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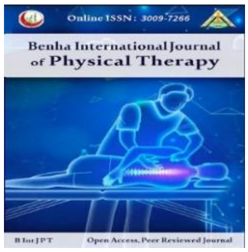


Original research

# Correlation between Forward Head Posture and Cobb's Angle in Adolescent Idiopathic Scoliosis.

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## Abstract

**Background:** Adolescent Idiopathic Scoliosis (AIS) is a prevalent spinal deformity that emerges during the adolescent growth spurt. It disrupts normal sagittal spinal alignment, which may affect posture and the function of deep cervical flexor muscles. **Purpose:** To examine the correlation between Cobb's angle and forward head posture, cervical sagittal curvature, and the performance of deep cervical flexor muscles in adolescents diagnosed with idiopathic scoliosis. **Materials and Methods:** A cross-sectional correlational study was conducted on 34 adolescents (25 females, 9 males), aged 11–23 years, with AIS, Lenke types from 1 to 6 (single and double curves). Cobb's angle and Sagittal Cervical Curve Angle (SCCA) were measured radiographically. Forward head posture was assessed using the Craniovertebral Angle (CVA), and deep cervical flexor muscle endurance was evaluated via the Cranio-Cervical Flexion Test (CCFT). **Results:** No statistically significant correlation was observed between Cobb's angle and CVA, SCCA, or deep cervical flexor performance ($p > 0.05$). However, a moderate, statistically significant positive correlation was found between SCCA and both the activation score and performance pressure index from the CCFT ($p < 0.01$), suggesting a relationship between cervical sagittal alignment and deep neck flexor muscle performance. The average SCCA of 13.5° indicates that cervical hypolordosis was common among participants. **Conclusion:** There was no significant correlation between Cobb's angle and forward head posture or deep cervical flexor performance. However, cervical sagittal curvature, especially hypolordosis, showed a significant association with muscle performance, highlighting its clinical importance in AIS assessment.

**Keywords:** Adolescent Idiopathic Scoliosis, Cervical Sagittal Curvature, Cobb's Angle, Deep Cervical Flexors, Forward Head Posture

## Introduction

Adolescent Idiopathic Scoliosis (AIS) is a characterized by an abnormal lateral curvature of the spine with no identifiable cause, Diagnosis is confirmed when the spinal curve exceeds 10° according to Cobb's angle and is often associated with vertebral rotation and it typically appears between the ages of 10 and 18. [1, 2]. This condition can alter posture and impair functional ability, and if not properly addressed, it may progress,

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possibly resulting in pain or, in advanced stages, respiratory or neurological issues.[3, 4]

Adolescent Idiopathic Scoliosis (AIS) is recognized as the most prevalent type of spinal curvature disorder in adolescence, affecting approximately 2% to 3% of individuals between the ages of 10 and 16. The reported prevalence varies based on factors such as gender distribution, geographic location, and the criteria or methods used for scoliosis screening. Females, in particular, are more likely to exhibit curve progression, especially in moderate to severe cases, which contributes to a higher female-to-male ratio among diagnosed patients.[1, 2]

Although the curve seen in the frontal plane is the most recognized feature of AIS, recent research not only highlights the importance of looking beyond that plane but also investigates the sagittal and axial planes of the spine. Many AIS patients show changes like reduced thoracic kyphosis and cervical lordosis, along with compensatory patterns such as forward head posture (FHP) [5, 6,] These postural changes can impact how muscles are activated, how forces are distributed along the spine, and how balance is maintained, especially in the neck region .[7,8]

Despite growing interest in sagittal alignment in Adolescent Idiopathic Scoliosis (AIS), the relationship between cervical sagittal curvature and coronal spinal deformity remains underexplored. Specifically, there is a lack of studies directly examining the correlation between the Sagittal Cervical Curve Angle (SCCA) and Cobb's angle, the standard measure of scoliosis severity. While some researchers have investigated cervical lordosis in relation to thoracic curve magnitude [9], and others have assessed cervical postural adaptations such as forward head posture [10, 11], none have especially focused on quantifying the releation between SCCA and scolosis severity in AIS. This highlights a gap in the literature and emphasizes the need to investigate whether changes in cervical sagittal alignment are biomechanically linked to the degree of scoliosis deformity.

One common way to assess FHP is by measuring the Craniovertebral Angle (CVA), where a value less than 48° typically signals a forward head position [12, 13]. Additionally, the Cranio-Cervical Flexion Test (CCFT) is often used in clinical settings to evaluate the endurance and control of the deep cervical flexor (DCF) muscles, which are key players in posture and neck stability. [14, 15]

This study included all Lenke types (1 to 6) to capture the full range of curve patterns seen in AIS. The Lenke classification provides a comprehensive system for categorizing scoliosis based on coronal, lumbar, and sagittal modifiers [16]. Including all curve types improves the generalizability of the findings and reflects the diversity of spinal deformities in clinical practice [9, 10] The Lenke classification system, widely accepted in AIS research and clinical practice, identifies and prioritizes the major (structural) curve, when double or triple curves are present, only the major (structural) curve is typically used for key angular and alignment assessments in both research and intervention decisions. [16]

Historically, sagittal balance has received limited attention in the correction of deformities in adolescent idiopathic scoliosis, despite the fact that many AIS patients present with sagittal imbalance. This imbalance can contribute to gait disturbances, pelvic tilt, back pain, and progressive deformity (adding-on) due to a disrupted sagittal profile. [17]

To date, very few studies have directly explored the relationship between craniocervical alignment specifically CVA and Cobb's angle in adolescents with idiopathic scoliosis. While some research has reported associations between thoracic curvature and cervical lordosis [18], the connection between CVA and the severity of scoliosis remains unclear. One study demonstrated that AIS patients often exhibit reduced CVA values, but no significant correlation with Cobb's angle was observed [10]. Therefore, further investigation is warranted to clarify whether cervical postural adaptations like FHP are biomechanically linked to the degree of spinal deformity, which could influence both assessment and rehabilitation strategies in scoliosis management.

Although deep cervical flexor (DCF) muscle dysfunction has been widely associated with poor cervical posture and forward head position, there is currently no direct evidence linking DCF performance with Cobb's angle in adolescents with idiopathic scoliosis. Existing studies have shown that altered cervical alignment and postural deviations common in AIS can impair DCF activation and endurance.

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However, the relationship between scoliosis severity and cervical muscle function remains unclear, highlighting a gap in the literature that warrants further investigation .[7, 19]

Despite how often these sagittal changes appear in AIS, the connection between the degree of spinal curvature (Cobb's angle) and other factors like FHP, cervical spine shape, and DCF endurance hasn't been fully explored. Gaining more insight into these links could help create more comprehensive and effective approaches to assessing and treating adolescents with scoliosis.

## patients and Methods

***Study Design and Setting:***

This cross-sectional correlational study was conducted at out clinic of the Physical therapy Department of Fayoum University Hospital. From November 2024 to March 2025.

***Sample size calculation***

The sample size for this study was calculated using the G*power program 3.1.9 (G-power program version 3.1, Heinrich-Heine-University, Düsseldorf, Germany) for two tailed test. Sample size calculation based on Exact - Correlation: Bivariate normal model, Type I error (α) = 0.05, power (1-β error probability) = 0.90, correlation ($pH_1$= 0.5477226) with a total sample size for 30 participants. Considering a 10% drop out rate, the appropriate minimum sample size for this study will be 34 participants. [20]

***Participants:***

Thirty-four adolescents (9 males and 25 females), aged 11 to 23 years, diagnosed with AIS based on radiographic evidence of a spinal curve >10° (Lenke types 1-6, single and double curves) were enrolled and are informed about the nature of the study and all steps of procedures and signed a consent form personally or by their legal guardians.

***Inclusion Criteria***

Participants were selected according to the following criteria:

1- Diagnosed cases of Adolescent Idiopathic Scoliosis (AIS).
2- Age range between 10 and 25 years. [9]
3- Radiographic confirmation of scoliosis with both anteroposterior (AP) and lateral X-rays, showing a Cobb angle greater than 10°. [21]
4- Classification within Lenke types 1 through 6 [10, 22]
5- No prior history of spinal surgery. [5]

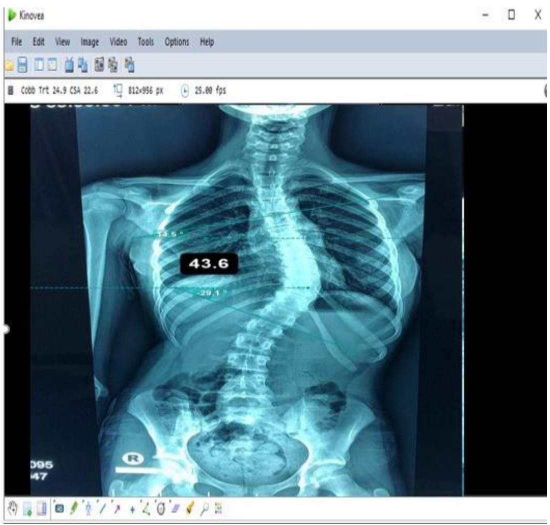
***Exclusion Criteria***

Participants were excluded if any of the following applied:

1- Presence of congenital scoliosis, including anomalies such as hemivertebrae, butterfly vertebrae, or failure of vertebral segmentation [21, 23].
2- Presence of other structural thoracic deformities (e.g., pectus excavatum).
3- Scoliosis resulting from known causes such as neurofibromatosis, Marfan syndrome, or syringomyelia.
4- Any neurological deficits or diagnosed spondylolisthesis [9].
5- History of spinal trauma, infection, or metabolic bone disorders.

***Instrumentation and Procedures:***
***Cobb's Angle Measurement***

Cobb's angle was measured using Anteroposterior spinal X-rays. In cases with more than one curve, only the major structural curve was measured for analysis, following standard classification protocols [16, 24]and analyzed through Kinovea software which a free valid and reliable software is known to yield valid measurements with a higher level of accuracy for both angular and linear assessments. [11, 25] (Fig.1).




**(Figure1)**: Cobb's angle measurement using kinovea software.

***Craniovertebral Angle Measurement (FHP Assessment):***

Two-dimensional digital photography has emerged as a valuable clinical tool for evaluating trunk alignment in individuals with idiopathic scoliosis (IS), offering a non-invasive alternative that may reduce the frequency of radiographic imaging used to monitor curve progression. [24]

In this study, the Craniovertebral Angle (CVA) was measured using a photogrammetric method via a smartphone camera. This technique is widely adopted in clinical and research settings due to its simplicity, objectivity, and strong measurement reliability [26]. Prior studies have demonstrated excellent inter- and intra-rater reliability for photogrammetric evaluation of head and cervical posture.[13]

CVA was assessed while participants stood in a relaxed, natural posture. Prior to image capture, participants were asked to remove any eyeglasses, hats, or hair accessories that could obscure key anatomical landmarks, such as the tragus or cervical spine (C7). No participants wore spinal braces during the assessment.[14, 26]

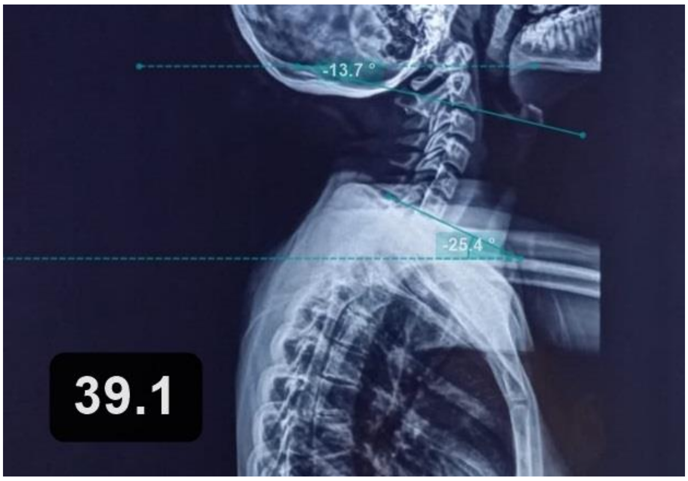
Sagittal images were taken using a smartphone placed 1.5 meters from the participant. The device's camera was aligned at shoulder height to maintain consistent framing. To enhance measurement reliability, three images were captured on the same day, with five-minute intervals between each. Before taking the image, participants were guided through full cervical flexion and extension movements, then asked to reduce the range gradually until achieving a neutral and relaxed cervical posture [12, 26]

Participants were instructed to fix their gaze on a target at eye level to ensure consistent head positioning. Clothing was adjusted to expose the cervical spine (particularly C7) and the shoulder region. Reflective adhesive markers were placed on the tragus of the ear and the spinous process of the vertebra prominent (C7). The CVA was calculated as the angle between a line drawn from the tragus to C7 and a horizontal reference line, using Kinovea software [27, 28] (Fig.2).


**(Figure2):** Craniovertebral Angle measurement.

***The Cervical Sagittal Curve Angle (SCCA) Measurement:***

Was measured from lateral cervical spine radiographs using the Jackson method. This angle is defined as the angle formed between the lower endplates of the C2 and C7 vertebrae [23, 29] and reflects the degree of cervical lordosis in the sagittal plane. In healthy individuals, the normal SCCA ranges from 20° to 40°, with angles below 20° indicating hypolordosis and angles approaching or below 0° suggesting cervical kyphosis [30,31]. (Fig.3).




**(Figure3):** Measurement of the Cervical Sagittal Curve Angle (SCCA

***Deep Cervical Flexor Endurance Measurement (CCFT):***

The Cranio-Cervical Flexion Test (CCFT) is a validated and reliable clinical method used to assess endurance and motor control of the deep cervical flexor (DCF) muscles. [32]

***Test Procedure:***

**Patient Position**: Supine crook lying with the neck in a neutral position. Towels may be used to maintain alignment and a Pressure Biofeedback Unit (PBU) is placed under the neck and inflated to a baseline of 20 mmHg and the patient performs gentle cranio-cervical flexion (nodding "yes") to progressively increase pressure by 2 mmHg increments (up to 30 mmHg), holding each level for 10 seconds.[14,31] (Fig. 4)

***Compensations to Avoid:*** (Fig. 5)

1- Loss of neutral neck/head position.
2- Visible or palpable contraction of sternocleidomastoid or scalene muscles.

***Scoring:***

**Activation Score:** Highest pressure level (above 20 mmHg) held correctly for 10 seconds.

**Performance Score:** Number of 10-second repetitions successfully performed at the activation level (maximum of 10).

**Performance Pressure Index (PPI)** = Activation Score (mmHg above baseline) × Number of correct repetitions.

Activation Score reflects muscle recruitment, PPI reflects isometric endurance of the deep cervical flexors. [14, 32]

**(Figure 4):** The Cranio-Cervical Flexion Test (CCFT

**(Figure 5):** Palpating muscles to avoid Compensations

### *Statistical analysis*

The statistical analysis was performed with SPSS for Windows, version 27 (SPSS, Inc., Chicago, IL). Before the final analysis, the data were checked for normality assumptions and the existence of extreme scores. This investigation was conducted as a prerequisite for parametric calculations of the analysis of difference. The Shapiro-Wilk test was used to determine the normality of the data, which revealed that the data was not normally distributed for all of the dependent variables. Spearman product moment correlation coefficient, was used to determine the correlations among the Cobb's angle and the forward head posture, cervical sagittal curve angle, and deep flexors muscles endurance. The initial alpha level for the correlation analysis was set at 0.05.

## Results

**General characteristics of the subjects:**

Thirty-four subjects with Adolescent Idiopathic Scoliosis participated in this study. Their mean ± SD age, weight, height and BMI were 15.53± 3.145 years, 62.74 ± 11.155 kg, 166.62± 10.269 cm and 21.853± 4.095 kg/m² respectively as shown in Table 1.

**Table 1: Descriptive statistics of age, weight, Height and BMI of participants.**

| | ±SD $\bar{X}$ | Maximum | Minimum |
|---|---|---|---|
| **Age (years)** | 15.53± 3.145 | 23 | 11 |
| **Weight (kg)** | 62.74 ± 11.155 | 89 | 31 |
| **Height (cm)** | 166.62± 10.269 | 186 | 141 |
| **BMI (kg/m²)** | 21.853± 4.095 | 27.9 | 2.9 |

**Mean $\bar{X}$ SD: Standard Deviation**

There was 23 cases with single curve and 11 cases with double curves and we selected the major structure curve for the analysis.

Cobb's Angle did not show a significant correlation with the Craniovertebral Angle (CVA) (ρ= 0.115, p-value= 0.516) or Sagittal Cervical Curve Angle (SCCA) (ρ = 0.064, p-value= 0.718).The results demonstrated that there was no association between Cobb's angle and the activation score (ρ = -0.012, p-value= 0.944), performance score (ρ= -0.055, p-value= 0.759), and performance pressure index (ρ = 0.007, p-value= 0.968). Table 2

**Table 2 : The correlation between Cobb's Angle forward head, cevical lordosis and deep neck flexors endurance**

| | Cobb's Angle | | |
|---|---|---|---|
| | **ρ** | P-value | 95% Confidence Intervals |
| Craniovertebral Angle (CVA) | 0.115 | 0.516 | (-0.242, 0.445) |
| Sagittal Cervical Curve Angle (SCCA) | 0.064 | 0.718 | (-0.290, 0.403) |
| Activation Score | -0.012 | 0.944 | (-0.358, 0.336) |
| Performance score | -0.055 | 0.759 | (-0.395, 0.298) |
| Performance Pressure Index | 0.007 | 0.968 | (-0.341, 0.354) |

**ρ** : sperman correlation coefficient p value: Probability value

There was a statistical significant moderate positive relationship between Sagittal Cervical Curve Angle (SCCA) and Activation score (ρ= 0.689, p-value <0.001) as well as between Sagittal Cervical Curve Angle (SCCA) and performance pressure index (ρ = 0.651, p-value<0.001). There was no correlation between Sagittal Cervical Curve Angle (SCCA) and performance score (ρ= 0.255, p-value= 0.146). Table 3

**Table 3 : The correlation between Sagittal Cervical Curve Angle (SCCA) and deep neck flexors endurance**

| Sagittal Cervical Curve Angle (SCCA | | | | |
|---|---|---|---|---|
| | | | 95% Confidence Intervals | |
| | **ρ** | P-value | Lower | Upper |
| Activation Score | 0.689 | <0.001 | 0.449 | 0.836 |
| Performance score | 0.255 | 0.146 | -0.101 | 0.553 |
| Performance Pressure Index | 0.651 | <0.001 | 0.393 | 0.814 |

**ρ** : spearman correlation coefficient p value: Probability value

***Cervical Hypolordosis Observation:***

The mean sagittal cervical curve angle (SCCA) among participants was 13.5°. Given that normal cervical lordosis typically ranges from 20° to 40°, this value reflects a consistent presence of cervical hypolordosis in the study population. [10]

## Discussion

This study aimed to investigate the relationship between Cobb's angle and sagittal spinal parameters specifically Cobb's angle, sagittal cervical curvature angle (SCCA), forward head posture (FHP), and deep cervical flexor (DCF) performance in adolescents with idiopathic scoliosis (AIS). Understanding these interactions is essential for optimizing conservative management strategies that target not only the primary spinal curve but also associated neuromuscular and postural impairments.

***Relationship between Cobb's angle and Cervical lordosis.***

No significant correlation was found between Cobb's angle and SCCA. This suggests that scoliosis severity, as measured by the Cobb's angle, may not directly influence cervical sagittal alignment.[11]

These findings align with those who reported no significant association between thoracic Cobb angle and cervical lordosis in AIS patients, proposing that cervical changes may evolve independently of thoracic deformities and it implies that the cervical spine may adapt differently and should be considered a distinct biomechanical and functional unit rather than simply a compensatory extension of the thoracic curve. [9]

Although some studies have shown a weak correlation between thoracic Cobb angle and cervical lordosis in more severe cases[19]. These discrepancies highlight the importance of evaluating the cervical spine as a distinct biomechanical and functional unit in scoliosis assessment.

The prevalence of cervical hypolordosis in the sample was notable, as many participants demonstrated reduced or reversed cervical curvature (i.e., cervical straightening or kyphosis). This observation aligns with a previous research which emphasized that the consistent hypolordosis may reflect compensatory mechanisms to maintain head position and visual orientation in response to postural imbalanc[6, 9]

Cervical hypolordosis in AIS is not merely a postural issue; it may also compromise proprioception, balance, and multisensory integration. Misalignment in this region alters the loading of cervical joint mechanoreceptors, disrupting input to the central nervous system and affecting the vestibular, visual, and somatosensory systems. [33, 34]

***Association between SCCA and DCF performance.***

A key finding of the present study is the strong positive correlation between SCCA and DCF performance, indicating that greater cervical lordosis is associated with better function of the deep cervical flexors. This result emphasizes the importance of sagittal cervical alignment in maintaining neuromuscular control and endurance of stabilizing muscles.

This is supported by studies that demonstrated altered cervical curvature is associated with impaired DCF recruitment patterns and reduced endurance [35]. Likewise, others reported reduced DCF function in patients with cervical straightening or kyphosis, proposing that mechanical disadvantage and altered proprioceptive input may underlie this dysfunction.[14]

Such relationships may be particularly relevant in AIS, where postural adaptations and compensatory strategies in the cervical spine may contribute to muscle imbalance. Our findings support previous studies suggesting that DCF performance may be enhanced by restoring physiological cervical lordosis. [14, 19]

***Association between Cobb's angle and CVA, FHP and DCF performance.***

Forward head posture, commonly observed in AIS patients, did not show a significant relationship with Cobb's angle in this study. This may reflect its multifactorial origin, influenced not only by spinal alignment but also by behavioral and ergonomic factors. Nevertheless, its impact on cervical muscle function and proprioception is well-documented.

Previous research has shown that FHP increases the mechanical demand on posterior cervical structures and compromises DCF performance[7, 8]. In AIS, where trunk balance is already compromised, FHP may further destabilize sensorimotor control, increasing the risk of musculoskeletal symptoms.

It is also possible that patients with similar Cobb angles adopt different cervical postural strategies to maintain equilibrium, explaining the absence of direct correlations. This variability supports the view that DCF dysfunction and FHP are not necessarily proportional to scoliosis severity, but may be components of a broader sensorimotor and behavioral pattern in AIS.[28]

Clinically, non-radiographic assessments such as the craniovertebral angle (CVA) and the craniocervical flexion test (CCFT) are effective tools for quantifying FHP and cervical function. These methods are particularly useful in pediatric populations, minimizing radiation exposure while offering repeatable and sensitive outcome measures. [12 32]

***Rehabilitation perspective***

Based on the observed correlation between SCCA and DCF function, targeted cervical rehabilitation should be considered an integral component of AIS management. Protocols involving low-load craniocervical flexion exercises have been shown to selectively activate and strengthen DCFs while minimizing compensation from superficial muscles [14].

Integrating such exercises into scoliosis-specific rehabilitation programs such as Schroth exercises may yield dual benefits, improved cervical muscle endurance and enhanced postural control [19, 35]. Additionally, proprioceptive retraining, postural re-education, and ergonomic counseling may contribute to long-term spinal health and symptom reduction.

**Limitations**

This study might have some limitations. Firstly, CVA and cervical angle measurements using 2D methods may have limitations in precision.

As this study employs a cross-sectional design, it cannot establish a cause-and-effect relationship between forward head posture and Cobb's angle, but rather highlights a potential association.

Lastly the cohort consisted of various Lenke curve types and a wide range of Cobb angles, reflecting considerable variation in the sample characteristics.

**Recommendations:**

Future studies should stratify participants by Lenke type and curve severity, and longitudinal studies are needed to assess the effect of interventions targeting cervical posture and DNF endurance. Including a healthy control group may help clarify whether observed DNF impairments are scoliosis-specific.

# Conclusion

Cobb's angle was not significantly associated with SCCA, Craniovertebral angle or forward head posture or deep cervical flexor endurance in adolescents with idiopathic scoliosis. However, cervical sagittal curve angle showed a significant relationship with deep neck flexor performance. There is observed prevalence of cervical hypolordosis in the majority of participants reflects a compensatory mechanism in response to postural imbalances caused by scoliosis. These findings highlight the importance of incorporating cervical sagittal assessment and hypolordosis screening, along with DCF evaluation, into the standard clinical examination of AIS patients.

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***Ethical approval***

This study received ethical approval from the Research Ethics Committee of the Faculty of Physical Therapy, Cairo University (Approval No: REC/PT/012/005269). Written informed consent was obtained from all participants or their legal guardians prior to data collection. And this trial is registered with ClinicalTrials.gov under ID NCT06629948.

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