

Research Article

Effectiveness of Methylphenidate Plus Integrated Training in Children with Comorbid SLD and ADHD: A Retrospective Pre–Post Intervention Study

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Abstract

Objective: This study aimed to evaluate the effects of methylphenidate controlled-release tablets combined with cognitive and sensory integration training on learning and behavioral outcomes in children with comorbid SLD and ADHD. **Methods:** A total of 55 children diagnosed with both SLD and ADHD were retrospectively included from a pediatric outpatient clinic in Guangzhou between June 2020 and December 2023. This single-group retrospective design allowed for within-subject comparisons before and after the intervention. All participants received a six-month intervention comprising daily oral methylphenidate and regular sessions of cognitive and sensory integration training. Cognitive and behavioral functioning were systematically assessed at two time points—pre- and post-intervention—using three standardized tools: the Children’s Learning Disability Characteristics Assessment Scale, the SNAP-IV scale, and the Conners’ Child Behavior Scale. This pre-post comparative framework enabled the evaluation of intervention-related changes across multiple domains. **Results:** Post-intervention, total and subscale scores across all three instruments were significantly reduced compared to baseline ($P < 0.01$), indicating marked improvements in attention, learning ability, and behavioral regulation. The most substantial gains were observed in attention control, visual perception, and hyperactivity/impulsivity symptoms. **Conclusion:** The combination of pharmacological treatment and structured non-pharmacological training produced significant improvements in both cognitive-perceptual and behavioral outcomes. This integrated approach may offer synergistic therapeutic benefits for children with co-occurring SLD and ADHD and provides promising clinical evidence to inform future large-scale, multidisciplinary intervention protocols.

Keywords

ADHD, Learning Disabilities, Comorbidity, Methylphenidate, Cognitive Behavioral Therapy, Self-Controlled Studies

1. Introduction

Attention Deficit Hyperactivity Disorder (ADHD) is a common neurodevelopmental disorder beginning in childhood, characterized by inattention, hyperactivity, and impulsivity, with a global prevalence of about 5.3% among

school-aged children [1]. Although symptoms may improve after adolescence, about two-thirds of affected children continue to show clinical or subclinical symptoms into adulthood, impacting academic, occupational, and social functioning.

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Genetic factors contribute significantly to the disorder [2, 3]. Diagnosis is often delayed due to lack of awareness from families and teachers, especially in females, leading to gender disparities in identification and consultation rates [4, 5].

Specific Learning Disorder (SLD) is a neurodevelopmental condition marked by persistent difficulties in reading, writing, or mathematics, which cannot be explained by intellectual disability, inadequate instruction, or sensory impairments [5]. Symptoms vary by age, from academic difficulties in childhood to emotional and adaptive problems in adolescence and adulthood [6]. The global prevalence ranges from 5% to 15% in children and around 4% in adults. SLD frequently co-occurs with other neurodevelopmental disorders, especially ADHD, with reported comorbidity rates between 31% and 54.9% [7, 8]. Individuals with both conditions often experience more severe academic failure, executive dysfunction, and social adjustment problems, complicating interventions.

Currently, there is no standardized treatment guideline for children with comorbid ADHD and SLD. Clinical practice commonly combines pharmacological treatments such as methylphenidate—which alleviates attention and hyperactivity symptoms—with non-pharmacological therapies like cognitive and sensory integration training to improve learning and attention control [9, 10]. However, evidence on the combined effectiveness of these interventions remains limited. Moreover, few studies have systematically examined the joint impact of these interventions on multidimensional outcomes, such as cognitive-perceptual functions and behavioral regulation, in children with comorbid SLD and ADHD. Therefore, this study aims to evaluate the effects of methylphenidate combined with integrated training on learning ability, attention regulation, and behavioral outcomes in children with comorbid ADHD and SLD. The goal is to assess clinical efficacy and provide a theoretical and empirical basis for future interventions.

2. Methods

2.1. Participants

Fifty-five children aged 6 to 14 years with comorbid ADHD and SLD were recruited from the pediatric outpatient clinic of a tertiary care hospital in Guangzhou City between June 2020 and December 2023. All participants were diagnosed according to the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5) criteria. Inclusion criteria were: meeting the diagnostic criteria for comorbid ADHD and SLD; age between 6 and 14 years; and a Wechsler Intelligence Scale for Children (C-WISC) score above 70. Exclusion criteria included: severe organic pathologies and withdrawal from the study for any reason; or incomplete participation in the intervention process.

2.2. Study Design

This study employed a single-group, pre- and

post-intervention self-controlled design to implement a six-month combined intervention for children with comorbid ADHD and SLD, and to evaluate changes in relevant outcome measures before and after the intervention. All participants underwent assessments and data collection at baseline (pre-intervention) and at the end of the six-month intervention period. Pharmacological treatment consisted of methylphenidate hydrochloride controlled-release tablets, administered orally at a dose of 18 mg once daily. The non-pharmacological component included cognitive training and sensory integration training. Cognitive training focused primarily on enhancing visual and auditory perceptual abilities, delivered in 60-minute sessions, two to three times per week. Sensory integration training involved the use of various sensory aids, such as slides and balance boards, conducted in 30-minute sessions, two to three times per week. All interventions were delivered by trained professionals. Children's compliance and the quality of training sessions were recorded throughout the study to ensure consistency and reproducibility of the intervention protocol. The goal was to explore both cognitive-perceptual and behavioral outcomes within a multidimensional therapeutic framework.

2.3. Outcome Measures

In this study, three standardized assessment tools were used to evaluate changes in learning ability, attention-related behaviors, and overall behavioral characteristics before and after the intervention. All scales were completed by the children's primary caregivers (parents) under the guidance of healthcare professionals at baseline and after six months of treatment. The completeness and logical consistency of the responses were verified. Specifically, the Children's Learning Disability Characteristics Assessment Scale (CLDCAS) consists of 42 items across seven dimensions: visual perception [10], auditory perception, attention, comprehension, social adaptability, motor skills, and sensory integration. Each item is rated on a four-point scale (0–3), and mean scores are calculated for each dimension and for the total scale. A mean score greater than 1.5 is considered abnormal, with higher scores indicating more severe impairment. In addition, Chinese version of Swan-son Nolan and Pelham, version IV scale-parent form (SNAP-IV) [11] includes 26 items developed based on DSM-IV criteria, divided into three dimensions: inattention, hyperactivity-impulsivity, and oppositional defiance. Each item is scored from 0 to 3, with higher scores indicating more pronounced symptoms. Finally, the Conners' Parent Rating Scale–Revised Short Form (CPRS–R:S) [12] is a 6-item tool used to assess behavioral and emotional problems, such as attention deficits, impulsivity, and mood swings. It is also rated on a 0–3 scale, and mean scores are calculated, with scores above 1.5 considered abnormal. Pre- and post-intervention scores from all three scales were compared to assess the effectiveness of methylphenidate combined with integrated training in improving the symptoms of children

with SLD comorbid with ADHD.

2.4. Data Analysis

All data were analyzed using SPSS version 25.0. Continuous variables were expressed as mean \pm standard deviation ($\bar{x} \pm s$). To compare pre- and post-treatment results, the Shapiro–Wilk test was first conducted to assess the normality of paired data. If the data followed a normal distribution, a paired-samples t-test was applied; otherwise, the Wilcoxon signed-rank test was used. All statistical tests were two-tailed, and a P-value of < 0.01 was considered statistically significant. To ensure accuracy, all data were independently entered and cross-verified by two researchers.

3. Results

3.1. Participant Characteristics

A total of 55 children with SLD comorbid with ADHD were included in this study, comprising 40 boys and 15 girls, with a male-to-female ratio of 2.7:1. The participants ranged in age from 6 to 12 years, with a mean age of 8.56 ± 1.50 years. Regarding the manifestations of learning disabilities, the most common issues were attention deficits (48 cases, 87.3%), visual perceptual impairments (46 cases, 83.6%), comprehension difficulties (34 cases, 61.8%), auditory perceptual impairments (33 cases, 60.0%), poor social adaptability (29 cases, 52.7%), motor coordination deficits (26 cases, 47.3%), and sensory integration disorders (21 cases, 38.2%). Among the ADHD subtypes, the mixed type was most prevalent (38 cases, 69.1%), followed by the inattentive type (17 cases, 30.9%); no cases of the hyperactive-impulsive type were observed. According to the CPRS-R:S, 53 children (96.4%)

exhibited learning problems, 50 (90.9%) showed hyperactivity, 46 (83.6%) had impulsivity-hyperactivity traits, 30 (54.5%) had conduct problems, 19 (34.5%) had psychosomatic symptoms, and 9 (16.4%) displayed anxiety-related symptoms.

3.2. Comparison of Pre- and Post-Intervention Scores on the CLDCAS

Children showed statistically significant improvements in all seven dimensions of the CLDCAS—visual perception, auditory perception, social adaptation, comprehension, attention, motor skills, and sensory skills—as well as in the total score after the intervention ($P < 0.01$). Detailed results are presented in [Table 1](#).

3.3. Comparison of Pre- and Post-Intervention Scores on the SNAP-IV

Scores for attention deficit, hyperactivity-impulsivity, oppositional defiance, and the total score on the SNAP-IV rating scale significantly decreased after the intervention ($P < 0.01$). Detailed results are presented in [Table 2](#).

3.4. Comparison of Pre- and Post-Intervention Scores on the CPRS-R:S

The results of the Conners Parent Questionnaire showed significant reductions in all six dimensions—conduct problems, learning problems, psychosomatic symptoms, impulsivity-hyperactivity, anxiety, and the hyperactivity index—after treatment ($P < 0.01$). Detailed results are presented in [Table 3](#).

Table 1. Comparison of CLDCAS Scores at Baseline and Six-Month Follow-Up (Mean \pm SD, points).

Dimension	Visual Perception	Auditory Perception	Social Adaptation	Comprehension	Attention	Motor Skills	Sensory Integration	Total Score
Baseline	2.07 \pm 0.54	1.89 \pm 0.73	1.48 \pm 0.46	1.79 \pm 0.66	2.05 \pm 0.59	1.39 \pm 0.52	1.44 \pm 0.52	1.78 \pm 0.41
Six-Month Follow-Up	1.26 \pm 0.25	1.30 \pm 0.39	1.12 \pm 0.31	1.51 \pm 0.48	1.40 \pm 0.35	1.01 \pm 0.33	1.04 \pm 0.30	1.24 \pm 0.19
t-value	13.83	10.61	10.79	6.48	14.92	8.17	10.24	17.02
P-value	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

Table 2. Comparison of SANP-IV Scores at Baseline and Six-Month Follow-Up (Mean \pm SD, points).

Dimension	Inattention	Hyperactivity-impulsivity	Oppositional defiance	Total Score
Baseline	1.98 \pm 0.20	1.62 \pm 0.21	1.45 \pm 0.30	1.69 \pm 0.15
Six-Month Follow-Up	1.31 \pm 0.21	1.21 \pm 0.15	1.12 \pm 0.22	1.22 \pm 0.11
t-value	33.88	22.87	18.31	40.07
P-value	<0.01	<0.01	<0.01	<0.01

Table 3. Comparison of CPRS-R:S Scores at Baseline and Six-Month Follow-Up (Mean \pm SD, points).

Dimension	Conduct problems	Learning problems	Psychosomatic symptoms	Impulsivity-Hyperactivity	Anxiety	Hyperactivity Index
Baseline	1.49 \pm 0.23	1.97 \pm 0.37	1.28 \pm 0.40	1.71 \pm 0.36	0.94 \pm 0.41	1.76 \pm 0.23
Six-Month Follow-Up	1.28 \pm 0.20	1.38 \pm 0.33	1.13 \pm 0.33	1.33 \pm 0.36	0.83 \pm 0.38	1.31 \pm 0.22
t-value	12.84	13.53	5.56	9.10	5.18	19.42
P-value	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

4. Discussion

This study was grounded in a neurodevelopmental framework tailored to children with comorbid SLD and ADHD, conditions often characterized by deficits in executive function, attention regulation, and sensory processing. Barkley's model of executive dysfunction in ADHD emphasizes impairments in self-regulation and behavioral inhibition, which are strongly linked to underactivation of the prefrontal cortex [13]. Methylphenidate, a first-line pharmacological agent, enhances dopaminergic and noradrenergic transmission in the prefrontal cortex, thereby improving sustained attention and impulse control [13]. Meanwhile, the integrated training component of this study—comprising cognitive and sensory integration exercises—draws upon Ayres' sensory integration theory, which posits that structured, multisensory input promotes adaptive neurological responses and facilitates learning in children with sensory processing deficits [14]. By targeting both neurochemical and neurofunctional pathways, this combined intervention is designed to address the multidimensional impairments seen in SLD-ADHD comorbidity. The present retrospective pre-post design enabled a pragmatic evaluation of this dual-modality approach in a real-world outpatient setting. In this study, a single-group pre- and post-intervention self-controlled design was used to implement a six-month integrated training program combined with methylphenidate controlled-release tablets in 55 children with

comorbid ADHD and SLD. The results showed significant improvements in learning functions—particularly attention, visual perception, and comprehension—as well as behavioral performance, including reductions in impulsivity, hyperactivity, and learning-related problems. These findings suggest that the combined intervention holds promising clinical potential.

First, analysis of learning function deficits showed that children with SLD comorbid with ADHD exhibited the most prominent impairments in attention, followed by deficits in visual perception, comprehension, and auditory perception, while motor skills and sensory integration abilities were comparatively less affected. After the intervention, all seven dimensions assessed—attention, visual perception, comprehension, auditory perception, social adaptation, motor ability, and sensory integration—showed statistically significant improvements ($P < 0.01$), with the greatest gains observed in the core areas of attention and visual perception. These findings suggest a possible synergistic effect between the central neural activation induced by methylphenidate and the multi-modal stimulation provided by integrated training, enhancing cognitive processing and perceptual integration. However, improvements in motor coordination and sensory integration were relatively modest. Although statistically significant, the degree of change in these areas was less pronounced than in other dimensions, possibly reflecting more stable and persistent structural neurodevelopmental differences that are less responsive to short-term interventions. This

interpretation is consistent with previous research indicating that motor coordination disorders may have a long-term structural basis, limiting the efficacy of short-term training [15]. Therefore, clinical assessments and intervention strategies should prioritize core cognitive domains such as attention regulation, visual-perceptual processing, and language comprehension, while motor and sensory integration training should be incorporated into a sustained, long-term rehabilitation plan.

Secondly, the SNAP-IV scale data indicated significant improvements in the dimensions of inattention, hyperactivity-impulsivity, and oppositional defiance ($P < 0.01$), with the most pronounced change observed in inattention scores, which decreased notably from 1.98 ± 0.20 to 1.31 ± 0.21 after the intervention. This further supports the effectiveness of methylphenidate, a central nervous system stimulant, in managing core symptoms of ADHD—particularly inattention—consistent with findings from current mainstream clinical studies [16, 17]. In the present sample, the majority of children were diagnosed with the combined type of ADHD (69.1%), followed by the inattentive type (30.9%), with no cases of the hyperactive-impulsive type. These results align with previous studies indicating that children with comorbid SLD and ADHD are more likely to present with either the inattentive or combined subtype, while the purely hyperactive-impulsive presentation is relatively rare in clinical settings [18-20].

Finally, the results of the CPRS-R:S indicated that, in addition to improvements in hyperactivity, impulsivity, and learning problems, the children also showed significant enhancements in emotional and behavioral dimensions such as conduct problems, psychosomatic symptoms, and anxiety after the intervention. This “secondary improvement” may be attributed to increased self-confidence, self-efficacy, and social adaptability resulting from enhancements in core cognitive functions, suggesting that academic improvement may have a positive transfer effect on emotional and behavioral outcomes. Previous studies have suggested that executive function deficits in children with ADHD may be associated with underdevelopment of the prefrontal cortex [21-23]. Methylphenidate has been reported to enhance the synaptic activity of dopamine and norepinephrine, which may help regulate prefrontal cortical excitability and improve attention control and behavioral inhibition [21-23]. Additionally, sensory and cognitive training may stimulate relevant brain networks and promote neuroplasticity at both structural and functional levels, thus contributing to the improvement of cognitive and behavioral functions in children with ADHD [24, 25].

5. Conclusions

The study demonstrated that controlled-release methylphenidate tablets combined with comprehensive training produced significant therapeutic effects in children

with comorbid ADHD and SLD. After six months of intervention, the children showed marked improvements across multiple domains, including learning function, attention regulation, behavioral control, and emotional performance. Notably, core symptoms such as inattention, visual perception deficits, and hyperactivity-impulsivity improved significantly, with statistically significant reductions in assessment scale scores. These findings suggest that pharmacological treatment and integrated training may exert synergistic effects by targeting different neural mechanisms, thereby offering considerable clinical value in enhancing cognitive function and reducing behavioral difficulties in affected children.

6. Limitations

Despite the positive findings, this study has several limitations. First, it adopted a single-group pre-post design without a control group, which limits the ability to infer causality. Second, the sample size was small and drawn from a single center, raising concerns about potential selection bias and limiting the generalizability of the results. Third, the assessments relied primarily on subjective rating scales, lacking objective neurophysiological indicators to support the findings. Finally, the absence of long-term follow-up data prevents evaluation of the durability and developmental impact of the intervention. Future research should employ multicenter, randomized controlled trials with extended follow-up periods to further assess the efficacy, stability, and generalizability of this intervention strategy.

Abbreviations

ADHD	Attention Deficit Hyperactivity Disorder
SLD	Specific Learning Disorder
DSM-5	Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition
C-WISC	Chinese version of the Wechsler Intelligence Scale for Children
CLDCAS	<i>Children's Learning Disability Characteristics Assessment Scale</i>
SNAP-IV	Swanson, Nolan, and Pelham, version IV scale – Parent Form
DSM-IV	Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition
CPRS-R:S	Conners' Parent Rating Scale – Revised Short Form

Conflicts of Interest

The authors declare no conflicts of interest.

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