these programs had worse outcomes, including accelerated curve progression.

Testing primitive reflexes between ages 3–8 is simple, low-cost, and can be integrated into rehabilitation and physical education programs. Alongside the evaluation of quadrupedal history and family history of scoliosis, it may contribute to more effective screening in pediatric populations. The development of functional, non-invasive, and reproducible risk factors for scoliosis screening is therefore warranted.

The Romanian-translated and applied SRS-22r questionnaire revealed an inverse relationship between curve severity and scores across all quality-of-life domains. Adolescents with curves under 20° scored better in physical function, body image, and emotional balance. Girls reported more negative body image and greater emotional fragility than boys, even though physical function and pain levels were comparable. Older age was associated with lower scores for function and self-image, reinforcing the importance of early intervention not only biomechanically but also psychosocially. The lack of an officially validated Romanian version of the SRS-22r is a barrier to its systematic application. Completing its validation process is essential for clinical integration and international comparability.

The data suggests that early vestibular testing and motion sickness screening may be useful tools for identifying children at higher risk for axial deviations. Early introduction of specific exercises (oculo-vestibular, anti-gravity) into preschool physical routines could contribute to postural stabilization and reduce the risk of scoliosis progression. Educating parents, pediatricians, and family physicians about the clinical significance of these early functional signs can shorten the interval between symptom onset and initiation of conservative treatment.

Study limitations include the minimum inclusion age (seven years), which does not allow investigation of primitive reflexes during the critical period of neuromotor development (2–3 years), and the small number of qualified evaluators for reflex testing and scoliosis therapy implementation. These constraints affected sample size and result generalizability. Expanding the research in a multicenter setting, with training of more specialists in neuromotor evaluation and conservative treatment, is needed to validate the hypotheses and develop standardized protocols for early AIS screening.

Chapter 8: Originality and Innovative Contributions of the Thesis

The thesis proposes an original approach to adolescent idiopathic scoliosis (AIS) screening by integrating the evaluation of primitive reflexes and vestibular function into the early detection algorithm. Persistence of primitive reflexes (ATNR, STNR, Galant) is analyzed as a potential marker of neurological immaturity, associated with postural imbalance and increased risk of scoliosis progression.

In parallel, vestibular function is assessed through simple tests (Fukuda, static/dynamic balance), revealing a correlation between vestibular dysfunctions and scoliosis curve severity. These observations suggest that integrating neuromotor and vestibular evaluation into screening practice could enhance diagnostic accuracy and allow early intervention.

The methodology is feasible, non-invasive, and adaptable to various clinical contexts, including school medicine and pediatric primary care. Early therapeutic interventions are proposed, focused on neuromotor reeducation and vestibular rehabilitation, as supportive measures in preventing curve progression.

The thesis also incorporates a dimension related to quality-of-life evaluation (SRS-22r), emphasizing the need for validating this tool in Romanian for standardized clinical use.

Through its interdisciplinary, patient-centered approach, the thesis offers a pragmatic direction for optimizing AIS screening and conservative management strategies, with immediate clinical relevance.

BIBLIOGRAPHY

1. Weinstein, Stuart L. "Advances in the Diagnosis and Management of Adolescent Idiopathic Scoliosis." *Journal of Pediatric Orthopaedics* 14, no. 5 (1994): 561–563. https://doi.org/10.1097/01241398-199409000-00001.
2. Weinstein, Stuart L.; Lori A. Dolan, Jack C.Y. Cheng, Aina J. Danielsson, and Jose A. Morcuende. "Adolescent Idiopathic Scoliosis." *The Lancet* 371, no. 9623 (2008): 1527–1537. https://doi.org/10.1016/S0140-6736(08)60658-3.
3. Negrini, Stefano, Sabrina Donzelli, Angelo Gabriele Aulisa, Daniel Czaprowski, Sabrina Schreiber, Jean Claude de Mauroy, Hans Diers, Theodoros B. Grivas, Peter Knott, Tomasz Kotwicki, et al. "2016 SOSORT Guidelines: Orthopaedic and Rehabilitation Treatment of Idiopathic Scoliosis during Growth." *Scoliosis and Spinal Disorders* 13, no. 3 (2018): 1–48. https://doi.org/10.1186/s13013-017-0185-2.
4. Konieczny, Marek R.; Hakan Senyurt, and Rüdiger Krauspe. "Epidemiology of Adolescent Idiopathic Scoliosis." *Journal of Children's Orthopaedics* 7, no. 1 (2013): 3–9. https://doi.org/10.1007/s11832-012-0457-4.
5. Singh, H.; Shipra Sharma, Vikas Sharma, Ishan Sharma, Aarti Modeel, Nikhil Gupta, Geeta Gupta, Anil K. Pandita, Mir F. Butt, Rohit Sharma, Sumeet Pandita, Vijay Singh, Ekta Rai, Shinji Ikegawa, and Sanjay Sharma. "The First Study of Epidemiology of Adolescent Idiopathic Scoliosis Shows Lower Prevalence in Females of Jammu and Kashmir, India." *American Journal of Translational Research* 14, no. 2 (2022): 1100–1106. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8902575/.
6. de Souza, Francisco Ivan, Rúbia Barros Di Ferreira, Daniela Labres, Rodrigo Elias, Adriana Paula de Sousa, and Renata Epifania Pereira. "Epidemiology of Adolescent Idiopathic Scoliosis in Students of the Public Schools in Goiânia-GO." *Acta Ortopédica Brasileira* 21, no. 4 (2013): 223–225. https://doi.org/10.1590/S1413-78522013000400008.
7. Zheng, Ying, Yan Dang, Xijuan Wu, Yang Yang, Jan D. Reinhardt, Chuntao He, and Martin Wong. "Epidemiological Study of Adolescent Idiopathic Scoliosis in Eastern China." *Journal of Rehabilitation Medicine* 49, no. 6 (2017): 512–519. https://doi.org/10.2340/16501977-2240.
8. Huang, Jie, Xiaoyan Zhou, Xiaolong Li, Hongwei Guo, Yan Yang, In On Hong Cheong, Qian Du, and Hui Wang. "Regional Disparity in Epidemiological Characteristics of Adolescent Scoliosis in China: Data from a Screening Program." *Frontiers in Public Health* 10 (2022): 935040. https://doi.org/10.3389/fpubh.2022.935040.
9. Peng, Yao, Sheng-Rong Wang, Guo-Xin Qiu, Jing-Gang Zhang, and Qi-Yong Zhuang. "Research Progress on the Etiology and Pathogenesis of Adolescent Idiopathic Scoliosis." Chinese Medical Journal 133, no. 4 (2020): 483–493. https://doi.org/10.1097/CM9.0000000000000652.
10. Zaydman, Alexander M.; Elena L. Strokova, Natalia Y. Pahomova, Andrey F. Gusev, Mikhail V. Mikhaylovskiy, Anna I. Shevchenko, Mikhail N. Zaidman, Alexey R. Shilo, and Vladimir M. Subbotin. "Etiopathogenesis of Adolescent Idiopathic Scoliosis: Review of the Literature and New Epigenetic Hypothesis on Altered Neural Crest Cells Migration in Early Embryogenesis as the Key Event." Medical Hypotheses 151 (2021): 110585. https://doi.org/10.1016/j.mehy.2021.110585.
11. Pérez-Machado, Guillermo, Eva Berenguer-Pascual, Marta Bovea-Marco, Patricia A. Rubio-Belmar, Estefanía García-López, María J. Garzón, Silvia Mena-Mollá, Francisco V. Pallardó, Teresa Bas, Juan R. Viña, and José L. García-Giménez. "From Genetics to Epigenetics to Unravel the Etiology of Adolescent Idiopathic Scoliosis." Bone 140 (2020): 115563. https://doi.org/10.1016/j.bone.2020.115563.
12. Burwell, R. Geoffrey. "Aetiology of Idiopathic Scoliosis: Current Concepts." Pediatric Rehabilitation 6, no. 3–4 (2003): 137–170. https://doi.org/10.1080/13638490310001642757.

13. Murray, David W.; and Christopher J. Bulstrode. "The Development of Adolescent Idiopathic Scoliosis." European Spine Journal 5, no. 4 (1996): 251–257. https://doi.org/10.1007/bf00301328.
14. Shi, Lin, Deqing Wang, Matthew Driscoll, Isabelle Villemure, Winnie C.W. Chu, Jack C.Y. Cheng, et al. "Biomechanical Analysis and Modeling of Different Vertebral Growth Patterns in Adolescent Idiopathic Scoliosis and Healthy Subjects." Scoliosis 6, no. 1 (2011): 11. https://doi.org/10.1186/1748-7161-6-11.
15. Crijins, Tom J.; Anco Stadhouder, Theodoor H. Smit. "Restrained Differential Growth: The Initiating Event of Adolescent Idiopathic Scoliosis?" Spine 42, no. 12 (2017): E726–E732. https://doi.org/10.1097/brs.0000000000001946.
16. Guo, Xinyan, Wai-Wai Chau, Ying-Ling Chan, Jack C.Y. Cheng, R. Geoffrey Burwell, Peter H. Dangerfield. "Relative Anterior Spinal Overgrowth in Adolescent Idiopathic Scoliosis – Result of Disproportionate Endochondral-Membranous Bone Growth? Summary of an Electronic Focus Group Debate of the IBSE." European Spine Journal 14, no. 9 (2005): 862–873. https://doi.org/10.1007/s00586-005-1002-7.
17. Will, Rachel E.; Ian A.F. Stokes, Xin Qiu, Michael R. Walker, John O. Sanders. "Cobb Angle Progression in Adolescent Scoliosis Begins at the Intervertebral Disc." Spine 34, no. 25 (2009): 2782–2786. https://doi.org/10.1097/BRS.0b013e3181c11853.
18. Brink, R.C.; T.P.C. Schlosser, D. Colo, L. Vavruch, M. van Stralen, K.L. Vincken, et al. "Anterior Spinal Overgrowth Is the Result of the Scoliotic Mechanism and Is Located in the Disc." Spine 42, no. 10 (2017): 818–822. https://doi.org/10.1097/brs.0000000000001919.
19. Yang, Zhi-De, and Min Li. "There May Be a Same Mechanism of the Left-Right Handedness and Left-Right Convex Curve Pattern of Adolescent Idiopathic Scoliosis." Medical Hypotheses 76, no. 2 (2011): 274–276. https://doi.org/10.1016/j.mehy.2010.10.021.
20. Chen, Bo, Qing Tan, Hui Chen, Fang Luo, Meng Xu, Jian Zhao, et al. "Imbalanced Development of Anterior and Posterior Thorax Is a Causative Factor Triggering Scoliosis." Journal of Orthopaedic Translation 17 (2019): 103–111.
21. Byl, Nancy N.; Sharon Holland, Angela Jurek, Stanley S. Hu. "Postural Imbalance and Vibratory Sensitivity in Patients with Idiopathic Scoliosis: Implications for Treatment." Journal of Orthopaedic & Sports Physical Therapy 26, no. 2 (1997): 60–68. https://doi.org/10.2519/jospt.1997.26.2.60.
22. Zeng, Wei, Lok Man Lui, Lin Shi, Deqing Wang, Winnie C.W. Chu, Jack C.Y. Cheng, et al. "Shape Analysis of Vestibular Systems in Adolescent Idiopathic Scoliosis Using Geodesic Spectra." Medical Image Computing and Computer-Assisted Intervention 13 (2010): 538–546. https://doi.org/10.1007/978-3-642-15711-0_67.
23. Catanzariti, Jean-François, Olivier Agnani, Michel A. Guyot, Sophie Wlodyka-Demaille, Hocine Khenioui, and Christian Donze. "Does Adolescent Idiopathic Scoliosis Relate to Vestibular Disorders? A Systematic Review." Annals of Physical and Rehabilitation Medicine 57, no. 7–8 (2014): 465–479. https://doi.org/10.1016/j.rehab.2014.04.003.
24. Man, Gregory C.W.; Wai W. Wang, Alvin P.Y. Yim, Jenny H. Wong, T.B. Ng, T.P. Lam, et al. "A Review of Pinealectomy-Induced Melatonin-Deficient Animal Models for the Study of Etiopathogenesis of Adolescent Idiopathic Scoliosis." International Journal of Molecular Sciences 15, no. 9 (2014): 16484–16499. https://doi.org/10.3390/ijms150916484.
25. Pinchuk, D.Y.; S.S. Bekshaev, S.A. Bumakova, M.G. Dudin, O.D. Pinchuk. "Bioelectric Activity in the Suprachiasmatic Nucleus-Pineal Gland System in Children with Adolescent Idiopathic Scoliosis." ISRN Orthopedics 2012 (2012): 987095. https://doi.org/10.5402/2012/987095.
26. Yim, Alvin P.Y.; Hung Y. Yeung, Guangming Sun, Kin Man Lee, T.B. Ng, T.P. Lam, et al. "Abnormal Skeletal Growth in Adolescent Idiopathic Scoliosis Is Associated with Abnormal Quantitative Expression of Melatonin Receptor, MT2." International Journal of Molecular Sciences 14, no. 3 (2013): 6345–6358. https://doi.org/10.3390/ijms14036345.
27. Fukuda, T. "The Stepping Test: Two Phases of the Labyrinthine Reflex." Acta Otolaryngologica 50, no. 2 (1959): 95–108. https://doi.org/10.3109/00016485909129172.
28. Zafeiriou, D.I. "Primitive Reflexes and Postural Reactions in the Neurodevelopmental Examination." Pediatric Neurology 31, no. 1 (2004): 1–8. https://doi.org/10.1016/j.pediatrneurol.2004.01.012.
29. Maciak, M.; K. Koszela, A. Beniuk, and M. Woldańska-Okońska. "The Assessment of Postural-Motor, Coordination, and Reflex Functions in Children and Adolescents with a History of Premature Verticalization and Ontogeny Disorders in Their First Year of Life." Children (Basel) 11, no. 9 (2024): 1071. https://doi.org/10.3390/children11091071.
30. Ghulyan, V.; M. Paolino, C. Lopez, M. Dumitrescu, and M. Lacour. "A New Translational Platform for Evaluating Aging or Pathology-Related Postural Disorders." Acta Oto-Laryngologica 125, no. 6 (2005): 607–617.
31. Briggs, Andrew, Tim Wrigley, Elaine Tully, Peter Adams, Alison Greig, and Kim Bennell. "Radiographic Measures of Thoracic Kyphosis in Osteoporosis: Cobb and Vertebral Centroid Angles." Skeletal Radiology 36, no. 8 (2007): 761–767. https://doi.org/10.1007/s00256-007-0302-9.

32. Risser, Joseph C. "The Iliac Apophysis: An Invaluable Sign in the Management of Scoliosis." Clinical Orthopaedics and Related Research 11 (1958): 111–119.
33. James, J.I. "Idiopathic Scoliosis: The Prognosis, Diagnosis and Operative Indications Related to Curve Patterns and the Age at Onset." Journal of Bone and Joint Surgery.
34. Knott, Peter, Ellen Pappo, Mary Cameron, Jean DeMauroy, Charles Rivard, Tomasz Kotwicki, Fabio Zaina, Jane Wynne, Lisa Stikeleather, James Bettany-Saltikov, Thomas B. Grivas, Jan Durmala, Tetsuro Maruyama, Stefano Negrini, John P. O'Brien, Manuel Rigo. "SOSORT 2012 Consensus Paper: Reducing X-ray Exposure in Pediatric Patients with Scoliosis." Scoliosis 9, no. 4 (2014): 1–7. https://doi.org/10.1186/1748-7161-9-4.
35. Zeng, Wei, Lok Man Lui, Lin Shi, Deqing Wang, Winnie C.W. Chu, Jack C.Y. Cheng, et al. "Shape Analysis of Vestibular Systems in Adolescent Idiopathic Scoliosis Using Geodesic Spectra." Medical Image Computing and Computer-Assisted Intervention 13 (2010): 538–546. https://doi.org/10.1007/978-3-642-15711-0_67.
36. Catanzariti, Jean-François, Olivier Agnani, Michel A. Guyot, Sophie Wlodyka-Demaille, Hocine Khenioui, and Christian Donze. "Does Adolescent Idiopathic Scoliosis Relate to Vestibular Disorders? A Systematic Review." Annals of Physical and Rehabilitation Medicine 57, no. 7–8 (2014): 465–479. https://doi.org/10.1016/j.rehab.2014.04.003.
37. Hitier, Martin, Mélanie Hamon, Philippe Denise, Julie Lacoudre, Marie-Anne Thenint, Jean-François Mallet, et al. "Lateral Semicircular Canal Asymmetry in Idiopathic Scoliosis: An Early Link between Biomechanical, Hormonal and Neurosensory Theories?" PLoS One 10, no. 7 (2015): e0131120. https://doi.org/10.1371/journal.pone.0131120.
38. Antoniadou, Niki, Vassilia Hatzitaki, Stavros Stavridis, and Elias Samoladas. "Verticality Perception Reveals a Vestibular Deficit in Adolescents with Idiopathic Scoliosis." Experimental Brain Research 236, no. 6 (2018): 1725–1734. https://doi.org/10.1007/s00221-018-5256-9.
39. Scheyerer, Matthias J.; Andreas Rohde, Klaus J. Stuermer, Hans D. Kluenter, Jens Bredow, Spyridon Oikonomidis, Johannes P. Klußmann, Peer Eysel, and Kirsten Eysel-Gosepath. "Impact of the Vestibular System on the Formation and Progression to Idiopathic Scoliosis: A Review of Literature." Asian Spine Journal 15, no. 5 (2021): 701–707. https://doi.org/10.31616/asj.2020.0308.
40. Hawasli, Ammar H.; Timothy E. Hullar, and Ian G. Dorward. "Idiopathic Scoliosis and the Vestibular System." European Spine Journal 24, no. 2 (2015): 227–233. https://doi.org/10.1007/s00586-014-3701-4.
41. Le Berre, Marie, Michel A. Guyot, Olivier Agnani, Isabelle Bourdeauducq, Marie C. Versyp, Christian Donze, Anne Thévenon, and Jean-François Catanzariti. "Clinical Balance Tests, Proprioceptive System and Adolescent Idiopathic Scoliosis." European Spine Journal 26, no. 6 (2017): 1638–1644. https://doi.org/10.1007/s00586-016-4802-z.
42. Assaiante, Christine, Sylvie Mallau, Jean-Luc Jouve, Georges Bollini, and Michel Vaugoyeau. "Do Adolescent Idiopathic Scoliosis (AIS) Neglect Proprioceptive Information in Sensory Integration of Postural Control?" PLoS One 7, no. 7 (2012): e40646. https://doi.org/10.1371/journal.pone.0040646.
43. Lambert, Fabrice M.; Dominique Malinvaud, Jérémie Glaunès, Christel Bergot, Hans Straka, and Pierre-Paul Vidal. "Vestibular Asymmetry as the Cause of Idiopathic Scoliosis: A Possible Answer from Xenopus." Journal of Neuroscience 29, no. 40 (2009): 12477–12483. https://doi.org/10.1523/JNEUROSCI.2583-09.2009.
44. Surowińska, Justyna, Magdalena Sobieska, and Ewa Gajewska. "Qualitative Assessment in the Third Month of Life Allows for a Better Prognosis of the Achievement of Motor Milestones Versus Assessment of Pathological Reflexes—Prospective Studies on Polish Children." Frontiers in Public Health 11 (2023): 1253137. https://doi.org/10.3389/fpubh.2023.1253137.
45. Cha, Y.H.; J.F. Golding, B. Keshavarz, J. Furman, J.S. Kim, J.A. Lopez-Escamez, M. Magnusson, B.J. Yates, B.D. Lawson, et al. "Motion Sickness Diagnostic Criteria: Consensus Document of the Classification Committee of the Bárány Society." Journal of Vestibular Research 31, no. 5 (2021): 327–344. https://doi.org/10.3233/VES-200005.
46. Gieysztor, Elzbieta Z.; Aleksandra M. Choińska, and Magdalena Paprocka-Borowicz. "Persistence of Primitive Reflexes and Associated Motor Problems in Healthy Preschool Children." Archives of Medical Science 14, no. 1 (2018): 167–173. https://doi.org/10.5114/aoms.2016.60503.
47. McWhirter, K.; A. Steel, and J. Adams. "The Association Between Learning Disorders, Motor Function, and Primitive Reflexes in Pre-school Children: A Systematic Review." Journal of Child Health Care 28, no. 2 (2024): 402–428. https://doi.org/10.1177/13674935221114187.
48. Zafeiriou, D.I.; I.G. Tsikoulas, and G.M. Kremenopoulos. "Prospective Follow-up of Primitive Reflex Profiles in High-risk Infants: Clues to an Early Diagnosis of Cerebral Palsy." Pediatric Neurology 13, no. 2 (1995): 148–152. https://doi.org/10.1016/0887-8994(95)00143-4.
49. Surowińska, Justyna, Magdalena Sobieska, and Ewa Gajewska. "Qualitative Assessment in the Third Month of Life Allows for a Better Prognosis of the Achievement of Motor Milestones Versus Assessment of Pathological Reflexes—Prospective Studies on Polish Children." Frontiers in Public Health 11 (2023): 1253137. https://doi.org/10.3389/fpubh.2023.1253137.
50. Negrini, Stefano, Angelo G. Aulisa, Petr Cerny, Jean-Claude de Mauroy, James McAviney, Andrew Mills, Sabrina Donzelli, Thomas B. Grivas, Michael T. Hresko, Tomasz Kotwicki, Hubert Labelle, Louis Marcotte, Matthew Matthews, John O'Brien, E. Casey Parent, Nancy Price, Riccardo Manuel, Lori Stikeleather, Michael G. Vitale, Man Sang Wong, Gary Wood, Jane Wynne, Fabio Zaina, Maristella Bruno, Silke B. Würsching, Cigdem Yilgor, Patrick Cahill, Eva Dema, Peter Knott, Alain Lebel, Greg Lein, Peter O. Newton, Brian G. Smith. "The Classification of

Scoliosis Braces Developed by SOSORT with SRS, ISPO, and POSNA and Approved by ESPRM." European Spine Journal 31, no. 4 (2022): 980–989. https://doi.org/10.1007/s00586-022-07131-z.
51. den Boer, W.A.; P.G. Anderson, J. van Limbeek, M.A. Kooijman. "Treatment of Idiopathic Scoliosis with Side-Shift Therapy: An Initial Comparison with a Brace Treatment Historical Cohort." European Spine Journal 8, no. 5 (1999): 406–410. https://doi.org/10.1007/s005860050195.
52. Landauer, Florian, Klaus Trieb. "Scoliosis: Brace Treatment – from the Past 50 Years to the Future." Medicine (Baltimore) 101, no. 37 (2022): e30556. https://doi.org/10.1097/MD.0000000000030556.
53. Del Prete, Carmen M.; Daniele Tarantino, Marco G. Viva, Massimo Murgia, Davide Vergati, Giorgio Barassi, et al. "Spinal Orthosis in Adolescent Idiopathic Scoliosis: An Overview of the Braces Provided by the National Health Service in Italy." Medicina (Kaunas) 60, no. 1 (2023): 3. https://doi.org/10.3390/medicina60010003.
54. Negrini, Stefano, Silvia Minozzi, James Bettany-Saltikov, Nachiappan Chockalingam, Thomas B. Grivas, Tomasz Kotwicki, et al. "Braces for Idiopathic Scoliosis in Adolescents." Cochrane Database of Systematic Reviews 2015, no. 6 (2015): CD006850. https://doi.org/10.1002/14651858.CD006850.pub3.
55. Maruyama, Tetsuro, Kazuo Takeshita. "Surgery for Idiopathic Scoliosis: Currently Applied Techniques." Clinical Medicine: Pediatrics 3 (2009): 43–48. https://doi.org/10.4137/CMPed.S3235.
56. Maruyama, Tetsuro, Kazuo Takeshita. "Surgical Treatment of Scoliosis: A Review of Techniques Currently Applied." Scoliosis 3 (2008): 6. https://doi.org/10.1186/1748-7161-3-6.
57. Tambe, Amol D.; Shyam J. Panikkar, Paul A. Millner, Athanasios I. Tsirikos. "Current Concepts in the Surgical Management of Adolescent Idiopathic Scoliosis." Bone & Joint Journal 100-B, no. 4 (2018): 415–424. https://doi.org/10.1302/0301-620X.100B4.BJJ-2017-0846.R2.
58. Cheung, Zoe B.; Stephen Selverian, Brian H. Cho, Christopher J. Ball, Samuel Kang-Wook Cho. "Idiopathic Scoliosis in Children and Adolescents: Emerging Techniques in Surgical Treatment." World Neurosurgery 130 (2019): e737–e742. https://doi.org/10.1016/j.wneu.2019.06.059.
59. Cordani, Chiara, Lorenzo Malisano, Federico Febbo, Giovanni Giranio, Maria J. Del Furia, Sabrina Donzelli, Stefano Negrini. "Influence of Specific Interventions on Bracing Compliance in Adolescents with Idiopathic Scoliosis—A Systematic Review of Papers Including Sensors' Monitoring." Sensors (Basel) 23, no. 17 (2023): 7660. https://doi.org/10.3390/s23177660.
60. Fregna, Giulia, Stefano Rossi Raccagni, Alessandra Negrini, Fabio Zaina, Stefano Negrini. "Personal and Clinical Determinants of Brace-Wearing Time in Adolescents with Idiopathic Scoliosis." Sensors (Basel) 24, no. 1 (2023): 116. https://doi.org/10.3390/s24010116.
61. Liu, Siqing, Li-Ying Ho, Behnam Hassan Beygi, Man Sang Wong. "Effectiveness of Orthotic Treatment on Clinical Outcomes of the Patients with Adolescent Idiopathic Scoliosis Under Different Wearing Compliance Levels: A Systematic Review." JBJS Reviews 11, no. 10 (2023): e23.00110. https://doi.org/10.2106/JBJS.RVW.23.00110.
62. Black, Deborah A.J.; C. Pilcher, S. Drake, E. Maude, D. Glynn. "Current Knowledge of Scoliosis in Physiotherapy Students Trained in the United Kingdom." Scoliosis and Spinal Disorders 12, no. 34 (2017): 1–9. https://doi.org/10.1186/s13013-017-0141-z.
63. Linhares, N.A.; J.C. Barbosa, P.J. Penha, R.M. Andrade, A.P. Ribeiro, M.O. Magalhães. "The Impact of Training Time on Understanding the Treatment of Adolescent Idiopathic Scoliosis According to SOSORT International Guidelines: An Online Survey Study." Children (Basel) 9, no. 11 (2022): 1673. https://doi.org/10.3390/children9111673.
64. du Toit, Anita, Nthabiseng Tawa, Diana C. Leibbrandt, James Bettany-Saltikov, Quinette A. Louw. "Current Knowledge of Idiopathic Scoliosis Among Practising Physiotherapists in South Africa." South African Journal of Physiotherapy 76, no. 1 (2020): 1500. https://doi.org/10.4102/sajp.v76i1.1500.
65. Wójcik, Patrycja, Anna Wójcik, Paulina Ewertowska, and Dariusz Czaprowski. "Physiotherapists' Knowledge About the Diagnosis, Treatment and Physical Activity of Patients with Idiopathic Scoliosis." Frontiers in Medicine (Lausanne) 11 (2024): 1414709. https://doi.org/10.3389/fmed.2024.1414709.
66. Yamawaki, Ryosuke, Yu Oda, Shunsuke Yamane, Kazuhiro Uotani, Hiroshi Misawa, Shinya Katayama, Masahiro Hamada, Toshihiko Ozaki. "Factors Affecting Dynamic Postural Control Ability in Adolescent Idiopathic Scoliosis." Acta Medica Okayama 78, no. 5 (2024): 357–362. https://doi.org/10.18926/AMO/67655.
67. Le Berre, Marie, Michel A. Guyot, Olivier Agnani, Isabelle Bourdeauducq, Marie C. Versyp, Christian Donze, Anne Thévenon, Jean-François Catanzariti. "Clinical Balance Tests, Proprioceptive System and Adolescent Idiopathic Scoliosis." European Spine Journal 26, no. 6 (2017): 1638–1644. https://doi.org/10.1007/s00586-016-4802-z.
68. Assaiante, Christine, Sylvie Mallau, Jean-Luc Jouve, Georges Bollini, Michel Vaugoyeau. "Do Adolescent Idiopathic Scoliosis (AIS) Neglect Proprioceptive Information in Sensory Integration of Postural Control?" PLoS One 7, no. 7 (2012): e40646. https://doi.org/10.1371/journal.pone.0040646.
69. https://www.srs.org/Research/Patient-Outcome-Questionnaires
70. Gunzburg, R.; F. Balagué, M. Nordin, M. Szpalski, D. Duyck, D. Bull, C. Mélot. "Low Back Pain in a Population of School Children." European Spine Journal 8, no. 6 (1999): 439–443. https://doi.org/10.1007/s005860050202.
71. Calvo-Muñoz, Inmaculada, Amelia Gómez-Conesa, and Juan Sánchez-Meca. "Prevalence of Low Back Pain in Children and Adolescents: A Meta-analysis." BMC Pediatrics 13, no. 1 (2013): 14. https://doi.org/10.1186/1471-2431-13-14.

72. Calvo-Muñoz, Inmaculada, Amelia Gómez-Conesa, and Juan Sánchez-Meca. "Prevalencia del dolor lumbar durante la infancia y la adolescencia: Una revisión sistemática [Prevalence of Low Back Pain During Childhood and Adolescence: A Systematic Review]." Revista Española de Salud Pública 86, no. 4 (2012): 331–356. https://doi.org/10.4321/S1135-57272012000400003.
73. Junge, Tina, Niels Wedderkopp, Eleanor Boyle, and Per Kjaer. "The Natural Course of Low Back Pain from Childhood to Young Adulthood—A Systematic Review." Chiropractic & Manual Therapies 27, no. 10 (2019): 1–15. https://doi.org/10.1186/s12998-018-0231-x.
74. Poquet, Nathalie, Cindy W.Y. Lin, Mark W. Heymans, Maurits W. van Tulder, Reza Esmail, Bart W. Koes, Chris G. Maher. "Back Schools for Acute and Subacute Non-specific Low-back Pain." Cochrane Database of Systematic Reviews 2016, no. 4 (2016): CD008325. https://doi.org/10.1002/14651858.CD008325.pub2.
75. Negrini, Stefano, Rosa Carabalona. "Backpacks On! Schoolchildren's Perceptions of Load, Associations with Back Pain and Factors Determining the Load." Spine 27, no. 2 (2002): 187–195. https://doi.org/10.1097/00007632-200201150-00014.
76. Hernández, Tomás L.; María C. Ferré, Susana G. Martí, and Isabel S. Salvat. "Relationship Between School Backpacks and Musculoskeletal Pain in Children 8 to 10 Years of Age: An Observational, Cross-Sectional and Analytical Study." International Journal of Environmental Research and Public Health 17, no. 7 (2020): 2487. https://doi.org/10.3390/ijerph17072487.
77. Reneman, Michiel F.; Bart J. Poels, Jan H.B. Geertzen, Pieter U. Dijkstra. "Back Pain and Backpacks in Children: Biomedical or Biopsychosocial Model?" Disability and Rehabilitation 28, no. 21 (2006): 1293–1297. https://doi.org/10.1080/09638280600638001.
78. Kistner, F.R.; I.R. Fiebert, K.A. Roach, J.A. Moore. "Postural Compensations and Subjective Complaints Due to Backpack Loads and Wear Time in Schoolchildren." Pediatric Physical Therapy 25, no. 1 (2013): 15–24. https://doi.org/10.1097/PEP.0b013e31827e48b3.
79. Conti, J.; P. Borràs, J. Cantallops, X. Ponseti, M. Gili, P. Palou. "Las Mochilas Escolares como Factor de Riesgo Asociado al Dolor de Espalda Inespecífico." Cronos 10 (2010): 37–43.
80. Skaggs, David L.; Stephen D. Early, Pasquale D'Ambra, Vernon T. Tolo, Roy M. Kay. "Back Pain and Backpacks in School Children." Journal of Pediatric Orthopaedics 26, no. 3 (2006): 358–363. https://doi.org/10.1097/01.bpo.0000217723.14631.6e.
81. Gualdi-Russo, Emanuela, Nicola Rinaldo, and Luca Zaccagni. "Physical Activity and Body Image Perception in Adolescents: A Systematic Review." International Journal of Environmental Research and Public Health 19, no. 20 (2022): 13190. https://doi.org/10.3390/ijerph192013190.
82. Palenzuela-Luis, Natalia, Gema Duarte-Clíments, Juan Gómez-Salgado, José Ángel Rodríguez-Gómez, and María B. Sánchez-Gómez. "International Comparison of Self-Concept, Self-Perception and Lifestyle in Adolescents: A Systematic Review." International Journal of Public Health 67 (2022): 1604954. https://doi.org/10.3389/ijph.2022.1604954.
83. Choukas-Bradley, Sophia, Stephanie R. Roberts, Amanda J. Maheux, and Jacqueline Nesi. "The Perfect Storm: A Developmental-Sociocultural Framework for the Role of Social Media in Adolescent Girls' Body Image Concerns and Mental Health." Clinical Child and Family Psychology Review 25, no. 4 (2022): 681–701. https://doi.org/10.1007/s10567-022-00404-5.
84. Petrovics, Petra, Annamária Nagy, Béla Sandor, Andrea Palfi, Zsolt Szekeres, Katalin Toth, Erika Szabados. "Examination of Self-Esteem, Body Image, Eating Attitudes and Cardiorespiratory Performance in Adolescents." International Journal of Environmental Research and Public Health 18, no. 24 (2021): 13172. https://doi.org/10.3390/ijerph182413172.
85. Belli, Graziana, Stefano Toselli, Pasquale M. Latessa, and Matteo Mauro. "Evaluation of Self-Perceived Body Image in Adolescents with Mild Idiopathic Scoliosis." European Journal of Investigation in Health, Psychology and Education 12, no. 3 (2022): 319–333. https://doi.org/10.3390/ejihpe12030023.
86. Schwieger, Traci, Stephanie Campo, Stuart L. Weinstein, Lori A. Dolan, Saori Ashida, and Kelly R. Steuber. "Body Image and Quality-of-Life in Untreated Versus Brace-Treated Females With Adolescent Idiopathic Scoliosis." Spine 41, no. 4 (2016): 311–319.
87. Potoupnis, M.; K. Papavasiliou, E. Kenanidis, S. Pellios, A. Kapetanou, F. Sayegh, G. Kapetanos. "Reliability and Concurrent Validity of the Adapted Greek Version of the Scoliosis Research Society-22r Questionnaire. A Cross-sectional Study Performed on Conservatively Treated Patients." Hippokratia 16, no. 3 (2012): 225–229. PMID: 23935288.
88. Haidar, R.K.; K. Kassak, K. Masrouha, K. Ibrahim, and H. Mhaidli. "Reliability and Validity of an Adapted Arabic Version of the Scoliosis Research Society-22r Questionnaire." Spine 40, no. 17 (2015): E971–E977. https://doi.org/10.1097/BRS.0000000000000956.
89. Antonarakos, P.D.; L. Katranitsa, L. Angelis, A. Paganas, E.M. Koen, E.A. Christodoulou, A.G. Christodoulou. "Reliability and Validity of the Adapted Greek Version of Scoliosis Research Society - 22 (SRS-22) Questionnaire." Scoliosis 4, no. 14 (2009): 1–7. https://doi.org/10.1186/1748-7161-4-14.
90. Sathira-Angkura, V.; K. Pithankuakul, S. Sakulpipatana, C. Piyaskulkaew, S. Kunakornsawat. "Validity and Reliability of an Adapted Thai Version of Scoliosis Research Society-22 Questionnaire for Adolescent Idiopathic Scoliosis." Spine 37, no. 9 (2012): 783–787. https://doi.org/10.1097/BRS.0b013e318230a92d.

91. Schlösser, Tom P.C.; Andries Stadhouder, Jurgen J.A. Schimmel, Annemarie M. Lehr, Gert J.M.G. van der Heijden, and René M. Castelein. "Reliability and Validity of the Adapted Dutch Version of the Revised Scoliosis Research Society 22-item Questionnaire." The Spine Journal 14, no. 8 (2014): 1663–1672. https://doi.org/10.1016/j.spinee.2013.09.046.
92. Simony, Ane, Leah Y. Carreon, and Mikkel O. Andersen. "Reliability and Validity Testing of a Danish Translated Version of the Scoliosis Research Society Instrument-22 Revised (SRS-22R)." Spine Deformity 4, no. 1 (2016): 16–21. https://doi.org/10.1016/j.jspd.2015.06.006.
93. Arima, Hideyuki, Yusuke Yamato, Yuki Shibata, Hiroki Oba, Jun Takahashi, Koji Watanabe, Ryosuke Sugawara, Kazuo Takeshita, Tomonori Omura, Leah Carreon, Yosuke Arai, Takashi Asada, Satoshi Demura, Takashi Doi, Akihiko Matsumura, Satoshi Suzuki, Satoru Takahashi, Tomoyuki Takeuchi, Hidetomi Ueda, Norimasa Hosogane. "The Validation of the Japanese Version of the Scoliosis Research Society-30 Questionnaire for Adolescent Idiopathic Scoliosis Patients." Spine Surgery and Related Research 8, no. 3 (2024): 280–286. https://doi.org/10.22603/ssrr.2023-0202.
94. Grivas, Theodoros B. "School Scoliosis Screening, a Program Useful Not Only for the Prevention of Scoliosis. Part One: Historical Data, Policies of Administration, Clinical and Practical Considerations, Setting Up a School Scoliosis Screening Program and an Effective Protocol." Acta Orthopaedica et Traumatologica Hellenica 74, no. 1 (2023): 20–31.
95. Grivas, Theodoros B.; Elias S. Vasiliadis, Olga D. Savvidou, and Georgios Triantafyllopoulos. "What a School Screening Program Could Contribute in Clinical Research of Idiopathic Scoliosis Aetiology." Disability and Rehabilitation 30, no. 10 (2008): 752–762. https://doi.org/10.1080/09638280802041086.
96. Grivas, Theodoros B., Elias S. Vasiliadis, and George Rodopoulos. "Aetiology of Idiopathic Scoliosis. What Have We Learned from School Screening?" Studies in Health Technology and Informatics 140 (2008): 240–44. https://pubmed.ncbi.nlm.nih.gov/18810030/.
97. Grivas, Theodoros B., Michael T. Hresko, Hubert Labelle, Nigel Price, Tomasz Kotwicki, and Toru Maruyama. "The Pendulum Swings Back to Scoliosis Screening: Screening Policies for Early Detection and Treatment of Idiopathic Scoliosis – Current Concepts and Recommendations." Scoliosis 8, no. 1 (October 29, 2013): 16. https://doi.org/10.1186/1748-7161-8-16.
98. Płaszewski, Maciej, Robert Nowobilski, Piotr Kowalski, and Maciej Cieśliński. "Screening for Scoliosis: Different Countries' Perspectives and Evidence-Based Health Care." International Journal of Rehabilitation Research 35, no. 1 (March 2012): 13–19. https://doi.org/10.1097/MRR.0b013e32834df622.
99. Labelle, Hubert, Steven B. Richards, Marinus De Kleuver, Theodoros B. Grivas, Kenneth D. Luk, Harry K. Wong, John Thometz, Michel Beauséjour, Isabelle Turgeon, and Doris Y. P. Fong. "Screening for Adolescent Idiopathic Scoliosis: An Information Statement by the Scoliosis Research Society International Task Force." Scoliosis 8 (October 31, 2013): 17. https://doi.org/10.1186/1748-7161-8-17.
100. https://www.who.int/health-topics/integrated-people-centered-care#tab=tab_2