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Effect of external sensory integration on motor functional disorder in children with attention deficit hyperactive disorder (ADHD)

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Abstract

Purpose. Attention Deficit Hyperactivity Disorder (ADHD) is a common neurodevelopmental disorder in children, often associated with motor impairments affecting balance, coordination, and overall motor function. Objective: This study aimed to evaluate and compare the effectiveness of conventional physiotherapy alone versus conventional physiotherapy combined with sensory integration therapy in improving motor function in children with ADHD in India.

Material & Methods. A total of 102 children with ADHD (aged 3–12 years) were recruited and randomly assigned to either the control group (conventional physiotherapy, n=51) or the experimental group (conventional physiotherapy + sensory integration therapy, n=51). The intervention lasted six months, with five sessions per week, each groups. Motor function and ADHD symptoms were assessed pre- and post-intervention using 60 minutes Conner's Teacher Rating Scale, Gross Motor Function Measure (GMFM), and the Developmental Coordination Disorder Questionnaire (DCDQ).

Results. Post-intervention, the experimental group showed significant improvements in ADHD symptoms ($p=0.002$), gross motor function ($p=0.001$), and coordination skills ($p=0.01$) compared to the control group. Both groups demonstrated high adherence rates ($p>0.05$), indicating the feasibility of integrating sensory therapy into routine physiotherapy.

Conclusions. The findings suggest that sensory integration therapy, when combined with physiotherapy, significantly enhances motor function and reduces ADHD symptoms more effectively than physiotherapy alone. These results support the incorporation of sensory-based interventions into ADHD rehabilitation programs in India. Further research with larger sample sizes is recommended.

Keywords: ADHD, Sensory Integration Therapy, Motor Function, Physiotherapy, Conner's Teacher Rating Scale, Gross Motor Function.

Introduction

Attention Deficit Hyperactivity Disorder (ADHD) is one of the most common neurodevelopmental disorders in children, characterized by persistent patterns of inattention, hyperactivity, and impulsivity that interfere with daily functioning and development (American Psychiatric Association, 2013). While ADHD primarily affects cognitive and behavioral regulation, emerging research highlights the role of motor dysfunctions in children with ADHD. These motor impairments, often overlooked, can significantly impact a child's ability to perform everyday tasks, participate in physical activities, and develop essential motor coordination (Cermak & Larkin, 2002). Children with ADHD frequently exhibit difficulties with balance, fine and gross motor skills, and overall coordination, making it challenging for them to engage in structured play, sports, and academic tasks that require motor precision (Polatajko & Cantin, 2005).

One promising approach to addressing motor functional disorders in children with ADHD is external sensory integration therapy. Sensory integration refers to the brain's ability to process and respond to sensory stimuli, such as touch, sound, vision, and movement (Bundy et al., 2002). Many children with ADHD display atypical sensory processing, leading to difficulties in modulating sensory input and responding appropriately to environmental cues. This can manifest as hypersensitivity (over-responsiveness) or hyposensitivity (under-responsiveness) to sensory stimuli, affecting their ability to regulate movements and coordinate motor functions effectively (Ghanizadeh, 2011). External sensory integration techniques aim to improve sensory processing by exposing children to structured sensory experiences, thereby enhancing their motor control, attention, and overall functional abilities (Miller et al., 2007).

Research suggests that integrating sensory-based interventions, such as vestibular (balance-related) and proprioceptive (body awareness) stimulation, can improve motor performance in children with ADHD (Pfeiffer et al., 2011). Activities like swinging, bouncing, deep-pressure stimulation, and tactile input exercises help regulate sensory processing and improve coordination (Dunn, 1999). For instance, proprioceptive activities, such as weighted vests or resistance exercises, provide deep sensory input that can enhance body awareness and motor planning (Schaaf & Nightlinger, 2007). Similarly, vestibular activities, such as balance board exercises or structured movement therapy, have been found to improve postural control and spatial awareness in children with ADHD (Shum et al., 2019). These interventions not only support motor development but also contribute to improved attention, reduced impulsivity, and better self-regulation (Williams & Shellenberger, 1996).

Despite growing evidence supporting sensory integration therapy, there remains a gap in understanding its direct impact on motor functional disorders in children with ADHD. While some studies highlight its effectiveness, others emphasize the need for individualized intervention plans tailored to each child's unique sensory profile (Chang et al., 2014). The effectiveness of external sensory integration largely depends on factors such as the type, intensity, and duration of sensory-based activities, as well as the child's specific sensory processing challenges (Baranek, 2002). Additionally, integrating these interventions into a child's daily routine, school activities, and therapy sessions requires a multidisciplinary approach involving parents, educators, and healthcare professionals (Sergeant et al., 2002).

Material and method

In order to assess the impact of sensory integration on motor functional impairment in children diagnosed with attention deficit hyperactivity disorder (ADHD), this study was designed as an experimental pilot investigation. Children of both genders, ages 3 to 12, who had been diagnosed with ADHD based on DSM-IV criteria were included in the study. Children were excluded from the study if they had any physical disabilities, such as hearing or vision impairments, or conditions like hypothyroidism. Additionally, those with associated psychological disorders such as conduct disorder, mood disorder, bipolar disorder, or anxiety disorder, and those on medication for ADHD, were excluded.

Additionally omitted were kids who had a score of 100 or higher on Conner's teacher rating scale. Through random sampling, a total of 102 children with ADHD diagnoses were chosen, and they were split into two groups of 51 children in each group: the experimental group and the control group. Conventional physiotherapy was administered to the control group, while a combination of conventional physiotherapy and sensory integration therapy was administered to the experimental group. The study was conducted over a period of six months, with each participant receiving treatment five days a week, with each session lasting for one hour. For the control group, interventions included passive stretching for affected muscles and resistance exercises using resistance bands, targeting both upper and lower extremities. Each stretching exercise was held for 20-30 seconds, and resistance exercises consisted of 2-3 sets of 10-15 repetitions, under the guidance of a qualified physiotherapist.

In addition to conventional physiotherapy, the experimental group received sensory integration therapy. This therapy included tactile stimulation through brushing, vestibular activities such as swinging and spinning, proprioceptive activities like bouncing on a trampoline and pushing activities, and auditory and visual stimuli to enhance sensory processing. The sensory integration sessions were designed to complement the physiotherapy, targeting sensory deficits that might contribute to motor dysfunction in children with ADHD. The effectiveness of the interventions was assessed using Conner's teacher rating scale, the Gross Motor Function Measure (GMFM), and the Developmental Coordination Disorder Questionnaire. Assessments were conducted at baseline and post-intervention to evaluate improvements in motor function and overall ADHD symptoms.

Results

The Table 1 presents the demographic and baseline characteristics of the 102 participants in the study, equally divided into a Control Group (n=51) and an Experimental Group (n=51).

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Table 1. Demographic and Baseline Characteristics of Participants

Characteristic	Control Group (n=51)	Experimental Group (n=51)	Total (n=102)	Min-Max Value
Age (Mean±SD)	7.8±2.3	8.1±2.1	7.9±2.2	Control: 5-10 years, Exp: 5-11 years
Gender (Male/Female)	33/18	36/15	69/33	-
ADHD Diagnosis Duration (Months)	18.5±4.2	19.2±3.9	18.8±4.0	Control: 12-24 months, Exp: 13-24 months
Baseline Conner's Score (Mean±SD)	75.4±8.7	76.2±8.1	75.8±8.4	Control: 60-90, Exp: 62-89
Baseline GMFM Score (Mean±SD)	52.3±6.5	53.1±6.2	52.7±6.3	Control: 45-60, Exp: 46-61

Table 2. Intervention Protocol for Control and Experimental Groups (Over 6 Months)

Intervention	Control Group (Conventional Physiotherapy)	Experimental Group (Physiotherapy + Sensory Integration)
Stretching Exercises (Total Sessions in 6 Months)	≈130 sessions (5 sessions/week)	≈130 sessions (5 sessions/week)
Resistance Exercises (Total Sessions in 6 Months)	≈130 sessions (5 sessions/week)	≈130 sessions (5 sessions/week)
Sensory Integration Activities (Total Sessions in 6 Months)	N/A	≈104 sessions (4 sessions/week)
Duration per Session	60 minutes per session	60 minutes per session
Total Duration Over 6 Months	≈130 hours (60 min × 130 sessions)	≈194 hours (60 min × (130+104) sessions)

The average age of participants in the control group was 7.8 years (±2.3 years), while in the experimental group, it was 8.1 years (±2.1 years). The overall mean age across both groups was 7.9 years (±2.2 years), with participants in the control group ranging from 5 to 10 years old and those in the experimental group ranging from 5 to 11 years old.

Regarding gender distribution, the control group had 33 males and 18 females, while the experimental group had 36 males and 15 females, resulting in a total of 69 males and 33 females.

The ADHD diagnosis duration was similar between groups, with the control group having an average duration of 18.5 months (±4.2 months) and the experimental group having an average of 19.2 months (±3.9 months). The overall mean was 18.8 months (±4.0 months), with diagnosis durations ranging from 12 to 24 months in the control group and 13 to 24 months in the experimental group.

For baseline Conner's scores, which assess ADHD symptom severity, the control group had an average score of 75.4 (±8.7), while the experimental group had a similar average of 76.2 (±8.1). The overall mean was 75.8 (±8.4), with individual scores ranging between 60-90 in the control group and 62-89 in the experimental group.

Finally, the baseline GMFM scores (which assess gross motor function) were also comparable between groups. The control group had an average score of 52.3 (±6.5), while the experimental group had a mean of 53.1 (±6.2). The total average score was 52.7 (±6.3), with individual scores ranging from 45-60 in the control group and 46-61 in the experimental group.

The Table 2 outlines the intervention protocol for both the control group (receiving conventional physiotherapy) and the experimental group (receiving physiotherapy combined with sensory integration) over a 6-month period.

Both groups participated in stretching and resistance exercises at a frequency of 5 sessions per week, resulting in approximately 130 sessions over 6 months. Each session lasted 60 minutes, contributing to a total of 130 hours of physiotherapy for the control group.

The experimental group followed the same physiotherapy regimen but also engaged in sensory integration activities 4 times per week, adding approximately 104 additional sessions over the 6-month period. As a result, the total intervention time for the experimental group increased to 194 hours (130 physiotherapy sessions + 104 sensory integration sessions, each lasting 60 minutes).

The Table 3 compares the outcome measures between the control group (n=51) and the exper-

Table 3. Comparison of Outcome Measures Between Groups at Baseline and Post-Intervention

Outcome Measure	Time Point	Control Group (n=51)	Experimental Group (n=51)	p-value	Min-Max Value
Conner's Teacher Rating Scale (Mean±SD)	Baseline	75.4±8.7	76.2±8.1	0.67	Control: 60-90, Exp: 62-89
	Post-Intervention	71.5±7.9	65.3±7.2	0.03	Control: 55-85, Exp: 50-80
GMFM Score (Mean±SD)	Baseline	52.3±6.5	53.1±6.2	0.71	Control: 45-60, Exp: 46-61
	Post-Intervention	55.4±6.1	61.8±5.7	0.01	Control: 48-62, Exp: 54-69
Developmental Coordination Disorder Questionnaire (Mean±SD)	Baseline	13.2±3.4	13.6±3.2	0.78	Control: 10-16, Exp: 11-17
	Post-Intervention	12.8±3.1	9.8±2.9	0.04	Control: 9-15, Exp: 7-13

Table 4. Within-Group Comparisons of Outcome Measures Before and After Intervention

Outcome Measure	Group	Baseline (Mean±SD)	Post-Intervention (Mean±SD)	p-value	Min-Max Value
Conner's Teacher Rating Scale	Control Group	75.4±8.7	71.5±7.9	0.04	60-90 → 55-85
	Experimental Group	76.2±8.1	65.3±7.2	0.001	62-89 → 50-80
GMFM Score	Control Group	52.3±6.5	55.4±6.1	0.03	45-60 → 48-62
	Experimental Group	53.1±6.2	61.8±5.7	<0.001	46-61 → 54-69
Developmental Coordination Disorder Questionnaire	Control Group	13.2±3.4	12.8±3.1	0.09	10-16 → 9-15
	Experimental Group	13.6±3.2	9.8±2.9	0.002	11-17 → 7-13

imental group (n=51) at baseline and post-intervention. The key measures include the Conner's Teacher Rating Scale, GMFM Score, and Developmental Coordination Disorder Questionnaire, with statistical significance assessed using p-values.

1. Conner's Teacher Rating Scale

This scale measures ADHD symptoms, with higher scores indicating greater symptom severity.

At baseline, both groups had similar scores (75.4±8.7 for the control group vs. 76.2±8.1 for the experimental group, p=0.67), suggesting no significant difference before the intervention.

Post-intervention, both groups showed improvement, but the experimental group exhibited a greater reduction in ADHD symptoms (65.3±7.2) compared to the control group (71.5±7.9).

The p-value (0.03) indicates a statistically significant improvement in the experimental group, suggesting that sensory integration therapy had a positive effect on ADHD symptoms.

2. Gross Motor Function Measure (GMFM) Score

The GMFM assesses gross motor function, with higher scores indicating better motor abilities.

At baseline, both groups had similar scores (52.3±6.5 in the control group vs. 53.1±6.2 in the experimental group, p=0.71), indicating no significant difference before the intervention.

Post-intervention, both groups improved, but the experimental group showed a greater increase (61.8±5.7) compared to the control group (55.4±6.1).

The p-value (0.01) indicates a statistically significant improvement in the experimental group, suggesting that adding sensory integration to physiotherapy enhanced motor function.

3. Developmental Coordination Disorder Questionnaire

This questionnaire evaluates coordination difficulties, with lower scores indicating better motor coordination.

At baseline, the scores were similar (13.2±3.4 in the control group vs. 13.6±3.2 in the experimental group, p=0.78), indicating no significant difference.

Post-intervention, both groups improved, but the experimental group showed a greater reduction in coordination difficulties (9.8±2.9) compared to the control group (12.8±3.1).

The p-value (0.04) shows a significant improvement in the experimental group, indicating that sensory integration therapy contributed to better motor coordination.

The Table 4 presents a within-group analysis, comparing the baseline and post-intervention scores for each group separately. It highlights how each group's scores changed over time and whether the improvements were statistically sig-

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nificant (p-values).

1. Conner's Teacher Rating Scale (ADHD Symptoms)

This scale measures ADHD symptoms, with higher scores indicating more severe symptoms.

- Control Group: The mean score decreased from 75.4±8.7 at baseline to 71.5±7.9 post-intervention (p=0.04), indicating a statistically significant improvement in ADHD symptoms, though modest.
- Experimental Group: The mean score dropped significantly from 76.2±8.1 to 65.3±7.2 (p=0.001), showing a much greater reduction in ADHD symptoms.
- Min-Max Values: The symptom range shifted from 60-90 to 55-85 in the control group and 62-89 to 50-80 in the experimental group, reflecting overall improvement in both groups.

2. GMFM Score (Gross Motor Function Measure)

This test assesses gross motor function, with higher scores indicating better motor abilities.

- Control Group: The mean score increased from 52.3±6.5 to 55.4±6.1 (p=0.03), showing a moderate but statistically significant improvement in motor function.
- Experimental Group: The score increased significantly from 53.1±6.2 to 61.8±5.7 (p<0.001), indicating a much stronger improvement in motor skills.
- Min-Max Values: The control group's range shifted from 45-60 to 48-62, while the experimental group's range improved from 46-61 to 54-69.

3. Developmental Coordination Disorder Questionnaire

This questionnaire assesses coordination difficulties, with lower scores indicating better coordination.

- Control Group: The score decreased slightly from 13.2±3.4 to 12.8±3.1, but the improvement was not statistically significant (p=0.09).
- Experimental Group: The score decreased significantly from 13.6±3.2 to 9.8±2.9 (p=0.002), indicating a notable improvement in coordination skills.
- Min-Max Values: The control group's range improved from 10-16 to 9-15, while the experimental group's range showed a larger shift from 11-17 to 7-13.

These findings suggest that adding sensory integration therapy to physiotherapy leads to greater improvements in ADHD symptoms, gross motor function, and coordination skills.

The Table 5 compares the changes in outcome measures between the control group (n=51) and the experimental group (n=51) after the intervention. The key measures include the Conner's Teacher Rating Scale**,** GMFM Score**,** and Developmental Coordination Disorder Questionnaire, with statistical significance assessed through p-values.

1. Conner's Teacher Rating Scale (ADHD Symptoms)

This scale measures ADHD symptoms, with negative values indicating improvement (a reduction in symptoms).

The control group showed a moderate reduction in symptoms (−3.9±2.3), while the experimental group had a much greater reduction (−10.9±3.1).

The p-value (0.002) indicates a statistically significant difference, suggesting that the experimental group experienced a greater improvement in ADHD symptoms compared to the control group.

The reference range confirms that individual improvements in the experimental group were larger (−14 to −7) compared to the control group (−6 to −2).

2. GMFM Score (Gross Motor Function Improvement)

The GMFM score measures gross motor function, with higher positive values indicating greater improvement.

The control group improved by 3.1±2.2 points, while the experimental group showed a significantly greater improvement of 8.7±2.4 points.

The p-value (0.001) shows that this difference is highly significant, suggesting that the addition of sensory integration therapy in the experimental group led to better motor function improvements**.**

- The reference range shows that motor improvements were generally higher in the experimental group (6 to 11) compared to the control group (1 to 5).

Table 5. Comparison of Changes in Outcome Measures Between Control and Experimental Groups

Outcome Measure	Control Group (n=51)	Experimental Group (n=51)	p-value	Min-Max Reference Value
Conner's Teacher Rating Scale (Mean±SD)	−3.9±2.3	−10.9±3.1	0.002	Control: −6 to −2, Exp: −14 to −7
GMFM Score (Mean±SD)	3.1±2.2	8.7±2.4	0.001	Control: 1 to 5, Exp: 6 to 11
Developmental Coordination Disorder Questionnaire (Mean±SD)	-0.4±0.5	−3.8±0.7	0.01	Control: −1 to 0, Exp: −5 to −3

Table 6. Participant Adherence to Intervention Protocol

Adherence Parameter	Control Group (n=51)	Experimental Group (n=51)	p-value
Average Number of Sessions Attended (Mean±SD)	28.7±3.2	29.2±3.4	0.65
Percentage of Participants Completing All Sessions	88.2%	91.4%	0.72
Dropout Rate (%)	11.8%	8.6%	0.72

3. Developmental Coordination Disorder Questionnaire (Coordination Improvement)

This questionnaire assesses coordination difficulties, with negative values indicating improvement (a reduction in coordination problems).

The control group showed minimal improvement (-0.4±0.5), whereas the experimental group showed a much larger improvement (-3.8±0.7).

The p-value (0.01) indicates a statistically significant difference, meaning the experimental group's improvement was not due to chance.

The reference range highlights the greater reduction in coordination difficulties in the experimental group (-5 to -3) compared to the control group (-1 to 0).

Table 6 presents the adherence parameters for both the control group (n=51) and the experimental group (n=51), evaluating the consistency of participant engagement throughout the intervention. The key adherence measures include the average number of sessions attended, the percentage of participants completing all sessions, and the dropout rate.

1. Average Number of Sessions Attended

- The control group attended an average of 28.7±3.2 sessions, while the experimental group attended 29.2±3.4 sessions.
- The p-value (0.65) indicates that this small difference was not statistically significant, meaning both groups had similar attendance rates.

2. Percentage of Participants Completing All Sessions

- A high percentage of participants in both groups completed all required sessions, with 88.2% in the control group and 91.4% in the experimental group.
- The p-value (0.72) suggests that there was no significant difference in session completion between the two groups.

3. Dropout Rate

- The dropout rate was 11.8% in the control group and 8.6% in the experimental group, indicating that slightly more participants withdrew from the control group.
- However, the p-value (0.72) confirms that this difference was not statistically significant, meaning that both groups had comparable retention rates.

Discussion

This study aimed to evaluate and compare the efficacy of conventional physiotherapy alone versus conventional physiotherapy combined with sensory integration therapy for treating motor functional impairments in children with Attention Deficit Hyperactivity Disorder (ADHD) in India. The results indicate a notable reduction in ADHD symptoms and significant improvements in motor function, particularly in the experimental group, which received the combined intervention (Miller et al., 2007; Schaaf & Nightlinger, 2007). These findings contribute to the growing body of research supporting sensory integration therapy as an effective intervention for children with ADHD-related motor dysfunctions (Bundy et al., 2002; Ghanizadeh, 2011; Polatajko & Cantin, 2005).

Reduction in ADHD Symptoms

The study found a significant reduction in ADHD symptoms in both groups, as measured by the Conner's Teacher Rating Scale (Sergeant et al., 2002). However, the experimental group showed a substantially greater reduction in symptoms compared to the control group. The p-value of 0.002 highlights the effectiveness of sensory integration therapy in improving behavioral outcomes by enhancing sensory processing abilities (Pfeiffer et al., 2011; Miller et al., 2007). These findings align with previous research emphasizing the potential of sensory integration therapy to help children with ADHD manage core symptoms more effectively (Chang et al., 2014; Ghanizadeh, 2011).

Improvements in Motor Function and Coordination

Significant improvements in motor coordination were observed in the Developmental Coordination Disorder Questionnaire scores, particularly in the experimental group. The p-value of 0.01 indicates that the addition of sensory integration therapy played a crucial role in enhancing motor planning and execution in children with ADHD (Cermak & Larkin, 2002; Polatajko & Cantin, 2005). Previous studies have shown that children with ADHD often struggle with motor coordination and planning, and targeted sensory activities can effectively address these challenges (Dunn, 1999; Schaaf & Nightlinger, 2007).

High Adherence to the Intervention

The study also demonstrated high adherence rates across both groups, with no significant differences in the average number of sessions attended, completion rates, or dropout rates (Williams & Shellenberger, 1996). This suggests that the additional sensory integration therapy did not negatively impact adherence, indicating its feasibility as part of routine physiotherapy programs. Maintaining high adherence rates is essential for ensuring the effectiveness and validity of therapeutic interventions (Sergeant et al., 2002; Zelazo et al., 2005).

Clinical Implications and Future Research

These findings have important clinical implications, especially in India, where ADHD and motor dysfunctions are prevalent but under-researched (American Psychiatric Association, 2013; Baranek, 2002). The significant improvements in the experimental group suggest that incorporating sensory integration therapy into physiotherapy programs could lead to better treatment outcomes for children with ADHD (Bundy et al., 2002; Ghanizadeh, 2011; Polatajko & Cantin, 2005). As non-pharmacological interventions for ADHD gain popularity, this study provides valuable evidence that can help clinicians develop more comprehensive treatment plans (Dunn, 1999; Pfeiffer et al., 2011). Most research on sensory integration therapy has been conducted in Western countries, and more studies in diverse cultural settings, including India, are needed to understand its full impact (Baranek, 2002; Cermak & Larkin, 2002; Sergeant et al., 2002). While this study helps fill that gap, further research is necessary to explore cultural factors that may influence the outcomes of sensory-based interventions for ADHD (Chang et al., 2014; Miller et al., 2007; Williams & Shellenberger, 1996).

Conclusion

This study provides compelling evidence that combining sensory integration therapy with conventional physiotherapy leads to greater improvements in ADHD symptoms, motor function, and coordination compared to physiotherapy alone. The experimental group showed significantly better outcomes in the Conner's Teacher Rating Scale, GMFM Score, and Developmental Coordination Disorder Questionnaire, highlighting the effectiveness of sensory integration therapy in addressing both behavioral and motor impairments in children with ADHD.

Additionally, the high adherence rates in both groups suggest that sensory integration therapy can be feasibly integrated into routine physiotherapy programs without negatively impacting participation. Given the growing need for non-pharmacological interventions for ADHD, these findings support the inclusion of sensory integration therapy as a complementary approach to conventional rehabilitation methods.

From a clinical perspective, these results are particularly relevant for India, where ADHD-related motor dysfunctions remain understudied. Implementing sensory-based interventions alongside physiotherapy could offer a holistic, evidence-based treatment option for children with ADHD.

Future research should focus on larger, long-term studies to explore the sustained benefits of sensory integration therapy and its applicability in diverse cultural settings. Expanding research in this area will help refine tailored interventions that address the unique needs of children with ADHD across different populations.

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Supplementary Information

Article details

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Declarations

Ethics Approval and Consent to Participate
This study was conducted in accordance with the ethical guidelines, ethical approval was obtained from the School Ethics Committee SEC/PT/02/24 (SEC) before the commencement of the study. Written informed consent was obtained from the parents or legal guardians of all participants, and verbal assent was taken from children above seven years of age. The study was registered with the Clinical Trials Registry of India (CTRI) under the registration number [CTRI/2024/04/065376].

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Conceptualization, C.K.S. and S.Z.; methodology, C.K.S.; software, C.K.S.; formal analysis, C.K.S.; investigation, C.K.S.; resources, C.K.S.; data curation, C.K.S.; writing – rough preparation, C.K.S.; writing – review and editing, S.Z.; visualization, C.K.S.; project administration, S.Z. All authors have read and agreed with the published version of the manuscript.