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Research Paper

Impact of a Polyherbal Intervention on Behavioural and Cognitive Functions in Neurodiverse Children- An Open Label Study

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ABSTRACT

Background: Attention Deficit Hyperactivity Disorder (ADHD) and Specific Learning Disorder (SLD) are prevalent neurodevelopmental disorders in children, frequently associated with impairments in behaviour, cognition, and adaptive and academic functioning. Conventional treatment strategies may not address all symptomatic dimensions and are often associated with adverse effects. This study evaluated the effectiveness of a polyherbal formulation (PHF) as a potential integrative therapeutic approach. **Aim:** To assess the impact of polyherbal formulation (PHF) on impulsivity, hyperactivity and inattention in neurodiverse children, with a focus on ADHD and SLD subtypes. **Materials and Methods:** A prospective open-label study conducted involving 30 children aged 3–12 years diagnosed with ADHD or SLD. Participants received polyherbal formulation (PHF) for two months in age-adjusted doses, administered thrice daily (6 a.m., 12 p.m., and 6 p.m.) with lukewarm water after meals. The formulation consisted of herbs traditionally used and pharmacologically validated for cognitive enhancement and behavioural regulation, including Withania somnifera (Rt), Glycyrrhiza glabra (Rt), Rauvolfia serpentina (Rt), and Nardostachys jatamansi (Rhz), prepared under GMP-compliant conditions. Pre and post intervention assessments were conducted using the Vineland Social Maturity Scale (VSMS), Binet-Kamat Test of Intelligence (BKT-IQ), ADHD Questionnaire (ADHD-Q), and Digit Span (Forward). Data were analysed using paired t-tests, with Pearson and Spearman correlations and Cronbach's alpha used to assess consistency and reliability. **Results and Conclusion:** Significant improvements were observed across all outcome measures: VSMS ($p < 0.001$), BKT-IQ, ($p < 0.001$), ADHD-Q ($p < 0.001$), and Digit Span ($p < 0.001$). High internal consistency and correlation coefficients reinforced the reliability of findings. The polyherbal formulation demonstrated significant improvements in core symptoms associated with ADHD and SLD, particularly in social functioning, cognitive performance, and working memory. These outcomes suggest that polyherbal formulation (PHF) with its holistic profile, favourable safety margin, and cost-effectiveness may serve as a complementary or alternative therapeutic modality in pediatric neurodevelopmental care.

Keywords: *Neurodevelopmental Disorders, Attention Deficit Hyperactivity Disorder, Specific Learning Disorder, Polyherbal formulation, Cognitive and behavioral outcomes*

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Neurodiversity denotes the variation in the human brain with regard to learning, sociability, mood, attention, and other mental functions in a non-pathological sense. Perceived as a natural phenomenon it can be defined as the diversity in the human cognitive processing or manner of making sense of the world that deviates from "typical" forms of thinking and being [1,2]. Presenting with unique cognitive and behavioral profiles, Attention-Deficit/Hyperactivity Disorder (ADHD), Specific Learning Disorders (SLD), and Autism Spectrum Disorders falls under this spectrum [3]. Among conditions underlying neurodiversity ADHD and SLD is more prevalent in childhood. ADHD is characterized by significant neurobehavioral challenges that impact cognitive, emotional, and social functioning with core symptoms include pronounced inattention, heightened distractibility, impaired impulse control, and hyperactivity [4]. While SLD manifest with impairment in difficulties in learning and academic skills, that impairs one or more aspects of academic functioning, including reading, writing and arithmetic reasoning [5]. Despite being classified as distinct entities, there exists a significant overlap in both the clinical presentations. Children with SLD frequently display attentional and executive function difficulties, and up to 45% of children with ADHD may also meet criteria for a learning disorder [6,7]. These dimensions have a widespread impact and significantly limit a child's functioning, influencing their social interactions, academic performance, and family dynamics. Conventional management strategies, such as stimulant medications for ADHD and academic interventions for SLD, have proven benefits but are associated with limitations like side effects, partial responses and the need for long-term adherence can be challenging for families and clinicians alike [8]. Moreover, interventions that address both behavioural dysregulation and cognitive inefficiency simultaneously are limited in scope [9]. In the light of these constraints, there is a growing interest in integrative and holistic approaches that offer broader therapeutic coverage with improved tolerability. Among these, herbal preparations have gained increasing attention for their ability to modulate neurological pathways through phytochemicals that support overall cognitive and behavioral regulation [10]. Several research studies with herbal formulations have shown promising effects in improving attention, working memory, neuroprotection, and behavioural control [11,12]. Their multi-targeted mechanisms may offer integrative benefits with reduced side effects compared to single-agent pharmacological treatments [10]. The present study inquires the impact of a polyherbal formulation (PHF), on core symptoms of inattention and impulsivity, as well as cognitive and social functioning in neurodiverse children diagnosed with ADHD and SLD. By using validated tools such as the Vineland Social Maturity Scale (VSMS), Binet-Kamat Test of Intelligence (BKT-IQ), ADHD Test Performa, and Digit Span Test, the study aims to assess the clinical utility of Polyherbal compound (PHF) as a potential auxiliary therapy to intensify the outcomes in this vulnerable population.

METHODOLOGY

This open-label, prospective, interventional study was conducted over two months at ATIDHI Vazhiyambalam, (Ayurveda and Therapeutic Integration for Developmental Habilitative Intervention), a specialized Ayurvedic center in Kerala, India, offering therapeutic interventions for children with neurodevelopmental disorders such as ADHD, SLD, ASD etc. As an open-label design, the absence of blinding introduces the potential for observer or participant bias; however, standardized assessment tools and blinded evaluators were used during outcome measurement to mitigate this limitation. The study aimed evaluate the effects of a polyherbal formulation (PHF) on behavioural and cognitive functioning in neurodiverse children diagnosed with Attention-Deficit/Hyperactivity Disorder (ADHD) and Specific Learning Disorder (SLD). Based on inclusion and exclusion

criteria a total of 30 children between the ages of 3 and 12 years were selected. Inclusion criteria were: (1) a formal diagnosis of ADHD or SLD according to DSM-5 criteria, (2) age between 3 and 12 years, and (3) presence of symptoms such as inattention, impulsivity, or learning difficulties reported by caregivers and confirmed by clinicians. Exclusion criteria included: (1) major neurological disorders such as epilepsy, cerebral palsy, bipolar Disorder, IDD (2) severe psychiatric illness such as psychosis or autism spectrum disorder, (3) current use of stimulant or antipsychotic medications, (4) Known cases of any acute or chronic illnesses e.g GE, TB and malignancy Diagnosis of each participant were confirmed based on DSM-5 criteria by qualified psychologists. A written informed consent was obtained from parents or legal guardians prior to participation. The intervention consisted of a polyherbal formulation (PHF) administered in appropriate dose based on their respective age thrice daily after food at 6am and 12pm and 6pm with a glass of lukewarm water for 2 months. The formulation comprised herbs traditionally indicated and therapeutically validated for cognitive enhancement and behavioural regulation including drugs Withania somnifera(Rt), Glycyrrhiza glabra (Rt), Rauvolfia serpentina (Rt) and Nardostachys jadamanji(Rhz). The dosage of the polyherbal formulation was determined based on principles outlined in the Sarangadhara Samhita, a classical Ayurvedic text widely used in pharmaceutics for its standardized guidelines on dosage forms and age-adjusted administration. Specifically, the formulation followed the Churna Kalpana (powder preparation) model described in the text, which provides dosage recommendations based on developmental stage and body constitution. Age-adjusted doses were assigned accordingly, ensuring traditional accuracy and clinical safety. Details of the dosing schedule stratified by age are provided (See.Table.1) to support transparency and reproducibility. No other pharmacological interventions were administered during the study period. (PHF) was prepared under GMP-compliant conditions. No other pharmacological interventions were provided during the study period. To evaluate the outcomes, participants were assessed at before and after the treatment with polyherbal formulation (PHF) using four validated tools like Vineland Social Maturity Scale (VSMS) to assess social and adaptive functioning; the Binet-Kamat Test of Intelligence (BKT-IQ) to evaluate general cognitive abilities; the ADHD Test Performa (ADHD-Q**)** to quantify core ADHD symptoms including inattention, impulsivity, and hyperactivity; and the Digit Span Forward Test, a subtest of working memory assessing auditory attention and immediate recall. All assessments were conducted in a structured, distraction-free environment by trained evaluators who were blinded to the purpose of the intervention. Statistical analysis was performed using IBM SPSS Statistics version 25. Paired t-tests were used to compare pre- and post-treatment scores across all outcome measures. A significance level (α) of 0.05 was set for all statistical tests, and results with $p < 0.05$ were considered statistically significant. scores across the outcome measures.

Table No.1 Dose of Drug in age groups according to Sharangadhara Samhitha

Sl.no	Age	Dose (in grams)
1	3yrs	4.5 gram
2	4yrs	6 gram
3	5yrs	7.5 gram
4	6yrs	9 gram
5	7yrs	10.6 gram
6	8yrs	12 gram
7	9 yrs	13.5 gram
8	10yrs	15 gram
9	11yrs	16.5 gram
10	12yrs	18 gram

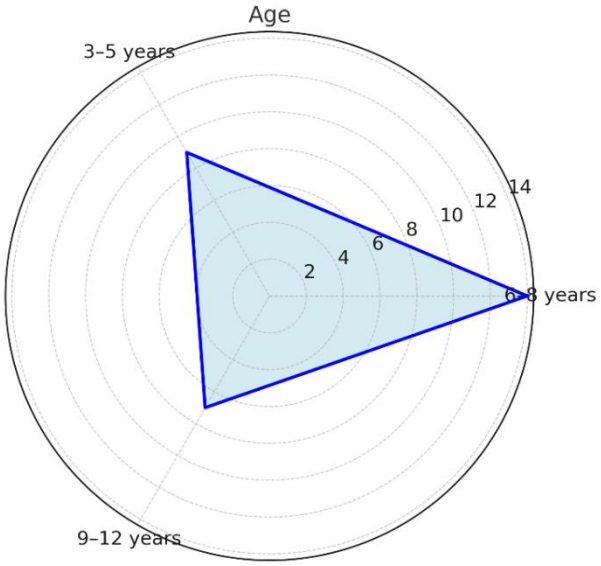
Observations

1. Sociodemographic profile of the study population

A. Distribution of children according to age

The age distribution among the 30 children reveals that the majority fall within the 6–8 years' age group, accounting for 46.7% of the sample. This is followed by 30% of children aged between 3–5 years, and 23.3% belonging to the 9–12 years' group.

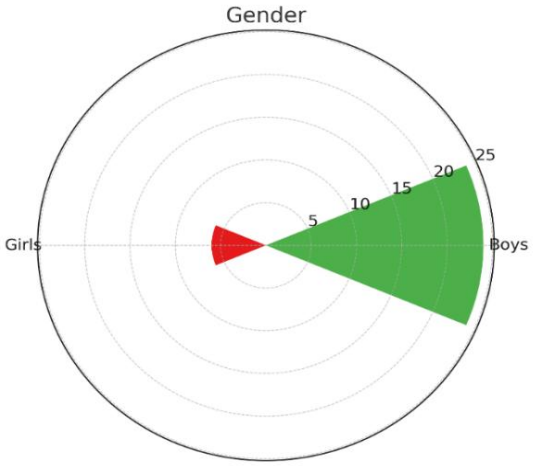
Figure No: 1 Age wise distribution of children



B. Distribution of children according to Gender

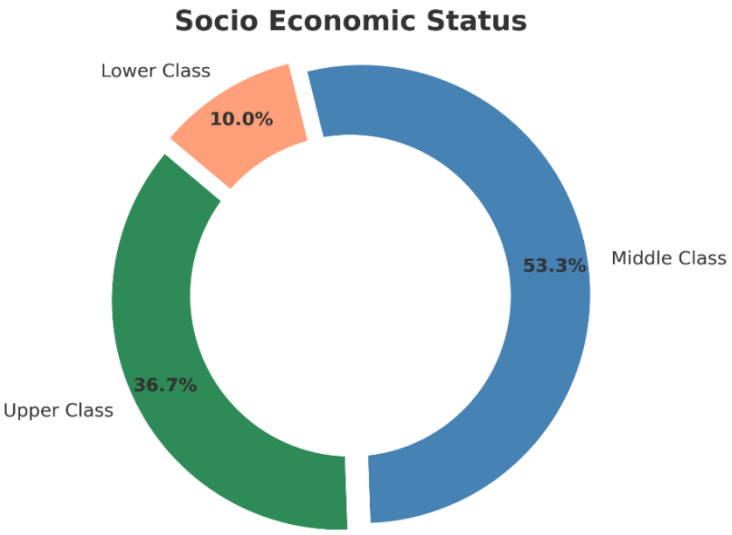
The majority of the children were boys (80%), while girls accounted for 20% of the study population.

Figure No: 2 Gender wise distribution of children



C. Distribution of children according to Socio -Economic status
Out of the 30 children studied the majority of the children (53.3%) belonged to the middle class, followed by 36.7% from the upper class and 10% from the lower class.

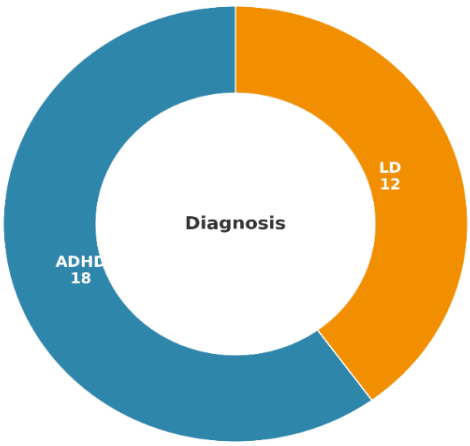
Figure No: 3 Socio-Economic wise distribution of children



2. Data relating to Clinical Profile of the Study Population

A. Data relating to clinical diagnosis
Among the 30 children studied, 60% were diagnosed with Attention Deficit Hyperactivity Disorder (ADHD) and 40% were diagnosed with Learning Disability (LD)

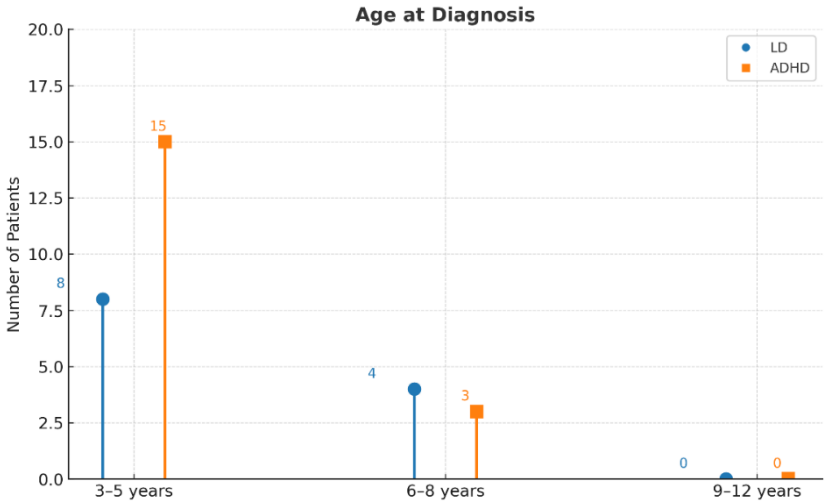
Figure No: 4 Diagnosis wise distribution of children



B. Data relating to Age at Diagnosis
Among children diagnosed with Learning Disability (LD), 66.7% were diagnosed between 3–5 years of age, and 33.3% were diagnosed between 6–8 years of age. No children with LD were diagnosed between 9–12 years of age. For Attention Deficit Hyperactivity Disorder

(ADHD), 83.3% were diagnosed between 3–5 years of age, while 16.7% were diagnosed between 6–8 years of age. No cases were diagnosed in the 9–12 years age group.

Figure No: 5 Age at Diagnosis wise distribution of children



RESULTS

I. Data relating to Outcome Measures and Statistical Findings

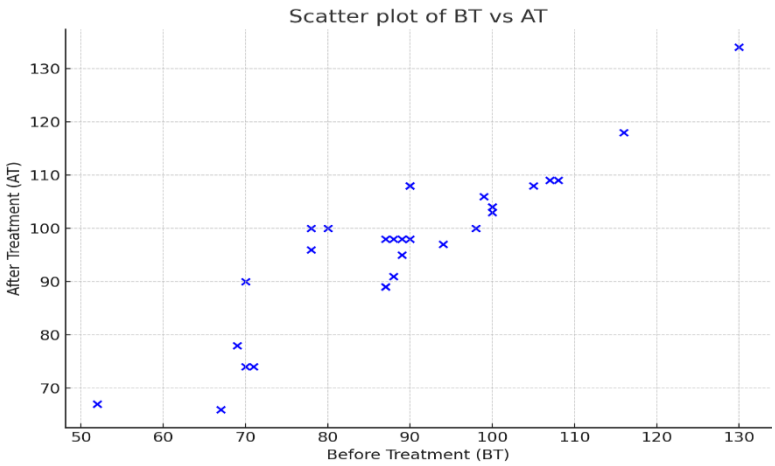
A total of 30 children participated in the study, including individuals diagnosed with ADHD, SLD. However, not all outcome tools were administered to every participant. The BKT-IQ was conducted in a subset of 20 children, based on clinical need and appropriateness for cognitive profiling. Similarly, the ADHD Questionnaire (ADHD-Q) was administered to 18 children who met formal diagnostic criteria for ADHD; children with only SLD were excluded from this particular assessment. These stratified assessments ensured the relevance of each tool to the specific neurodevelopmental profile of the child

A. Statistical Analysis of VSMS Scores

Table no 2. Statistical Analysis of VSMS Scores

Metric	**Value**
Mean BT	89.23
Mean AT	96.97
N (sample size)	30
SD BT	16.14
SD AT	14.63
SEM BT	2.95
SEM AT	2.67
t value (paired)	-6.21
p value	< 0.001
Cronbach's alpha	0.948
Pearson correlation	0.906
Spearman correlation	0.877

Figure No 6 Scatter plot showing correlation of VSMS Scores before treatment and after treatment

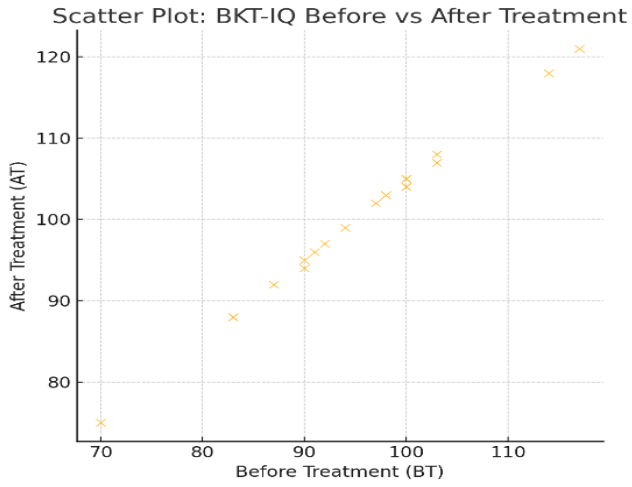


B. Statistical Analysis of BKT scores

Table no 3. Statistical Analysis BKT Scores

Metric	Value
Mean BT	95.50
Mean AT	100.20
N (sample size)	20
SD BT	10.62
SD AT	10.38
SEM BT	2.38
SEM AT	2.32
t value (paired)	44.71
p value	<0.001
Cronbach's alpha	0.9999
Pearson correlation	0.9999
Spearman correlation	0.9996

Figure No 7. scatter plot showing correlation of BKT Scores before treatment and after treatment



C. Statistical Analysis of ADHD-Q Scores

Table no 4. Statistical Analysis ADHD-Q Scores

Measure	Value
Mean BT	94.42
Mean AT	90.00
N (Sample size)	19
SD BT	10.70
SD AT	11.05
SEM BT	2.46
SEM AT	2.53
t-value	7.27
p-value	<0.001
Cronbach's Alpha (internal consistency)	0.985
Pearson Correlation (linear)	0.971
Spearman Correlation (rank)	0.973

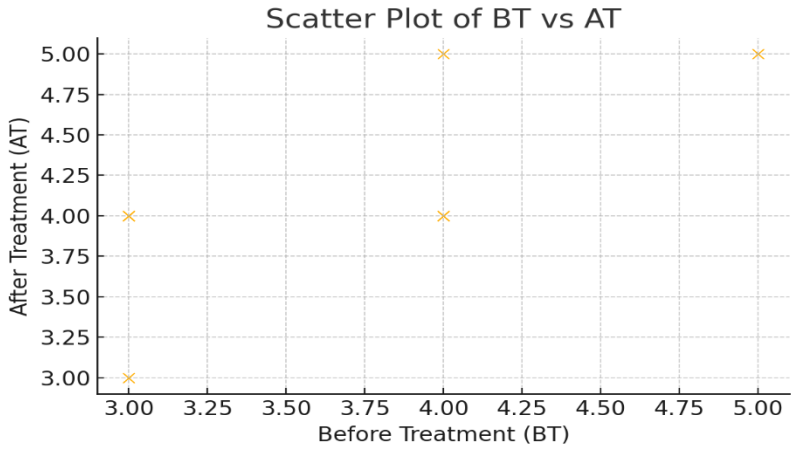
Figure No 8 Scatter plot showing correlation of ADHD-Q Scores before treatment and after treatment

D. Statistical Analysis of Digit span test (Digit Forward scores)

Table no 5. Statistical Analysis Digit Span Test Scores

Measure	Value
Mean BT	3.67
Mean AT	4.10
N	30
SD BT	0.66
SD AT	0.55
SEM BT	0.12
SEM AT	0.10
t-value	-4.71
p-value	<0.001
Cronbach's alpha	0.79
Pearson correlation	0.67
Spearman correlation	0.64

Figure No 9 Scatter plot showing correlation of digit span score before treatment and after treatment



DISCUSSION

This study evaluated the effect of a polyherbal formulation (PHF) on core cognitive and behavioural symptoms in children diagnosed with ADHD and SLD. The results demonstrate a statistically significant and clinically meaningful improvement across several domains, including adaptive behaviour, cognitive function, attention, and working memory. These outcomes support the potential role of the polyherbal formulation in managing neurodevelopmental disorders. However, the study employed as an open label design, the possibility of the placebo effect and the observer bias cannot be entirely ruled out, these factors need to be considered while interpreting the observed results.

The age distribution observed in the study highlights a positive shift toward early diagnosis. Nearly half of the children were between 6–8 years, with a notable 30% identified between 3–5 years—substantially earlier than the national average of 7–9 years for ADHD and ASD diagnosis [13]. This trend likely reflects increased awareness among caregivers and educators, and may also be attributed to Kerala's robust public health infrastructure, which emphasizes early developmental surveillance [14,15]. Early identification is crucial, as interventions initiated in the preschool years have been shown to yield better long-term outcomes across cognitive, behavioural, and academic domains [16,17].

The male predominance (80%) observed in the cohort aligns with established epidemiological data indicating higher prevalence rates of ADHD, ASD, and learning disabilities in males [18,19]. This consistency with global patterns enhances the external validity of the sample. However, the socioeconomic profile dominated by middle and upper class families likely reflects barriers to access for lower-income groups due to the cost of care at the study center. This selection bias may limit the generalizability of the findings to the broader population and highlights the need for more inclusive sampling in future research [20,21].

It is important to note that outcome measures such as the BKT-IQ and ADHD-Q were not administered to all participants. The BKT-IQ was applied to a subset of 20 children for whom a comprehensive cognitive assessment was deemed clinically appropriate. Likewise, the ADHD-Q was completed by 19 children who met diagnostic criteria for ADHD, with those diagnosed exclusively with SLD excluded from this assessment. While this selective

application of tools may limit comparability across the entire sample, it was essential to maintain diagnostic relevance and methodological rigor.

The findings from the report clearly demonstrate that there was a notable improvement in VSMS scores following treatment. The mean value after treatment was substantially higher than the mean before treatment, suggesting that the intervention had a positive impact. This numerical difference was further supported by statistical testing: the paired t-test revealed a highly significant difference between the BT and AT scores, as evidenced by a very low p-value, well below the standard threshold of 0.05. Therefore, it can be confidently concluded that the observed improvement is unlikely due to random chance and is statistically significant. The high value of Cronbach's alpha (0.948) indicates excellent internal consistency between the BT and AT measures, implying that the data collected is highly reliable and consistent across participants. This reliability strengthens the trustworthiness of the findings. Furthermore, the strong positive correlations found through both Pearson and Spearman coefficients suggest that individuals who initially performed better also tended to perform better after treatment, maintaining a consistent relative ranking. This indicates that while there was a general increase in scores, the treatment effect was fairly uniform across different individuals, rather than benefiting only a specific subset of the group. This significant improvement in VSMS scores post-treatment may reflect enhanced emotional regulation and interpersonal functioning, potentially influenced by the combined effects of Withania somnifera and Nardostachys jatamansi. Withania modulates the hypothalamic-pituitary-adrenal axis and enhances GABAergic signaling thereby reducing anxiety and promoting emotional stability [22]. Meanwhile, Jatamansi with its antioxidant property and action in serotonergic pathways might have resulted in reduction in restlessness and supporting mood balance [23]. These effects likely contributed to the children's improved adaptive behaviour, social engagement, and emotional control as captured by the Vineland Social Maturity Scale.

The findings from the analysis clearly demonstrate a significant improvement in BKT-IQ scores following treatment. The post treatment mean score has increased indicating that the intervention had a positive effect on cognitive performance. The consistency in the standard deviation, which remained around 10.6 at both time points, indicates that the variability in individual scores was stable, suggesting the treatment effect was relatively uniform across participants. The paired t-test results ($t = 44.71$, $p < 0.001$) confirmed that this improvement was statistically significant, demonstrating that the observed change is unlikely to be due to chance and supports the effectiveness of the intervention. Furthermore, the exceptionally strong positive correlations between pre- and post-treatment scores, with Pearson's $r = 0.999$ and Spearman's $\rho = 0.996$, indicate that individual differences were maintained consistently over time, meaning those who scored higher before treatment tended to remain higher after treatment. This also underscores the reliability of the measurement. Supporting this, Cronbach's alpha was found to be 0.999, reflecting excellent internal consistency of the BKT-IQ test across the two time points. Overall, these results suggest that the treatment led to a meaningful and reliable improvement in the cognitive abilities of the children assessed. This statistically significant increase in the Binet-Kamat Test of Intelligence (BKT-IQ) IQ scores after treatment may be attributed to the nootropic effects of Withania and Glycyrrhiza glabra. Withania enhances the synaptic plasticity and supports hippocampal function essential for learning and memory consolidation [24]. Modulating the GABAergic system, Glycyrrhiza, promotes mental clarity and attention span [25]. Jatamansi can contribute to cognitive stability by protecting neurons from oxidative stress [26].

The results of the analysis of (ADHD-Q) scores strongly suggest that the treatment led to a statistically significant and practically meaningful improvement in scores. The reduction in the mean score from BT to AT highlights the effectiveness of the intervention. The high Cronbach's alpha value (0.985) confirms the excellent internal consistency of the measurements, ensuring the reliability of the data collected. The strong Pearson and Spearman correlations indicate that while scores generally improved, the order of performance among individuals remained consistent, suggesting a uniform treatment effect across the sample. The highly significant t-test result further supports the conclusion that the observed improvement is unlikely to have occurred by chance. Overall, the findings affirm that the intervention was effective and that the measurement tools used were both consistent and robust. This decline in scores of (ADHD-Q) post-treatment suggests behavioural regulation. This might be due to the action of serpentine, an active constituent in Rauvolfia and modulation of the neurotransmitters involved in arousal and impulsivity by Withania. Reserpine, an active compound present in Rauvolfia, can alter catecholamine storage, potentially reducing hyperactivity and aggression when used in appropriate doses [27]. The adaptogenic effects of Withania may have contributed in reducing the behavioral volatility and emotional lability [28].

Finally, the treatment led to a statistically significant improvement in the Digit Span scores, as evidenced by the significant t-test results and the increase in mean scores. The high Cronbach's alpha (0.79) suggests good internal consistency between the before and after treatment scores, while the moderate to high Pearson and Spearman correlations indicate that participants who performed better before treatment tended to perform better after treatment as well. This supports the effectiveness of the treatment in enhancing working memory capacity. The improvement in Digit Span Forward scores, which reflect working memory and auditory attention, aligns with the cognitive-enhancing potential of Glycyrrhiza and Jatamansi. Licorice root has demonstrated effectiveness in improving short-term memory and attention via GABA modulation [29]. Jatamansi through its neuroprotective and antioxidant effects supports attentional stability [26].

Together, these findings suggest that polyherbal formulation (PHF) offers multi-domain cognitive and behavioral support by targeting multiple neurochemical and neurodevelopmental pathways. The polyherbal herbal design enables it to simultaneously enhance executive function, regulate the functions like mood and arousal, and improve social and adaptive skills that are typically impaired in children with ADHD and SLD. Together, these findings suggest that the polyherbal formulation (PHF) offers multi-domain cognitive and behavioral support by targeting multiple neurochemical and neurodevelopmental pathways. Its multi-herbal design may enable it to simultaneously enhance executive function, regulate mood and arousal, and improve social and adaptive skills areas commonly impaired in children with ADHD and SLD. To build on these promising results, future research should aim for more inclusive and diverse sampling to enhance generalizability. Rigorous randomized controlled trials (RCTs) are needed to address the inherent limitations of the current open-label design and confirm the observed effects under blinded conditions. Longitudinal studies with extended follow-up periods would help assess the durability and long-term safety of the intervention. Further, isolating the specific contributions of individual herbs within the formulation could offer insight into the mechanisms of action. Finally, identifying potential biomarkers correlated with clinical improvement may advance the development of more targeted, personalized treatment strategies.

CONCLUSION

Despite the encouraging outcomes observed in this open-label study, the relatively small sample size and the specific socioeconomic background of participants necessitate cautious interpretation. Nonetheless, the polyherbal formulation (PHF) shows potential as an integrative therapeutic option for managing core symptoms in children with ADHD and SLD. Improvements noted in social functioning, cognitive abilities, and working memory suggest a multi-targeted mechanism of action. The statistically significant gains across standardized tools including the VSMS, BKT-IQ, ADHD-Q, and Digit Span tests support the potential of this formulation as an adjunctive or alternative therapy in pediatric neurodiversity. Its holistic, safe, and potentially cost-effective profile highlights the value of traditional Indian medicine in addressing complex neurodevelopmental conditions. To strengthen these preliminary findings, future research should involve larger, more diverse populations and employ rigorous randomized controlled designs. Such studies are essential to validate the efficacy, safety, and generalizability of this approach, and to further explore its role in clinical practice.

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Conflict of Interest

The author(s) declared no conflict of interest.

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