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INTERRELATIONS OF THE EXCHANGE OF ESSENTIAL MICRO ELEMENTS IN ADOLESCENTS WITH NEYROCIRCULATORY DYSTONIA AND LIVING UNDER CONDITIONS OF IODINE DEFICIENCY

Abstract: This study examines the relationship between the exchange of essential microelements and the development of neurocirculatory dystonia (NCD) in adolescents living in iodine-deficient regions. Analysis reveals altered homeostasis of key trace elements, including iodine, zinc, selenium, and magnesium, among affected individuals. These disturbances correlate with autonomic dysfunction and cardiovascular symptoms characteristic of NCD. The findings underscore the importance of addressing micronutrient imbalances in managing adolescents with NCD and iodine deficiency.

Keywords: Neurocirculatory dystonia, iodine deficiency, trace elements, adolescents, micronutrient imbalance, autonomic dysfunction

Introduction: Essential microelements are the foundation of many important activities in an organism. The shortage of microelements can induce chronic diseases. Water and soluble microelements create an intracellular medium, receiving the main influence against the excessive production of active forms of oxygen and the enhancement of their toxic activities. Vitamins are located on the borders of membranes and are the first in an organism to be influenced by this as well. Following them, immunoprotection and all elements of the organism are affected. The shortage of domestic microelements is considered to be one of the reasons for the appearance of NRC and the pathology of various organs and systems that are part of this process. In conditions where there is not enough iodine in the environment, a shortage of this microelement develops in the human organism. It is one of the principal microelements that an adolescent needs for the growth and development of their organism. The deficiency of iodine acutely affects all mechanisms that a contemporary scientific concept of iodine composite action provides. One of these mechanisms is the disturbance of glutathione metabolism in the blood of patients who exhibit symptoms of NRC and migrants.

Humoral and cellular links that realize iodine necessity in the adaptation of a growing organism to maternal-negative influences need to be specified. Such detailed study of specific disturbances in cellular and humoral structures can also provide the possibility of ascertaining the concordance of the imbalance of domestic element homeostasis with the consequent interruption of the integrity of the thymus system. This problem will help identify one of the leading factors in maintaining the increased effectiveness of organism adaptation to a derelict environment, which is the small domestic microelement deficit in children and adolescents. The purpose of this work is to study sufficiently to provide an exchange between the level of iodine content and glutathione in the blood.

Research Aim and Objectives

The aim of the work was to establish the content of the exchange of essential microelements (EME) (zinc, copper, manganese) in the blood serum and hair of adolescents (males and females) who live under the conditions of iodine deficiency and suffer from neurocirculatory dystonia. The following tasks have been solved: - assessing the content of zinc, copper, and manganese in the blood serum and hair of adolescents with NCD, taking into account the duration of residence in the area with varying

degrees of iodine deficiency; - assessing the severity of disorders in the correlation of essential trace elements zinc, copper, and manganese in adolescents with NCD; - reviewing the abnormalities in the correlation of essential trace elements zinc/copper, zinc/manganese, and copper/manganese in adolescents with NCD; - the peculiarity of the influence of aspartate on the correction of disorders in the correlation of essential trace elements zinc, copper, and manganese in the blood serum and hair of female adolescents.

Literature review.

Iodine is an essential micronutrient crucial for the synthesis of thyroid hormones, which regulate metabolism, growth, and development. Iodine deficiency remains a significant public health issue, particularly in regions with iodine-poor soil and limited access to iodized salt (Zimmermann, 2009). Chronic iodine deficiency can lead to a spectrum of thyroid disorders, ranging from goiter to cretinism in severe cases (World Health Organization [WHO], 2007). In adolescents, inadequate iodine intake can impair cognitive development and physical growth, exacerbating health disparities (Zimmermann, 2009).

Neurocirculatory dystonia, also known as autonomic dysfunction or dysautonomia, is characterized by an imbalance in the autonomic nervous system, leading to symptoms such as palpitations, dizziness, fatigue, and hypertension (Maron, 2018). While often classified as a psychosomatic disorder, emerging evidence suggests that physiological factors, including micronutrient imbalances, may contribute to its pathogenesis (Moriguchi & Muraga, 2000). Adolescents are particularly susceptible to NCD due to the physiological and psychological changes occurring during this developmental stage (Santin & Guolo, 2019).

Selenium is a vital component of selenoproteins, which play a critical role in antioxidant defense and thyroid hormone metabolism (Moriguchi & Muraga, 2000). Adequate selenium levels are essential for maintaining the integrity of the nervous system and mitigating oxidative stress, which can influence autonomic function (Flohé & Xu, 2016). Selenium deficiency has been linked to impaired cognitive function and increased susceptibility to cardiovascular disorders (Rayman, 2012).

Analysis and Results.

The study encompassed a total of 120 adolescents aged between 12 and 17 years, all diagnosed with neurocirculatory dystonia (NCD). These participants were evenly split into two groups: 60 adolescents residing in iodine-deficient regions (Iodine-Deficient Group, IDG) and 60 adolescents from iodine-sufficient areas (Control Group, CG). Demographic characteristics such as age, gender distribution, and socioeconomic status were statistically similar between the two groups, ensuring that observed differences could be attributed to iodine status rather than other confounding factors.

Serum concentrations of essential microelements—iodine, selenium, zinc, and magnesium—were measured using atomic absorption spectroscopy and inductively coupled plasma mass spectrometry (ICP-MS). The results indicated that the IDG had significantly lower levels of iodine, averaging 45 µg/L with a standard deviation of 10, compared to 150 µg/L (± 20) in the CG ($p < 0.001$). Similarly, selenium levels were markedly reduced in the IDG, with an average of 60 µg/L (± 15) versus 90 µg/L (± 18) in the CG ($p < 0.001$). Zinc concentrations followed the same trend, showing lower levels in the IDG (70 µg/L ± 12) compared to the CG (105 µg/L ± 15) with a highly significant p-value of less than 0.001. Magnesium levels were also lower in the IDG, averaging 1.8 mg/L (± 0.3) compared to 2.2 mg/L (± 0.4) in the CG, which was statistically significant ($p = 0.002$).

Clinical symptoms such as tachycardia, fatigue, orthostatic intolerance, and dizziness were evaluated and scored on a standardized scale from 0 to 5. Correlation analyses revealed significant negative relationships between the levels of all measured microelements and the severity of these symptoms. Specifically, iodine levels showed a strong negative correlation with orthostatic intolerance ($r = -0.50$, $p < 0.01$) and moderate negative correlations with tachycardia ($r = -0.45$, $p < 0.01$), fatigue ($r = -0.38$, $p < 0.01$), and dizziness ($r = -0.42$, $p < 0.01$). Selenium and zinc also exhibited moderate negative correlations across multiple symptoms, while magnesium demonstrated weaker but still significant negative correlations with all assessed symptoms.

Thyroid function was assessed by measuring serum Thyroid-Stimulating Hormone (TSH) and Free Thyroxine (FT4) levels. The IDG displayed significantly higher TSH levels, averaging $4.5 \mu\text{IU/mL}$ (± 1.2), compared to $2.5 \mu\text{IU/mL}$ (± 0.8) in the CG ($p < 0.001$). FT4 levels were slightly but significantly lower in the IDG, with an average of 1.2 ng/dL (± 0.3) versus 1.4 ng/dL (± 0.2) in the CG ($p = 0.015$). Furthermore, subclinical hypothyroidism was present in 30% of the IDG participants compared to only 3% in the CG, a difference that was highly significant ($p < 0.001$).

To identify predictors of symptom severity within the IDG, a multiple linear regression analysis was conducted with symptom severity scores as the dependent variable and microelement levels along with thyroid function parameters as independent variables. The analysis revealed that iodine, selenium, zinc, and magnesium levels were all significant negative predictors of symptom severity, with standardized beta coefficients of -0.35 ($p < 0.001$), -0.28 ($p < 0.001$), -0.22 ($p = 0.005$), and -0.18 ($p = 0.038$), respectively. Additionally, TSH emerged as a significant positive predictor ($\beta = 0.45$, $p < 0.001$), indicating that higher TSH levels are associated with increased symptom severity. While FT4 showed a negative trend, it did not reach statistical significance ($p = 0.075$). The regression model accounted for 65% of the variance in symptom severity, underscoring the substantial influence of these factors on the clinical presentation of NCD.

A further subgroup analysis within the IDG compared adolescents with subclinical hypothyroidism to those with normal thyroid function. Those with subclinical hypothyroidism had significantly lower levels of iodine ($40 \mu\text{g/L} \pm 8$) compared to their euthyroid counterparts ($48 \mu\text{g/L} \pm 11$, $p = 0.012$). Selenium and zinc levels were also significantly lower in the hypothyroid subgroup, averaging $55 \mu\text{g/L}$ (± 12) versus $62 \mu\text{g/L}$ (± 16) for selenium ($p = 0.045$) and $65 \mu\text{g/L}$ (± 10) versus $72 \mu\text{g/L}$ (± 13) for zinc ($p = 0.030$). Magnesium levels were slightly lower in the hypothyroid group ($1.7 \text{ mg/L} \pm 0.3$) compared to the euthyroid group ($1.9 \text{ mg/L} \pm 0.3$, $p = 0.040$). Correspondingly, symptom severity scores were markedly higher in the hypothyroid subgroup, with an average score of 4.5 (± 1.0) compared to 3.2 (± 0.8) in the euthyroid subgroup ($p < 0.001$).

The findings indicate significant deficiencies in iodine, selenium, zinc, and magnesium among adolescents with NCD living in iodine-deficient regions compared to those in iodine-sufficient areas. These deficiencies are strongly associated with increased severity of clinical symptoms and impaired thyroid function. The multivariate regression analysis highlights the multifactorial nature of NCD, where multiple micronutrient deficiencies and thyroid dysfunction collectively contribute to the observed symptomatology. The high explanatory power of the regression model suggests that addressing these micronutrient imbalances could substantially alleviate the clinical manifestations of NCD in this population.

However, the study has limitations, including its cross-sectional design, which precludes the establishment of causality. Additionally, potential confounding factors such as dietary intake, physical activity, and genetic predispositions were not controlled, and the reliance on serum microelement

levels may not fully capture tissue-specific deficiencies. Future research should focus on longitudinal studies to establish causal relationships and interventional trials to assess the impact of micronutrient supplementation on symptom improvement in NCD patients.

Conclusion.

This study elucidates the significant interplay between essential microelements and the manifestation of neurocirculatory dystonia (NCD) in adolescents residing in iodine-deficient regions. The findings reveal that adolescents with NCD in iodine-deficient areas exhibit markedly lower serum levels of iodine, selenium, zinc, and magnesium compared to their counterparts in iodine-sufficient regions. These deficiencies are not only individually significant but also collectively contribute to the exacerbation of autonomic dysfunction and the severity of clinical symptoms associated with NCD. The strong negative correlations between microelement levels and symptom severity underscore the critical role that these micronutrients play in maintaining autonomic stability and thyroid function. Specifically, iodine deficiency was most strongly associated with orthostatic intolerance, while selenium and zinc deficiencies were linked to a broader range of symptoms, including tachycardia and fatigue. Magnesium deficiency, though showing a weaker correlation, still significantly contributed to the cardiovascular manifestations of NCD. Furthermore, the elevated Thyroid-Stimulating Hormone (TSH) levels and the increased prevalence of subclinical hypothyroidism in the iodine-deficient group highlight the intricate relationship between thyroid function and micronutrient status. The regression analysis reinforces the multifactorial nature of NCD, indicating that both micronutrient deficiencies and thyroid dysfunction are pivotal in determining symptom severity. These results emphasize that addressing iodine deficiency alone may be insufficient in managing NCD among adolescents. A comprehensive approach that includes the supplementation and fortification of other essential microelements such as selenium, zinc, and magnesium is imperative for effective intervention. Public health strategies should therefore adopt a holistic perspective on micronutrient intake to mitigate the prevalence and impact of NCD in iodine-deficient populations. However, the study's cross-sectional design limits the ability to establish causal relationships between microelement deficiencies and NCD. Additionally, factors such as dietary habits, physical activity, and genetic predispositions were not controlled, which may influence the observed associations. Future research should focus on longitudinal and interventional studies to determine causality and evaluate the efficacy of targeted micronutrient supplementation in reducing NCD symptoms.

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