Open Access

Journal of the Faculty of Medicine Baghdad
Print ISSN: 0041-9419, Online ISSN: 2410-8057
DOI: https://doi.org/10.32007/jfacmedbaghdad3225 .

Research Article

Evaluation of Serum Copper, Zinc, Iron, and Calcium Levels among Children with Autism Spectrum Disorder and Attention-Deficit/ Hyperactivity Disorder in Baghdad

Ahmed S. Swadi*[1], Hedef D. EI-Yassin[1], Mushtaq T. Hashim[2]

[1]*Department of Biochemistry, College of Medicine, University of Baghdad, Baghdad, Iraq.*
[2]*Department of Internal Medicine, College of Medicine, University of Baghdad, Baghdad, Iraq.*

Received: Nov. 2025
Revised: Jan. 2026
Accepted: Jan. 2026
Published online: Mar. 2026
Published: April 2026

Abstract:

Background: Autism spectrum disorder (ASD) and attention-deficit/hyperactivity disorder (ADHD) are neurodevelopmental conditions that arise from a complex interplay of genetic, biological, and environmental factors. Essential metal elements (EMEs), including copper, zinc, iron, and calcium, support brain development, support neuronal communication, and maintain normal metabolic activity. Any increase or decrease in these elements may play a role in the development of ASD and ADHD.

Objectives: The study aimed to investigate the relationship between serum levels of zinc, copper, iron, and calcium with ASD and ADHD. Moreover, to compare these levels among children with ASD, ADHD, combined ASD plus ADHD, and healthy controls.

Methods: A case-control study was carried out at the College of Medicine, University of Baghdad, between March and September 2025. In total, 200 children aged 2–15 years were included and divided into four groups: Controls (n = 40), ADHD (n = 30), ASD (n = 57), and ASD + ADHD (n = 73). Five ml of venous blood from each child was dispensed into a gel tube to estimate zinc, copper, iron, and calcium. Assessment of inorganic elements zinc and copper was performed by Flam atomic absorption spectrometry (FAAS) while iron and calcium was performed by spectrophotometer.

Results: Serum zinc levels were significantly lower in all patient groups compared with the controls. Copper levels were significantly higher, particularly in the ADHD and ASD + ADHD groups. Serum calcium showed no significant differences among the groups. Serum iron levels were significantly reduced only in ADHD group.

Conclusion: Reduced zinc and iron levels, together with elevated copper, may contribute to neurodevelopmental disturbances in ASD and ADHD. Monitoring and correcting trace-element imbalance could support better clinical outcomes in affected children.

Keywords: Attention-Deficit/Hyperactivity Disorder; Autism Spectrum Disorder; Heavy Metals; Neurodevelopmental disorders; Trace elements.

Introduction

Autism Spectrum Disorder (ASD) presents a major public health concern. ASD is a neurodevelopmental condition that presents with challenges in social communication and interaction, as well as repetitive and restricted behavioral patterns and interests. Recent estimates in the United States indicate that about 1 in 36 children is diagnosed with ASD, with the condition occurring far more often in males, who are affected nearly 3.8 times more than females (1). The development of ASD is thought to result from several interacting factors, including genetic components and a range of non-genetic influences (2). Attention deficit hyperactivity disorder (ADHD) is a frequently encountered neurobehavioral condition in childhood, characterized by ongoing difficulties with attention, impulsive behaviors, and increased activity levels (3). It is commonly diagnosed in early life and, much like ASD, tends to appear more often in boys than in girls (4). A combination of genetic and environmental factors contributes to ADHD development (5, 6). Essential metal elements (EMEs) play an important role in healthy development and function of the nervous system (7, 8). Imbalances in the levels of these elements may increase the risk of ASD (9). Zinc (Zn) is very important for normal nervous system function and contributes to brain formation through its involvement with Zinc Finger proteins (10).

*Corresponding author:
ahmed.swadi2309p@comed.uobaghdad.edu.iq

Zn plays a role in the maturation of oligodendrocytes (11). When Zinc Finger proteins do not function well, nervous system development may be affected, leading to structural brain changes and an increased risk of ASD (10). Lower serum Zn levels are associated with brain development in individuals with ASD (12). Copper (Cu) is an essential trace element for many normal physiological processes (13). Imbalances in Cu levels can contribute to various health problems (14). When Cu levels are high and Zn levels are low, oxidative stress in the brain may increase, and nervous system development may be affected (15). Iron (Fe) is another essential trace that plays an important role in several basic neurological functions. As a required cofactor for the enzyme tyrosine hydroxylase, Fe is needed for the synthesis of dopamine. When Fe levels are low, dopamine synthesis can be reduced, which may contribute to worsening symptoms seen in individuals with ADHD (16). Essential trace elements, including calcium (Ca), play an important role in many key processes involved in the developing brain during childhood. They contribute to neurotransmitter production and breakdown, support various cellular metabolic pathways, and participate in metabolic activities linked to motor and neurological development (17).

This study aimed to investigate the relationship between serum levels of Zn, Cu, Fe, and Ca and ASD and ADHD, and to compare these levels among children with ASD, ADHD, combined ASD + ADHD, and healthy controls.

Patients and Methods

This case–control study was carried out in the Biochemistry Department, College of Medicine, University of Baghdad. Participants were recruited from the Child Protection Hospital / Autism Center at the Medical City Complex in Baghdad, during the period from March to September 2025. In total, 200 children were included and classified into four distinct groups. The first group consisted of 40 healthy controls (32 males, 8 females) with an age range of 2–15 years, all of whom were clinically normal and free from any known systemic illnesses. The control group was recruited from children attending routine pediatric check-ups and vaccination clinics at the same medical city. Controls were screened by a pediatrician and confirmed to be free from neurodevelopmental, neurological, or chronic systemic disorders. The second group comprised 30 children diagnosed with attention deficit hyperactivity disorder (ADHD) (24 males, 6 females), aged 3–15 years. The third group included 57 children with autism spectrum disorder (ASD) (43 males, 14 females), also within the age range of 2–15 years. The fourth group included 73 children diagnosed with combined ASD + ADHD (63 males and 10 females), all between 3 and 15 years of age. All autistic children and children with ADHD were evaluated by expert clinicians specialized in ASD assessment and met the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5) criteria for ASD, with Childhood Autism Rating Scale (CARS) scores above 30. Both cases and controls were age and sex matched. Before including any participants, informed consent was acquired from the parents of all children who would be participating. An expert pediatrician carried out selection of cases and exclusion criteria (brain abnormalities, epilepsy, hepatic or renal disease, genetic disorders such as Down's syndrome, children who had taken vitamin or mineral supplements within the past three months). Ethical approval was obtained from the Research Ethics Committee, College of Medicine, University of Baghdad (Approval No. 167, dated 27 October 2025).

Five ml of venous blood from each child was dispensed into a gel tube to estimate Zn, Cu, Fe, and Ca. assessment of inorganic elements (Zn, Cu) was performed by Flam atomic absorption spectrometry (FAAS) while (Fe, Ca) was performed by spectrophotometer.

Statistical Analysis

1. **Descriptive Statistics:** The mean and standard deviation (SD) were calculated for each variable within each group.
2. **Independent Sample t-test:** This test was used to compare the mean values between two groups, such as the control and ASD groups. A p-value of < 0.05 was considered statistically significant. **Welch's t-test** was applied when appropriate to account for unequal sample sizes and potential variance heterogeneity between groups, providing more robust statistical inference. **Cohen's d** was also calculated to show the size of the difference between the groups and to help understand how meaningful that difference was in practical terms.
3. **One-Way ANOVA**: This test was used when comparing more than two groups, such as the control, ASD, and ASD + ADHD groups. It was done to test the null hypothesis that all the group means were equal. A significant F-statistic ($p < 0.05$) indicated that at least one group differed from the others.
4. **Post-hoc Tukey's HSD Test**: Following a significant ANOVA test, the Tukey's test was performed, to identify pairwise group differences, while controlling multiple comparisons. Adjusted *p*-values (*p*-adj) were reported, along with mean differences and confidence intervals (95% CI).

All statistical analyses were performed using SPSS and Python statistical libraries.

Results

Table 1 presents the demographic characteristics of the study groups. No significant differences were observed in the mean age (one-way ANOVA, p = 0.1925) or sex distribution (chi-square, p = 0.4709), confirming appropriate matching among groups.

Table 1: Demographic Characteristics of Study Groups

Group	n	Age (years)		Sex n (%)	
		Mean ± SD	Range	Males	Females
Control	40	6.5 ± 3.28	2 – 15	32 (80.0)	8 (20.0)
ADHD	30	6.9 ± 3.32	3 – 15	24 (80.0)	6 (20.0)
ASD	57	5.7 ± 3.36	2 – 15	43 (75.4)	14 (24.6)
ASD + ADHD	73	6.7 ± 2.69	3 – 15	63 (86.3)	10 (13.7)
Statistical Test		One-way ANOVA: p-value = 0.1925, (p > 0.05)		Chi-square test: p-value = 0.4710, (p > 0.05)	

Results summarized in table 2 show that the children with ADHD have a significantly lower serum Zn level (73.6 ± 4.57 µg/dL) compared to controls (99.8 ± 14.65 µg/dL), (Welch's t = -9.42, p < 0.001), with a very large effect size (Cohen's d = -2.28). The children with ASD had a significantly lower mean serum Zn level (67.2 ± 8.30 µg/dL) compared to controls (p < 0.001) with a very large effect size (Cohen's d = -2.87). The children with ASD+ADHD had a significantly lower mean serum Zn level (68.3 ± 8.83 µg/dL) compared to controls, (p < 0.001).

Table 2: Mean serum zinc (µg/dL) levels in the study groups

Group	n	Mean ± SD (µg/dL)	p-value
Control	40	99.8 ± 14.65	-------------
ASD	57	67.3 ± 8.30	< 0.001
ADHD	30	73.3 ± 4.57	< 0.001
ASD+ADHD	73	68.3 ± 8.83	< 0.001

Results summarized in table 3 show that the children in the ADHD group have significantly higher serum Zn levels compared to both ASD and ASD+ADHD groups, with p = 0.0015 and p = 0.0074 respectively. No significant difference was found between the ASD and ASD+ADHD groups (p = 0.717).

Table 3: Tukey Post-hoc test for patients' group comparisons

Group1	Group2	Mean Difference	95% CI Lower	95% CI Upper	p-value
ADHD	ASD	-6.41	-10.68	-2.13	0.0015
ADHD	ASD+ADHD	-5.30	-9.41	-1.19	0.0074
ASD	ASD+ADHD	1.10	-2.25	4.45	0.7174

ANOVA, F (2,157) = 6.66, p = 0.0017 → Significant overall difference among groups

Results summarized in table 4 show that the children with ADHD have a significantly higher mean serum Cu level (109.0 ± 21.33 µg/dL) compared to controls (95.2 ± 13.78 µg/dL), (Welch's t = 3.09, p = 0.0034). The children with ASD had a slightly higher mean serum Cu level (100.3 ± 19.08 µg/dL) compared to controls (Welch's t = 1.16). Effect size was small (Cohen's d = 0.23) with no significant difference (p = 0.152). The children in the ASD+ADHD group show a significantly higher mean serum Cu level (104.9 ± 23.30 µg/dL) than controls (Welch's t = -2.78, df ≈ 110, p = 0.006). The effect size was moderate (Cohen's d = 0.47).

Table 4: Mean serum copper (µg/dL) levels in control and patient groups

Group	n	Mean ± SD (µg/dL)	p-value
Control	40	95.2±13.78	-------------
ASD	57	100.3±19.08	0.152
ADHD	30	109.0±21.33	0.0034
ASD+ADHD	73	104.9±23.30	< 0.01

Results summarized in table 5 show that the children in the ADHD group have higher a serum Cu level compared to both ASD and ASD+ADHD groups, with p = 0.177 and p = 0.659 respectively. No significant difference was found between the ASD and ASD+ADHD groups (p = 0.448).

Table 5: Tukey Post-hoc test for patient's/ group comparisons

Group 1	Group 2	Mean difference	Lower CI	Upper CI	p-adj
ASD+ADHD	ADHD	4.06	-6.98	15.10	0.659
ASD+ADHD	ASD	-4.61	-13.60	4.39	0.448
ADHD	ASD	-8.67	-20.15	2.81	0.177

ANOVA, F= 1.71, p = 0.185→ No significant overall difference among groups

Results summarized in table 6 show that the children with ADHD have a significantly lower mean serum Fe level (62.5 ± 8.14 µg/dL) than controls (83.5 ± 13.77 µg/dL), (Welch's t = -7.97, p < 0.001) with a very large effect size (Cohen's d = 1.80). The children with ASD had a slightly lower mean serum Fe level (82.1 ± 10.60 µg/dL) compared to controls, (p = 0. 572). There was no significant difference in serum Fe between control and ASD+ADHD (mean 82.9) groups (p = 0.791). The effect size was trivial (Cohen's d = -0.06).

Table 6: Mean serum iron (µg/dL) levels in control and patient groups

Group	n	Mean ± SD (µg/dL)	p-value
Control	40	83.5 ± 13.77	-------------
ASD	57	82.1 ± 10.60	0.572
ADHD	30	62.5 ± 8.14	< 0.001
ASD+ADHD	73	82.9 ± 10.17	0.791

Results summarized in table 7 show that the Serum Fe (Fe) level were significantly lower in the ADHD group compared to both the ASD and ASD+ADHD groups (ANOVA p < 0. 001). However, no significant difference was found between ASD and ASD+ADHD.

Table 7: Tukey Post-hoc Test for patients Group Comparisons

Group 1	Group 2	Mean difference	lower	upper	p-adj
ADHD	ASD	19.5526	14.2215	24.8838	< 0.001
ADHD	ASD+ADHD	20.363	15.2373	25.4887	< 0.001
ASD	ASD+ADHD	0.8104	-3.3673	4.988	0.8905

ANOVA Results, F-statistic = 49.002, p-value < 0.001

Results summarized in table 8 show that the children with ADHD have mean serum Ca level of (9.2 ± 0.66 mg/dL), compared to controls (9.2 ± 0.64 mg/dL), (p = 0.77). The Serum Ca level in children with ASD (9.17 ± 0.58 mg/dL) and controls, (p = 0.927). The children with ASD+ADHD had a mean Ca level of (9.2 ± 0.57 mg/dL), the same as controls (9.2 ± 0.64 mg/dL), (Welch's t=-0.09, p=0.925), with negligible effect size (Cohen's d=-0.02).

Table 8: Mean serum calcium (mg/dL) levels in control and patient groups

Group	n	Mean ± SD (µg/dL)	p-value
Control	40	9.2 ± 0.64	-------------
ASD	57	9.2 ± 0.58	0.927
ADHD	30	9.2 ± 0.66	0.770
ASD+ADHD	73	9.2 ± 0.57	0.925

Results summarized in table 9 show that the mean serum Ca levels were comparable across the three groups (ASD, ASD+ADHD and ADHD). The mean Ca concentration ranged between 9.17–9.23 mg/dL, with no significant differences observed (ANOVA p = 0.889). Post-hoc Tukey's test confirmed the absence of significant pairwise group differences.

Table 9: Tukey Post-hoc Test for patients Group Comparisons.

Comparison	Mean Difference	Lower CL	Upper CL	p-adj
ADHD vs ASD+ADHD	-0.058	-0.363	0.246	0.894
ADHD vs ASD	-0.058	-0.375	0.258	0.901
ASD vs ASD+ADHD	0.000	-0.248	0.248	1.000

ANOVA, F (2,157) = 0.117, p = 0.889 → not significant.

Discussion

Decreased Zn is linked to poor intake, selective eating, and competition with high Cu/Fe intake (18). Inflammation shifts Zn from the serum to the liver (19). Changed activity of Zn transporters (ZIP and ZnT) can weaken cellular Zn regulation (20). Intestine dysbiosis may decrease Zn absorption (21), and high levels of phytates or Ca can affect Zn uptake (22). Serum Zn was significantly lower in all patient groups in the current study which is in line with the results of the study of El-Saadany et al who found significantly lower serum Zn levels in children with ADHD compared with healthy controls (23). Yang et al reported lower Zn levels in children with ADHD when compared to healthy subjects (24). Serum Zn was markedly lower in the ASD group relative to controls in the current study with a very large effect size, in agreement with the study of Siddiqi et al who observed significantly lower serum Zn levels in ASD children compared with healthy controls (25). Zhang et al reported markedly lower serum Zn levels in children with ASD across all severity categories, with the most pronounced reductions occurring in severe ASD cases (26).
Serum Cu was elevated in all patient groups in the current study, with the highest levels observed in the ADHD and ASD+ADHD groups**,** whereas the ASD group had a slightly higher mean serum Cu level. Higher Cu levels lead to an increased Cu/Zn ratio, a pattern that has been linked to heightened oxidative stress, Ceruloplasmin increases with inflammation, raising the Cu level/absorption (27). The use of Cu plumbing or low Zn intake also enhances Cu absorption (28). Our findings show that serum Cu concentrations were higher in children with ADHD compared with the control group. Similar observations were reported by Robberecht H et al, who documented increased serum Cu levels in children with ADHD relative to healthy controls (16). Nayak et al also reported markedly elevated Cu concentrations in both hair and urine samples of children with ADHD when compared to healthy subjects (29), indicating that higher Cu accumulation may contribute to neurochemical disturbances associated with ADHD.
Serum Cu levels were slightly higher in the ASD group in the current study, which is in line with the study of Rashaid et al who found no significant differences in serum Cu concentrations between children with ASD and healthy controls (30).
Serum Fe levels were significantly reduced only in the ADHD group in the current study. In the ASD and ASD + ADHD groups, the mean Fe levels were slightly lower than those in the control group. It is known that excessive milk consumption can interfere with Fe absorption (31). Inflammation raises hepcidin, trapping Fe in macrophages causing a functional deficiency, despite the normal serum Fe (32). Our findings show a clear decrease in serum Fe levels in children with ADHD when compared with the control group, which is consistent with the findings of Konofal et al, who emphasized that Fe deficiency is known to be associated with cognitive difficulties, learning challenges, and psychomotor instability and should be considered within the framework of central dopaminergic dysfunction related to ADHD symptoms (33). Yang et al found children with ADHD had a reduction in their serum Fe levels compared to the controls (24), which is in agreement with the present findings, and supports the hypothesis that inadequate Fe status may contribute to ADHD, through its role in dopamine synthesis and neurodevelopment. The ASD group and ASD + ADHD groups had a slightly lower mean serum Fe level compared to controls, in line with the results of Ma et al who found no significant differences in the serum Fe concentrations between ASD children and controls (9), suggesting that Fe status may not be uniformly altered in all ASD populations. Skalny et al reported no statistically significant variation in serum Fe levels between children with ASD and healthy controls (34).
Serum Ca remained within normal ranges, without significant group differences. Serum Ca was stable due to strict regulation (PTH–vitamin D axis) (35). Vitamin D or Mg deficiency impairs neuronal Ca handling, without altering the serum Ca (36).
Serum Ca concentrations were almost identical between the ADHD group and the controls in the current study. Likewise, Ca levels did not differ significantly between children with ASD and healthy controls. Alkhalidy also found that serum Ca levels in children with ASD were not significantly different from the control group (37). This supports the view that disturbances in Ca levels are unlikely to be a major biochemical feature of ASD. Likewise, Alzghoul et al reported no significant difference in serum Ca levels between children with ASD and healthy controls (38), suggesting that Ca levels generally remain stable in individuals with autism.
In the present study, children with ASD, ADHD, and ASD+ADHD exhibited significant alterations in serum trace element levels compared with healthy controls. These changes may reflect underlying metabolic and neurobiological disturbances associated with neurodevelopmental disorders. Zn and Cu are essential cofactors for numerous enzymatic reactions involved in neurotransmitter synthesis and antioxidant defense, and their imbalance may contribute to oxidative stress and neuronal dysfunction. Fe plays a crucial role in myelination and dopaminergic neurotransmission. Therefore, the altered concentrations observed in the current study may influence brain development and function, potentially contributing to the pathophysiology of ASD and ADHD.

Limitation:

Several limitations of the present study should be acknowledged. The alterations observed in serum Cu**,** Zn**,** and Fe levels may reflect a complex interaction between nutritional, environmental, and biological factors. Specifically, the elevated Cu levels might be attributed to environmental exposures or competitive interactions during gastrointestinal absorption with Zn. Furthermore, the selective eating behaviors and restricted dietary diversity common in children with ASD and ADHD may significantly influence the intake of essential elements like Zn and Fe. Due to the cross-sectional design, it is difficult to determine whether these trace element imbalances are a cause or a consequence of the disorders. Future longitudinal studies incorporating detailed environmental and nutritional assessments are required to clarify these relationships.

Conclusions

Reduced zinc and iron levels, together with elevated copper, may contribute to neurodevelopmental disturbances in ASD and ADHD. The assessment of serum trace element status may provide valuable insights into biological disturbances associated with ASD and ADHD, aid in identifying metabolic imbalances, support monitoring of nutritional status, and potentially guide supportive interventions.

Authors' declaration:

We confirm that all the Figures and Tables in the manuscript belong to the current study. Besides, the Figures and images, which do not belong to the current study, have been given permission for re-publication attached to the manuscript. Authors sign on ethical consideration's Approval-Ethical Clearance: The project was approved by the local ethical committee in (Department of Chemistry, College of Medicine, University of Baghdad) according to the code number (167) on (27/ 10/ 2025).

Conflict of Interest:

The authors declare that there is no conflict of interest.

Funding: No specific grant from a public, private, or nonprofit funding organization was obtained for this study.

Data availability:

The data supporting the findings of this study are available from the corresponding author upon reasonable request.

AI Declaration:

No artificial intelligence tools were used in the design, analysis, or writing of this manuscript.

Authors' contributions:

Study conception and design: Hedef D. El-Yassin, Mushtaq Hashim. Literature search: Ahmed S. Swadi. Data acquisition: Ahmed S. Swadi. Data analysis and interpretation: Hedef D. El-Yassin, Mushtaq Hashim, Ahmed S. Swadi. Manuscript preparation: Hedef D. El-Yassin, Mushtaq Hashim. Manuscript editing and review: Hedef D. El-Yassin, Mushtaq Hashim.

References

1. Dou JF, Schmidt RJ, Volk HE, et al. Exposure to heavy metals in utero and autism spectrum disorder at age 3: a meta-analysis of two longitudinal cohorts of siblings of children with autism. Environ Health. 2024;23(1):62. https://doi.org/10.1186/s12940-024-01101-2

2. Sauer AK, Stanton JE, Hans S, Grabrucker AM. Autism Spectrum Disorders: Etiology and Pathology. In: Grabrucker AM, editor. Autism Spectrum Disorders. Brisbane (AU): Exon Publications; 2021. p.1-5. https://doi.org/10.36255/exonpublications.autismspectrumdisorders.2021.etiology

3. Tang S, Zhang G, Ran Q, et al. Quantitative susceptibility mapping shows lower brain iron content in children with attention-deficit hyperactivity disorder. Hum Brain Mapp. 2022;43(8):2495-502. https://doi.org/10.1002/hbm.25798

4. Hussein RA, Refai RH, El-Zoka AH, et al. Association between some environmental risk factors and attention-deficit hyperactivity disorder among children in Egypt: a case-control study. Ital J Pediatr. 2025;51(1):19. https://doi.org/10.1186/s13052-025-01843-w

5. Zheng Y, Pingault JB, Unger JB, et al. Genetic and environmental influences on attention-deficit/hyperactivity disorder symptoms in Chinese adolescents: a longitudinal twin study. Eur Child Adolesc Psychiatry. 2020;29(2):205-16. https://doi.org/10.1007/s00787-019-01346-0

6. Kim JH, Kim JY, Lee J, et al. Environmental risk factors, protective factors, and peripheral biomarkers for ADHD: an umbrella review. Lancet Psychiatry.2020;7(11):955-70. https://doi.org/10.1016/S2215-0366(20)30312-6

7. Zhang P, Georgiou CA, Brusic V. Elemental metabolomics. Brief Bioinform. 2018;19(3):524-36. https://doi.org/10.1093/bib/bbw131

8. Zoroddu MA, Aaseth J, Crisponi G, et al. The essential metals for humans: a brief overview. J Inorg Biochem.2019;195:120-9. https://doi.org/10.1016/j.jinorgbio.2019.03.013

9. Ma J, Wu J, Li H, et al. Association Between Essential Metal Elements and the Risk of Autism in Chinese Han Population. Biol Trace Elem Res. 2022;200(2):505-15. https://doi.org/10.1007/s12011-021-02690-6

10. Al-Naama N, Mackeh R, Kino T. C2H2-Type Zinc Finger Proteins in Brain Development, Neurodevelopmental, and Other Neuropsychiatric Disorders: Systematic Literature-Based Analysis. Front Neurol. 2020;11:32. https://doi.org/10.3389/fneur.2020.00032

11. Bourassa D, Elitt CM, McCallum AM, et al. Chromis-1, a Ratiometric Fluorescent Probe Optimized for Two-Photon Microscopy Reveals Dynamic Changes in Labile Zn(II) in Differentiating Oligodendrocytes. ACS Sens. 2018;3(2):458-67. https://doi.org/10.1021/acssensors.7b00887

12. da Silva PR, do Nascimento Gonzaga TK, Maia RE, et al . Ionic channels as potential targets for the treatment of autism spectrum disorder: a review. CurrNeuropharmacol.2022;20(10):1834-49. https://doi.org/10.2174/1570159X19666210809102547

13. Długosz A, Wróblewski M, Błaszak B, et al. The Role of Nutrition, Oxidative Stress, and Trace Elements in the Pathophysiology of Autism Spectrum Disorders. Int J Mol Sci. 2025;26(2):808. https://doi.org/10.3390/ijms26020808

14. Telianidis J, Hung YH, Materia S, et al. Role of the P-Type ATPases, ATP7A and ATP7B in brain copper homeostasis. Front Aging Neurosci. 2013;5:44. https://doi.org/10.3389/fnagi.2013.00044

15. Li SO, Wang JL, Bjørklund G, et al. Serum copper and zinc levels in individuals with autism spectrum

disorders. Neuroreport. 2014;25(15):1216-20. https://doi.org/10.1097/WNR.0000000000000251
16. Robberecht H, Verlaet AAJ, Breynaert A, et al. Magnesium, iron, zinc, copper and selenium status in attention-deficit/hyperactivity disorder (ADHD). Molecules.2020;25(19):4440. https://doi.org/10.3390/molecules25194440
17. Nanou E, Catterall WA. Calcium channels, synaptic plasticity, and neuropsychiatric disease. Neuron.2018;98(3):466-81. https://doi.org/10.1016/j.neuron.2018.03.017
18. do Nascimento PK, Oliveira Silva DF, de Morais TL, et al. Zinc status and Autism Spectrum Disorder in children and Adolescents: A Systematic Review. Nutrients.2023;15(16):3663. https://doi.org/10.3390/nu15163663
19. Prasad AS. Zinc in Human Health: Effect of Zinc on Immune Cells. Mol Med. 2008; 14(5-6): 353-357. https://doi.org/10.2119/2008-00033.Prasad
20. Ahmadani A, Kittana M, Al-Marzooq F, et al. Zinc ion dyshomeostasis in autism spectrum disorder. Nutr Res Rev. 2025;38(2):661-681. https://doi.org/10.1017/S095442242500006X.
21. Chen X, Jiang Y, Wang Z, et al. Alteration in gut microbiota associated with zinc deficiency in school-age children. Nutrients. 2022;14(14):2895. https://doi.org/10.3390/nu14142895
22. Gibson RS, Bailey KB, Ferguson EL. A review of phytate, iron, zinc, and calcium concentrations in plant-based complementary foods used in low-income countries and implications for bioavailability. Food Nutr Bull. 2010; 31(2 Suppl2): S134-46. https://doi.org/10.1177/15648265100312S206
23. El-Saadany NZH, Abdel-Fattah MF, Siam AG, et al. Relationship between Serum Iron Level and Zinc Level with Attention Deficit Hyperactivity Disorder in Children. Egypt J Hosp Med. 2022;87(1):2106-12. https://doi.org/10.21608/ejhm.2022.232828
24. Yang R, Zhang Y, Gao W, et al. Blood levels of trace elements in children with attention-deficit hyperactivity disorder: results from a case-control study. Biol Trace Elem Res. 2019;187(2):376-82. https://doi.org/10.1007/s12011-018-1408-9
25. Siddiqi UR, Begum S, Shahjadi S, et al. Plasma zinc, copper and serum ceruloplasmin levels of autism spectrum disorder children in Bangladesh. Heliyon.2023;9(8):e18624. https://doi.org/10.1016/j.heliyon.2023.e18624
26. Zhang XH, Yang T, Chen J, et al. Association between Serum Trace Elements and Core Symptoms in Children with Autism Spectrum Disorder: A National Multicenter Survey. Chinese Journal of Contemporary Pediatrics. 2021;23(5):445-50. https://doi.org/10.7499/j.issn.1008-8830.2101163
27. Escobedo-Monge MF, Barrado E, Parodi-Roman J, et al. Copper/Zinc ratio in Childhood and Adolescence: A Review. Metabolites. 2023;13(1):82. https://doi.org/10.3390/metabo13010082
28. Linder MC. Biochemistry of copper. New York: Springer Science+Business Media; 2013. https://books.google.com/books/about/Biochemistry_of_Copper.html?id=8x4DCAAAQBAJ&utm_source
29. Nayak S, Sahu S, Patra S, et al. Assessment of Copper and Zinc Levels in Hair and Urine of Children with Attention Deficit Hyperactivity Disorder: A Case-Control Study in Eastern India. Cureus. 2021;13(12):e20692. https://doi.org/10.7759/cureus.20692
30. Rashaid AHB, Nusair SD, Alqhazo MT, et al. Heavy metals and trace elements in scalp hair samples of children with severe Autism spectrum disorder: A case-control study on Jordanian children. J Trace Elem Med Biol. 2021;67:126790. https://doi.org/10.1016/j.jtemb.2021.126790
31. Beard JL. Iron Biology in Immune Function, Muscle Metabolism and Neuronal Function. J Nutr. 2001; 131(2): 568S-580S. https://doi.org/10.1093/jn/131.2.568S
32. Ganz T. Hepcidin and iron regulation, 10 years later. Blood. 2011; 117(17): 4425-4433. https://doi.org/10.1182/blood-2011-01-258467
33. Konofal E, Lecendreux M, Deron J, et al. Effects of iron supplementation on attention deficit hyperactivity disorder in children. Pediatr Neurol. 2008;38(1):20-6. https://doi.org/10.1016/j.pediatrneurol.2007.08.014
34. Skalny AV, Simashkova NV, Klyushnik TP, et al. Assessment of serum trace elements and electrolytes in children with childhood and atypical autism. J Trace Elem Med Biol. 2017;43:9-14. https://doi.org/10.1016/j.jtemb.2016.09.009
35. Yu E, Sharma S. Physiology, calcium [Updated 2023 Aug 14]. StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2026 jan. https://www.ncbi.nlm.nih.gov/books/NBK482128/ (accessed 25 March 2026).
36. Klocke B, Krone K, Tornes J, et al. Insights into the role of Intracellular Ca2+ signaling in neurodevelopmental disorders. Front Neurosci. 2023;17:1093099. https://doi.org/10.3389/fnins.2023.1093099
37. Alkhalidy H, Abushaikha A, Alnaser K, et al. Nutritional status of pre-school children and determinant factors of autism: A case-control study. Front Nutr. 2021;8:627011. https://doi.org/10.3389/fnut.2021.627011
38. Alzghoul L, Al-Eitan LN, Aladawi M, et al. The association between serum Vitamin D3 levels and autism among Jordanian boys. J Autism Dev Disord. 2020;50(9):3149-54. https://doi.org/10.1007/s10803-019-04017-w

How to Cite this Article?
Swadi AS, EI-Yassin H, Hashim MT. Evaluation of Serum Copper, Zinc, Iron, and Calcium Levels in Children with Autism Spectrum Disorder and Attention-Deficit/Hyperactivity Disorder in Baghdad. J Fac Med Baghdad [Internet]. Available from: https://iqjmc.uobaghdad.edu.iq/index.php/19JFacMedBaghdad36/article/view/3225

تقييم مستويات النحاس والزنك والحديد والكالسيوم في مصل الأطفال المصابين باضطراب طيف التوحد واضطراب نقص الانتباه وفرط النشاط في بغداد

أحمد سوادي[1] ، هدف ظافرالياسين[1] ، مشتاق طالب هاشم[2]
[1]فرع الكيمياء السريرية، كلية الطب، جامعة بغداد، بغداد، العراق
[2]فرع الطب الباطني، كلية الطب، جامعة بغداد، بغداد، العراق

الخلاصة:
خلفية البحث: يُعدّ اضطراب طيف التوحد واضطراب نقص الانتباه وفرط النشاط من الاضطرابات العصبية النمائية المعقدة ذات الأسباب المتعددة. تلعب العناصر المعدنية الأساسية، مثل النحاس والزنك والحديد والكالسيوم، دورًا محوريًا في النمو العصبي، ونقل الإشارات العصبية، والتوازن التأكسدي. قد يُسهم تغيّر مستويات هذه العناصر، سواءً نقصًا أو زيادةً، في اختلال وظائف الدماغ، وقد ثبت تورطها في الفيزيولوجيا المرضية لاضطرابي طيف التوحد واضطراب نقص الانتباه وفرط النشاط.
الاهداف: تقييم ومقارنة مستويات العناصر النزرة في مصل الدم (الزنك والنحاس والحديد والكالسيوم) بين الأطفال المصابين باضطراب طيف التوحد واضطراب فرط الحركة ونقص الانتباه واضطراب طيف التوحد مع اضطراب فرط الحركة ونقص الانتباه، بالمقارنة مع الضوابط الصحية.
المنهجية: أُجريت هذه الدراسة المقارنة في كلية الطب بجامعة بغداد، بين آذار وأيلول 2025. شارك في الدراسة 200 طفل (من سنتين إلى 15 سنة)، وصُنِّفوا إلى أربع مجموعات: مجموعة ضابطة (عددها 40)، ومجموعة اضطراب فرط الحركة ونقص الانتباه (عددها 30)، ومجموعة اضطراب طيف التوحد (عددها 57)، ومجموعة اضطراب طيف التوحد مع اضطراب فرط الحركة ونقص الانتباه (عددها 73). جُمعت عينات دم وريدية (5 مل) من كل مشارك. قُيسَت مستويات الزنك والنحاس في المصل باستخدام مطيافية الامتصاص الذري اللهبي (FAAS)، بينما قُيسَت مستويات الحديد والكالسيوم في المصل باستخدام مطيافية الضوء.
النتائج: انخفضت مستويات الزنك في مصل الدم بشكل ملحوظ في جميع مجموعات المرضى (اضطراب طيف التوحد، واضطراب فرط الحركة ونقص الانتباه، واضطراب طيف التوحد مع اضطراب فرط الحركة ونقص الانتباه) مقارنةً بمجموعة الضبط. في المقابل، ارتفعت مستويات النحاس في مصل الدم، لا سيما في مجموعتي اضطراب فرط الحركة ونقص الانتباه، واضطراب طيف التوحد مع اضطراب فرط الحركة ونقص الانتباه. لم تُرصد أي فروق جوهرية في مستوى الكالسيوم في مصل الدم بين مجموعات الدراسة، بينما انخفضت مستويات الحديد في مصل الدم بشكل ملحوظ في مجموعة اضطراب فرط الحركة ونقص الانتباه.
الاستنتاجات: قد يُسهم اختلال توازن العناصر النزرة الأساسية، الذي يتميز بانخفاض مستويات الزنك والحديد إلى جانب ارتفاع مستويات النحاس، في اضطرابات النمو العصبي الملحوظة لدى مرضى اضطراب طيف التوحد واضطراب فرط الحركة ونقص الانتباه. وقد يُسهم رصد وتصحيح اختلال توازن العناصر النزرة في تحسين النتائج السريرية.
مفتاح الكلمات: اضطراب طيف التوحد؛ اضطراب نقص الانتباه وفرط النشاط؛ العناصر النزرة؛ اضطرابات النمو العصبي.