Original Article

Status of micronutrients and their relation with cognition level among children with attention deficit hyperactivity disorder

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ABSTRACT

Background: *Attention deficit hyperactivity disorder (ADHD) is a prevalent, multifactorial and highly hereditary neuropsychiatric disorder affecting 8-12% of children globally, characterized by inattention, hyperactivity, impulsivity and cognitive impairments. Poor dietary habits contribute to nutritional imbalances, which potentially worsen ADHD symptoms, emphasizing the importance of nutrition management in treatment. This study aimed to explore any nutritional imbalances in children with ADHD and evaluate their cognitive levels, which could have significantly supported their treatment.*

Methods: *The study was an observational one, done in 2020, involving 63 participants (43 ADHD cases and 20 healthy controls). The ADHD cases were children, aged 1–18 years from the outpatient department (OPD) of the Institute of Paediatric Neurodisorder and Autism (IPNA) at Bangabandhu Sheikh Mujib Medical University (BSMMU), diagnosed based on DSM-5 criteria. The control group consisted of healthy children from Kazipara, Dhaka matched for age and socio-economic status. After selection, blood samples were collected and analyzed for zinc, magnesium, iron and vitamin D levels at the BSMMU biochemistry laboratory. An assigned psychologist assessed the cognitive levels of the participants.*

Results: *For ADHD children, serum zinc level (M±SD) was 100.30±31.24 micro-g/dl, magnesium level was 1.98±.54 mg/dl, iron level was 59.30±24.09 micro-g/dl and vitamin D was 22.09±6.90 ng/dl. Among ADHD children, 14% had serum zinc levels below the normal range, whereas 10% of normal children had below normal zinc levels. Surprisingly, 37% of ADHD children had serum zinc levels above the normal range. Regarding serum magnesium, 12% of ADHD children had levels below normal, while 10% of normal children had levels above normal. For serum iron, 70% of ADHD children had below normal levels, compared to 35% of normal children. Regarding serum vitamin D, only 9% of ADHD children had levels below the normal range, whereas 35% of normal children had low levels. A significant association was found between low IQ levels and low serum vitamin D levels, when Vit D level. Other micronutrients did not have any association with congnitive levels.*

Conclusion: *The study found that children with ADHD had different plasma concentrations of zinc, magnesium, iron and vitamin D compared to typically developing children. There was significant association between low IQ level and vitamin D but not with other micronutrients.*

Key words: *attention-deficit hyperactivity disorder, micronutrients, cognition level.*

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INTRODUCTION

Attention deficit hyperactivity disorder (ADHD) is a prevalent neurodevelopmental disorder affecting 8-12% of children globally, characterized by inattention, impulsivity and hyperactivity.[1] While pharmacological and behavioral interventions provide short-term symptom relief, their long-term effectiveness remains uncertain and concerns about adverse effects, including growth retardation and cardiovascular risks, have prompted the search for alternative treatments.[2] Diet and nutrition play a crucial role in brain function and may contribute to ADHD symptoms.[2] Studies have shown differences in dietary patterns between children with ADHD and their neurotypical peers, with growing evidence linking micronutrient deficiencies to the disorder.[1] Essential nutrients such as zinc, iron, magnesium and vitamin D have been implicated in ADHD pathophysiology. Zinc, for instance, regulates dopamine levels and may enhance the efficacy of stimulant medications.[2] Iron deficiency, particularly lower ferritin levels, has been associated with ADHD symptoms and supplementation has shown potential benefits, though excessive intake can be harmful.[1] Magnesium supports neurotransmitter function and has a calming effect, while vitamin D is linked to dopamine and serotonin regulation, influencing mood and cognitive function.[1]

The effectiveness of micronutrient supplementation in ADHD remains inconclusive, with varying responses based on baseline nutrient levels and coexisting conditions.[1] Observational studies suggest correlations between diet and ADHD symptoms but do not establish causality. Screening for micronutrient deficiencies before treatment may improve management strategies.[1] Since ADHD diagnosis relies on behavioral assessments rather than cognitive evaluation, addressing cognitive impairments alongside nutritional interventions could optimize treatment outcomes.[1] This study was done with aims to assess micronutrient levels in children with ADHD, compare them with neurotypical peers and explore their association with cognitive function to enhance management approaches.

METHODS

An observational study was conducted over the course of one year (January–December 2020) following the receipt of a research grant from Bangabandhu Sheikh Mujib Medical University (BSMMU). Children with ADHD were selected as cases from the outpatient department (OPD) of the Institute of Paediatric Neurodisorder and Autism (IPNA) at BSMMU, where patients regularly visit for the diagnosis, assessment and management of various neurodevelopmental disorders. The comparison group comprised children of the same age group and similar socio-economic backgrounds who screened negative for any neurological disabilities using the Red Flag screening tool. The sample size consisted of 63 participants, ranging in age from 1 to 18 years.

Study procedure

The ADHD group consisted of children (aged 1–18 years) who visited the OPD of IPNA, BSMMU and had a confirmed diagnosis of ADHD (according to DSM-5 criteria[3]), with or without comorbidities, as determined by a clinical psychologist at IPNA, BSMMU. The comparison group was selected from Sunlight Kindergarten School, West Kazipara, Mirpur, Dhaka.

Written informed consent was obtained from the parents of the selected children (both ADHD and neurotypical). Blood specimens were collected by a designated pathology technician under appropriate safety precautions and sent to the biochemistry laboratory for analysis of serum levels of zinc (Zn), magnesium (Mg), iron (Fe) and vitamin D (vit D). These assessments were conducted using an automated analyzer, the Atellica machine from Siemens, Germany. The reference ranges for normal serum levels were as follows: zinc (68–107 ìg/dl), magnesium (1.60–2.60 mg/dl), iron (65–175 ìg/dl) and vitamin D (20–50 ng/ml). Psychological assessments were conducted by a psychologist assigned by IPNA to evaluate the cognitive levels of children with ADHD.

Ethical consideration

Ethical approval for the study was obtained from the Institutional Review Board of BSMMU (IRB No. BSMMU/2020/559) and done by BSMMU Research Grant, 2021-2022 (BSMMU/2022/5314(25). The study's purpose and procedures were explained to the parents or guardians of children with ADHD and written informed consent was obtained. Confidentiality was maintained and potential risks were considered.

RESULTS

Total study participants were 63, 43 were ADHD group and 20 were for comparison. Base-line characteristics are show in in Table I. Education levels and income of parents are also shown in Table I. Among 43 ADHD children, 30 (70%) had normal level of IQ. There was significant association with low IQ and vitamin D level but no significant association was with other micronutrients (Table II).

Table I. General characteristics of study participants

Variables		Frequency ADHD (43)/ comparison (20) group	Percentage ADHD/comparison group
Sex of children	Male	34/12	79/60
	Female	9/8	21/40
Age of children	1-4 years	2/4	5/20
	5-8 years	33/3	77/15
	9 years & above	8/13	18/65
Father's education	Illiterate	1/2	2/10
	Primary	5/3	12/15
	Secondary	6/8	14/40
	Higher secondary	16/1	37/5
	Graduation and above	15/6	35/30
Mother's education	Illiterate	2/4	4/20
	Primary	2/4	5/20
	Secondary	12/4	28/20
	Higher secondary	12/3	28/15
	Graduation and above	15/5	35/25
Father's occupation	Agriculture	2/0	5/0
	Business	9/11	21/55
	Service holder	2/3	4/15
	Others including working abroad	30/6	70/30
Mother's occupation	Agriculture	0/0	0/0
	Business	0/0	0/0
	Service holder	8/5	18/25
	Home maker	35/13	82/65
Family monthly income (in Taka)	<20,000	18/9	42/45
	20,000-59,000	24/8	56/40
	>60,000	1/3	2/15
Housing status of the parents	Own house	20/6	46/30
	Govt. house	2/1	5/5
	Rented house	21/13	49/65

Table II. IQ level with serum zinc, magnesium, iron and vitamin D level of ADHD children (n=43)

IQ level	S.Vit. D level (ng/dl)				T.Zinc level (micro-g/dl)				S.Mg level (mg/dl)			S. Iron level(micro-g/dl)		
	<10	10-30	30-100	P-value	<68	68-107	>107	P-value	<1.7	1.7-2.7	P-value	<70	70-180	P-value
Normal	4	25	1		3	14	13		2	28		20	10	
Mildly low	0	9	0	.006	2	5	2	.691	2	7	.302	8	1	2.96
Significantly low	0	2	2		1	2	1		1	3		2	2	

Table III. Comparison of micronutrients status of study participant (ADHD/comparison group) (n=43/20)

Micro-nutrients	Within normal range		Below normal range		Above normal range		
	Frequency (ADHD/ comparison group)	Percent (ADHD/ comparison group)	Frequency (ADHD/ comparison group)	Percent (ADHD/ comparison group)	Frequency (ADHD/ comparison group)	Percent (ADHD/ comparison group)	(ADHD group/ comparison) (M±SD)
S. Zinc (68–107 µg/dl)	21/17	49/85	06/02	14/10	16/01	37/5	(100.30±31.24/ 100.40±30.20)
S.Mg (1.7–2.7 mg/dl)	38/18	88/90	05/0	12/0	0/02	0/10	(1.98±.54/ 2.58±.16).
S. Iron (70-180 µg/dl)	13/13	30/65	30/07	70/35	0/0	0/0	(59.30+24.09/ 77.75±12.88)
S.Vit D (10-30 ng/ml)	36/13	84/65	04/07	09/35	03/0	07/0	(22.09±6.90/ 72.25±33.19)

Among the ADHD cases, 49% had serum zinc levels within the normal range, 37% were above and 14% were below normal (Table III). In contrast, 85% of the controls had normal serum zinc levels, with only 5% above and 10% below normal. Regarding serum magnesium, 88% of the cases had levels within the normal range, while 12% were below normal, compared to 90% of controls within the normal range and 10% above normal. For serum iron, 70% of the cases had below normal levels, while 30% had normal levels; conversely, 65% of the controls had normal iron levels and 35% were below normal. For serum vitamin D, 84% of the ADHD cases had normal levels, 9% were below normal and 7% were above normal, while 65% of the controls had normal levels, with 35% below normal (Table III).

DISCUSSION

Emerging research highlights the potential role of micronutrients—specifically iron, zinc and vitamin D—in the management of ADHD. Children with ADHD often exhibit lower levels of these essential nutrients compared to their neurotypical peers. Addressing these deficiencies may offer therapeutic benefits for certain individuals.

Iron and zinc are crucial for optimal neurological function. Iron is integral to dopamine metabolism, a neurotransmitter associated with attention and behavior regulation, while zinc contributes to neurotransmitter synthesis and modulation. Systematic review of randomized clinical trials assessed the efficacy of iron and zinc supplementation in children and adolescents with ADHD.[4,5] The findings indicated that supplementation over 6 to 12 weeks was associated with improvements in ADHD severity compared to placebo. However, the effect sizes were modest and benefits varied across specific ADHD symptoms and measures, with zinc showing more consistent results.[6]

Vitamin D plays a pivotal role in brain development and function. A meta-analysis of four randomized controlled trials involving 256 children examined the effects of vitamin D supplementation as an adjunct to methylphenidate, a common ADHD medication. The results demonstrated a small but statistically significant improvement in total ADHD scores, hyperactivity, inattention and behavior. However, the quality of evidence was limited, suggesting the need for further research to substantiate these findings.[7]

While the current evidence suggests that supplementation with iron, zinc and vitamin D may benefit certain subgroups of children with ADHD, it is imperative to approach supplementation cautiously. Healthcare professionals should consider assessing the nutritional status of individuals with ADHD and address any deficiencies as part of a comprehensive management plan. Routine screening for these micronutrient levels can help identify candidates who might benefit from supplementation. Nonetheless, supplementation should be personalized and conducted under medical supervision to avoid potential adverse effects associated with excessive intake. Maintaining optimal levels of iron, zinc and vitamin D is essential for individuals with ADHD. While supplementation shows promise, further high-quality research is necessary to

establish definitive guidelines and to identify which individuals are most likely to benefit from such interventions.

Limitations

The study encountered several limitations. The sample size was confined to 63 participants, which may limit the generalizability of the results.

Conclusion

The study suggests that children with ADHD have altered plasma levels of zinc, magnesium, iron and vitamin D compared to normal controls, potentially influencing cognitive function. A notable percentage of ADHD children displayed abnormal zinc and iron levels, with 70% having below-normal iron levels. In contrast, a higher proportion of normal children had low vitamin D levels and low IQ was linked to low vitamin D levels. There was no significant association with low IQ and other micronutrients levels. These findings may inform treatment strategies for children with ADHD and benefit the community, although larger studies are needed for further confirmation.

Authors' contribution: JS and MFUR developed the original idea and wrote the protocol and analyzed data. MS collected data, analyzed data and reviewed writing.

Conflict of interest: Nothing to declare.

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