



**STUDY OF COGNITIVE FUNCTIONS IN CHILDREN WITH ADHD AGAINST
THE BACKGROUND OF COMPLEX TREATMENT USING HYDROGEN
THERAPY**

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Introduction

Attention deficit hyperactivity disorder (ADHD) is one of the most common neurodevelopmental disorders in childhood. It is clinically characterized by attention deficit, hyperactivity, and impulsivity, accompanied by deficits in executive functions, working memory, and cognitive control (1-2). Despite the proven effectiveness of psychostimulants (e.g., methylphenidate) and behavioral therapy, some patients demonstrate an incomplete therapeutic response or experience side effects. In recent years, researchers have focused on the role of oxidative stress, neuroinflammation, and mitochondrial dysfunction in the pathogenesis of ADHD (4). Molecular hydrogen (H₂) is considered a potential selective antioxidant and cytoprotector. Its use in clinical practice is being studied in various neurological conditions, but its effect on cognitive function in children with ADHD remains understudied (7).

Hypothesis: Adding hydrogen therapy to standard treatment contributes to a more pronounced improvement in attention and executive function compared to standard therapy.

Research objective: to evaluate the dynamics of cognitive functions in children with ADHD against the background of complex treatment including hydrogen therapy.

Materials and methods.

Study design

Prospective randomized controlled study with parallel groups.

The study included 60 children aged 7–12 years diagnosed with ADHD (according to DSM-5).

Participant selection criteria

Inclusion criteria	Exclusion criteria
Confirmed diagnosis of ADHD	Epilepsy
Absence of severe neurological diseases	Autism spectrum disorders
Informed consent of parents	Severe somatic diseases

Group	n	Type of therapy
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Control	30	Standard therapy
Primary	30	Standard therapy + hydrogen therapy

Distribution by group

Hydrogen therapy

Daily use of hydrogen water (1.2–1.6 ppm) for 8 weeks. The dosage was calculated individually based on body weight.

Assessment methods

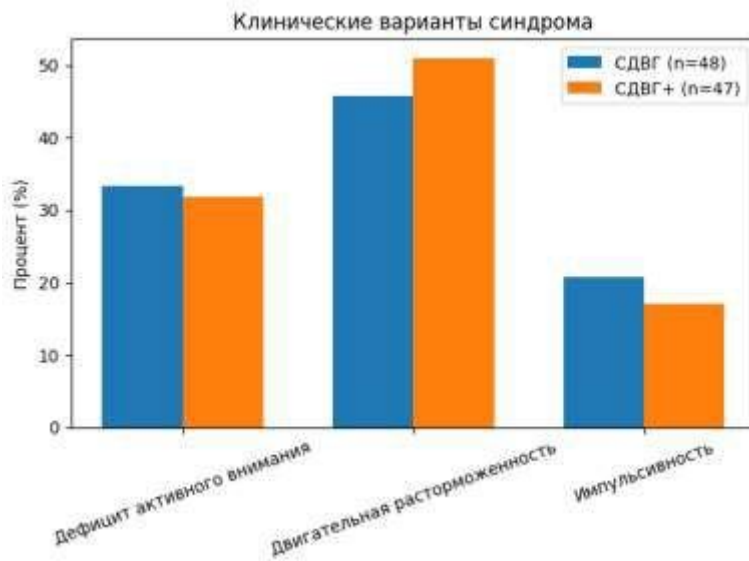
Cognitive functions:

- TOVA (assessment of attention span and impulsivity)
- WISC-V (working memory, information processing speed)
- Neuropsychological examination
- M. Alward and P. Baker's Hyperactivity and ADHD Test for Preschoolers

RESULTS OF THE STUDY. Of the total number of patients with ADHD examined, 31 (32.6%) children were found to have a deficit in active attention, 46 (48.4%) were dominated by motor disinhibition, and 18 (18.9%) were dominated by impulsivity.

Clinical variants of ADHD				
	ADHD (n=48)		ADHD+ (n=47)	
	Abs.	%	Abs.	%
Inattention deficit (n=31)	16	33.3	15	31.9
Motor disinhibition (n=46)	22	45.8	24	51
Impulsivity (n=18)	10	20.8	8	17

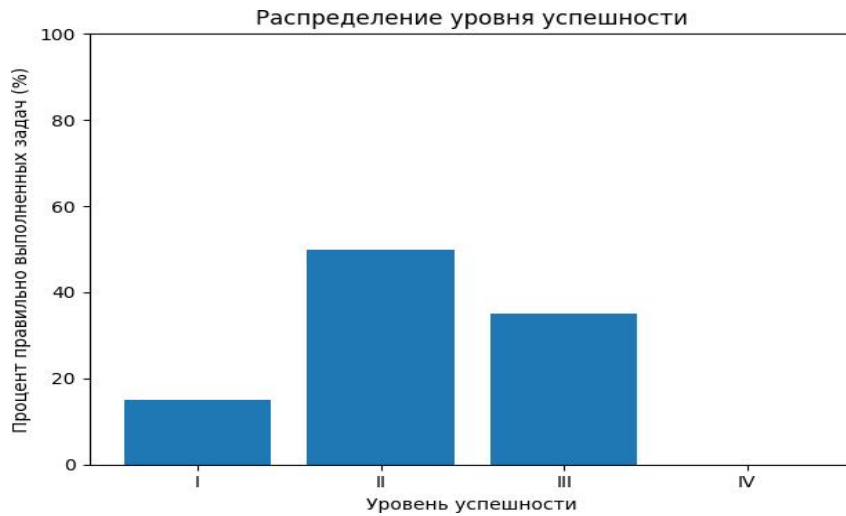
- Assessment of mental ability using the Raven's Progressive Matrices test



Level of success in the Raven's Progressive Matrices test.

Success rate	Points	Percentage of correctly completed tasks
I	17 and less	Less than 15%
II	17.5-22.5	50
III	22.75-27.9 b	35
IV	28 and above b	0

•Methodology for determining the level of speech development in preschool children according to O.A. Bezrukov and O.N. Kalenkov



Speech development coefficients at the stage of patient inclusion in the study

Patient groups	AD HD (n=48)	ADH D+ (n=47)	χ^2	P
Speech development coefficient Mean [25th and 75th quartiles] in points	34 [28; 38]	32 [25; 35]	11.5 98	0.003

- Auditory memory test. Methodology: "Memorizing 10 words" according to A.R. Luria.

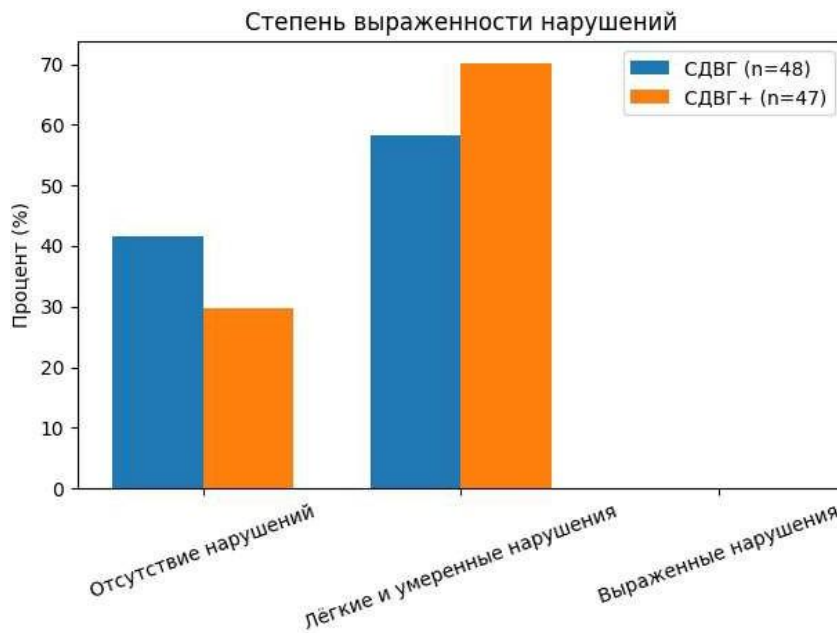
Assessment of mnemonic disorders of varying severity in patients with ADHD based on the results of the LURIA test.

Degree	ADHD n=48	ADHD+ n=47
No disorders	20 (41.6)	14 (29.7)
Mild and moderate disorders	28 (58.3)	33 (70.2)



Severe disorders	(0.0)	(0.0)
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* – statistically significant differences (P < 0.05)



•Methodology for studying visual memory

Diagnostic results using the visual memory study method

	ADHD (n=48)	ADHD+ (n=47)
Average value	7.09	6.85
Standard deviation	1.90	1.48

The levels of development of logical and mechanical memory of the subjects were diagnosed individually for each subject based on the mean value and standard deviation.

Research results and discussion



After 8 weeks of therapy, the following was observed in the main group:

- statistically significant improvement in attention span ($p < 0.01$)
- Decrease in impulsivity scores ($p < 0.05$)
- increase in working memory index according to WISC-V ($p < 0.05$)

In the control group, the improvements were less pronounced and did not reach statistical significance for a number of indicators.

The effect size (Cohen's d) for the attention span indicator was 0.65 (moderate effect). No side effects were reported in the main group.

Discussion. The data obtained indicate a possible adjuvant effect of hydrogen therapy in the complex treatment of ADHD. The improvement in cognitive indicators may be associated with a reduction in oxidative stress and an improvement in metabolic processes in the prefrontal cortex. The results are consistent with current understanding of the role of neuroinflammation in the pathogenesis of ADHD and support the hypothesis that antioxidant strategies should be included in complex therapy. Current research on the pathogenesis of attention deficit hyperactivity disorder points to the multifactorial nature of the disorder, involving neurotransmitter, neuroinflammatory, and metabolic mechanisms. In addition to dysfunction of the dopaminergic and noradrenergic systems, there is growing evidence confirming the role of oxidative stress and mitochondrial disorders.

In the context of ADHD, meta-analytic studies in recent years demonstrate:

1. Regarding oxidative stress
 - \uparrow malondialdehyde (MDA)
 - \downarrow superoxide dismutase (SOD)
 - \downarrow total antioxidant status

The effect size usually varies from small to moderate.

2. Inflammatory markers
 - Moderate increase in IL-6
 - increase in TNF- α
 - Heterogeneity of results (high heterogeneity)
3. Antioxidant

interventions Meta-
analyses on omega-3
show:

- a small but statistically significant effect on inattention
- a smaller effect on hyperactivity

Therefore, the use of hydrogen therapy is a justified method in the complex therapy of ADHD



Discussion of results and conclusion

Attention deficit hyperactivity disorder is considered a neurodevelopmental disorder with multifactorial pathogenesis involving neurotransmitter and metabolic mechanisms. In recent years, the role of oxidative stress has been actively studied.

Systematic reviews and meta-analyses demonstrate increased levels of lipid peroxidation markers and decreased antioxidant defense in children with ADHD [1,2]. In particular, there is an increase in malondialdehyde (MDA) and a decrease in the activity of superoxide dismutase (SOD), catalase, and glutathione.

These data confirm the hypothesis that oxidative damage is involved in the formation of cognitive deficits, primarily attention and executive function disorders.

2. Neuroinflammatory mechanisms

Recent studies have demonstrated a moderate increase in pro-inflammatory cytokines (IL-6, TNF- α) in children with ADHD [3]. Meta-analytic data indicate the existence of a systemic inflammatory component, but there is a high degree of heterogeneity.

Neuroinflammation can disrupt the functioning of the frontostriatal networks responsible for cognitive control and behavior regulation.

3. Antioxidant interventions

Interest in metabolic strategies for correcting ADHD is driven by data on antioxidant imbalance.

A meta-analysis of randomized studies showed a moderate positive effect of omega-3 polyunsaturated fatty acids on symptoms of inattention [4]. However, the magnitude of the effect is significantly inferior to pharmacotherapy with psychostimulants (e.g., methylphenidate), which indicates the auxiliary nature of such interventions.

Studies of N-acetylcysteine and coenzyme Q10 show preliminary positive results, but require further confirmation [5].

4. Molecular hydrogen as a promising antioxidant

Molecular hydrogen (H₂) is considered a selective neutralizer of hydroxyl radicals and a potential modulator of the Nrf2 signaling pathway [6].

Experimental studies on models of ischemia and neurodegeneration have shown:

- a decrease in the level of pro-inflammatory cytokines
- a decrease in oxidative damage
- improved mitochondrial function

Clinical studies in children with ADHD have demonstrated improvements in both cognitive and behavioral functions when hydrogen water is used [7].



References

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