COMPARATIVE AND INTEGRATED ASSESSMENT OF HEALTH STATUS, TRACE ELEMENT PROFILE, AND VITAMIN D SUFFICIENCY IN CHILDREN WITH DOWN SYNDROME.

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Abstract. *This article analyzes the health of children with Down syndrome, their trace element status, vitamin D levels, and the effectiveness of interventions aimed at improving their quality of life. Inclusion of these children in early intervention programs, along with comprehensive support, contributes to the development of self-care skills, enhancement of quality of life, and social integration, as well as the improvement of interdisciplinary approaches to their treatment.*

Keywords: *factors, Down syndrome, analysis, pregnancy, hair, children.*

Аннотация: *В этой статье анализируется здоровье детей с синдромом Дауна, их микроэлементный статус, витамин Д, а также эффективность мер, направленных на улучшения качества их жизни. Включение солнечных детей в программы раннего вмешательства и комплексная поддержка способствуют развитию навыков самообслуживания, улучшению качества жизни и интеграции в общество, а также совершенствованию междисциплинарных подходов к их лечению.*

Ключевые слова: *факторы, синдром Дауна, анализ, беременность, волосы, дети.*

Introduction. Down syndrome (DS) is one of the most common genetic anomalies, representing a significant medical, social, and psychological challenge. According to the World Health Organization, the incidence of DS is approximately 1 in 700–800 live births, with maternal age being a major risk factor [WHO, 2018]. Children with DS often present with complex health disturbances, including specific patterns of physical and intellectual development, making the study of their trace element status and vitamin D levels particularly relevant. Early intervention and comprehensive support contribute to improved social adaptation and integration of these children into society. Investigating the health status, trace element levels, and vitamin D sufficiency in children with DS is crucial for developing effective preventive and therapeutic strategies aimed at improving their quality of life.

Aim of the study was to assess the health status, trace element status, and vitamin D levels in children with Down syndrome and to develop methods for their correction.

Objectives of the study: to investigate the role of trace elements in children with Down syndrome in relation to the clinical features of somatic disorders.

Materials and methods. A total of 50 children with Down syndrome aged 1 to 8 years underwent clinical examination. The control group consisted of 50 practically healthy children within the same age range. The study included the collection of medical history, objective clinical examination, and analysis of available medical documentation. Follow-up was conducted according to a specially designed protocol. Subsequently, non-pharmacological and pharmacological treatment methods were prescribed with mandatory evaluation of their effectiveness.

It is considered that the mineral composition of hair reflects the long-term (monthly and yearly) intake of micro- and macroelements into the body, whereas biological fluids, including blood, more clearly demonstrate short-term fluctuations in bioelement levels that occur in response to intensive external or internal influences.

Results and discussion. At the subsequent stage of the study, a comparative analysis of trace element content in the hair of children with Down syndrome was conducted. The obtained data are presented in Table 1.

Table 1

Comparative indicators of trace element levels in the hair of children with Down syndrome

Parameters	**Main group**		**Control group**		**Statistical significance**
	M	m	M	m	P<
Na	573,160	131,380	462,833	49,958	0,05
Cl	3569,400	392,732	1614,167	79,756	0,01
Ca	456,122	27,856	1318,056	38,764	0,001
Sc	0,002	0,000	0,003	0,000	0,05
Cr	0,273	0,073	0,754	0,057	0,01
Mn	0,477	0,112	0,684	0,044	0,05
Fe	15,290	0,758	23,444	0,717	0,05
Co	0,012	0,001	0,069	0,005	0,05
Cu	10,714	3,192	16,972	0,500	0,05
Br	4,925	0,560	7,933	5,877	0,05
Rb	0,636	0,120	0,755	0,066	0,05
Ag	0,075	0,015	0,138	0,014	0,01
Sb	0,049	0,013	0,033	0,006	0,05

I	0,381	0,110	1,018	0,062	0,001
La	0,033	0,005	0,029	0,002	0,05
Au	0,015	0,003	0,035	0,003	0,01
Hg	0,049	0,004	0,037	0,006	0,05
U	0,039	0,006	0,177	0,030	0,001

Children with Down syndrome (DS) exhibited significantly elevated levels of Na (573.2 ± 131.4 vs. 462.8 ± 49.9; $p < 0.05$) and Cl (3569.4 ± 392.7 vs. 1614.2 ± 79.7; $p < 0.01$) against a background of reduced Ca, Sc, Cr, Mn, Fe, Co, Cu, Zn, and I. Of particular importance is the reduction in Fe and I, which reflects the presence of anemia and thyroid dysfunction in this patient group. Deficiencies in Zn and Cu may influence the GABAergic system, which undergoes alterations in children with DS.

Additionally, deficiencies of macro- and trace elements (Fe, Zn, Mn, Se, Co) were observed, which play a key role in epigenetic regulation of the genome. Disruptions at this level are considered a potential factor contributing to neurodevelopmental disorders, which in turn affect somatic health and growth retardation in children with DS.

The results of the study confirm a pronounced deficiency of essential macro- and trace elements that affect water-electrolyte balance, musculoskeletal function, and the endocrine system. Iodine deficiency is associated with impaired intellectual development and reduced quality of life. Timely correction of micronutrient status can positively influence the overall development of children with DS.

Furthermore, children with DS were found to have disturbances in physical and somatic status, trace element imbalances, and vitamin D deficiency against the background of elevated C-reactive protein (CRP) levels, highlighting the importance of early correction of these disorders.

Using a blind sampling method from the 50 examined children with Down syndrome, two groups were formed. The first group included 30 children who underwent correction of health status, trace element levels, and vitamin D. The second group consisted of 20 children in whom corrective interventions were either not carried out or were implemented partially, without accounting for the identified trace element imbalances and vitamin D deficiency in the context of elevated CRP levels.

Non-pharmacological correction consisted of individually tailored dietary therapy based on the hair analysis results of each child. Pharmacological correction included the administration of vitamin D (Aquadetrim – cholecalciferol), trace elements (I – Iodomarin 100, Fe – Maltofer), as well as other macro- and trace elements (Ca, Co, Cu, Mn, Se, Cr) as part of the “Alphabet” vitamin-mineral complex.

The period of dynamic observation lasted 6 months. A follow-up assessment of hair trace element composition and vitamin D levels was conducted after 12 months. The results indicated that children in the first group showed a trend toward normalization of these indicators. The obtained data are presented in Table 2.

Table 2

Dynamics of trace element levels in the hair of children with Down syndrome during follow-up

Parameters	Baseline	After correction	
		1 group, n=30	2 group, n=20
Ca	456,1±27,8	901,8±29,7^^	501,8±32,1*
Cr	0,273±0,073	0,394±0,029^	0,289±0,06**
Fe	15,3±0,76	20,8±0,57^	16,8±0,62*
Co	0,012±0,001	0,061±0,009^^^	0,014±0,001**
Cu	10,7±3,2	16,1±0,254^^	11,3±2,8*
Zn	170,7±5,9	189,5±4,04^	169,8±6,2*^
Se	0,491±0,09	0,484±0,02	0,502±0,08*^
I	0,381±0,11	0,878±0,04^^	0,402±0,13**

According to the presented data, children with Down syndrome (DS) in Group 1 showed a significant reduction in trace element imbalance compared to the indicators of Group 2.

Serum vitamin D levels in children of Group 1 increased significantly relative to baseline values (44.5 ± 2.6 ng/mL vs. 36.2 ± 2.7 ng/mL), whereas in Group 2, levels decreased to 34.3 ± 2.8 ng/mL. By the end of the 6-month correction course, the average vitamin D level in Group 1 children was 1.3 times higher than that in Group 2 (44.5 ± 2.6 ng/mL vs. 34.3 ± 2.8 ng/mL).

C-reactive protein (CRP) levels in the blood of Group 1 children decreased on average to 4.6 ± 0.31 mg/L, which is 1.5 times lower than baseline (4.6 ± 0.31 mg/L vs. 6.9 ± 0.72 mg/L). In Group 2, changes were minimal: values remained almost at baseline levels (6.2 ± 0.61 mg/L vs. 6.9 ± 0.72 mg/L).

According to parent surveys, 89.3% of families in Group 1 reported significant improvement in the child's physical and somatic condition, while in Group 2, this figure was almost twice lower—44.6%.

Anthropometric analysis at baseline showed that children in both groups predominantly had a disharmonious body type. After the correction, Group 1 showed a trend toward positive changes, although statistically significant differences were not observed.

Functional assessment revealed that prior to correction, the efficiency of cardiovascular and respiratory systems in the children was insufficient. After the interventions, Group 1 children demonstrated a 7.2% decrease in the Robinson index, an 11.3% increase in respiratory rate ($p < 0.05$), and a 10.5% increase in the Hildebrandt index ($p < 0.05$), indicating improved intersystem coordination. In Group 2, these indicators changed minimally and were significantly different from Group 1 results ($p < 0.05–0.01$).

Conclusions: The study established that children with Down syndrome exhibit a deficiency of essential trace elements in hair. These elements play a crucial role in regulating water balance, the functioning of the musculoskeletal system (including growth retardation), and the endocrine system. Iodine deficiency is associated with impaired intellectual development, which in turn leads to a reduced quality of life for the child.

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