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# Intensity of nitroso-oxidative processes in the oral fluid in children with a combination of latent iron and mild iodine deficiency

**O.V. Zaiats, N.M. Voronych-Semchenko, T.P. Kryvenkyi**

*Ivano-Frankivsk National Medical University; e-mail: ozayats@ifnmu.edu.ua*

*Proper supply of bioelements that participate in physiological processes is especially important in childhood, because it significantly affects for the formation of the hormonal profile. The prevalence of dental pathology among schoolchildren reflects the priority of early diagnosis and thorough prevention of pathological processes. In order to find out the risks of dental health disorders, the intensity of nitroso-oxidative processes in the oral fluid of children (boys and girls aged 6-11 and young men and girls aged 12-18) with combined latent iron and mild iodine deficiency was studied and in conditions of sufficient supply of trace elements (control group). As a result of the study, the activation of the peroxidation processes of proteins (the level of products of oxidative modification of proteins increases by 87.3% - 3.3 times) and lipids (the content of diene conjugates increases by 62.7% - 12.4 times) in case of imbalance of antioxidant protection of oral fluid (inhibition of SOD by 20.4-30.7%, activation of glutathione peroxidase by 92.0-93.3%) compared to data in healthy teenagers. The development of iron and iodine deficiency is accompanied by an 8.3-fold increase in $NO_2^-$ content, a 3.3-fold increase in the amount of $NO_2^-$ and $NO_3^-$ in the oral fluid of boys, and a 2.5-11.4-fold increase in the concentration of peroxynitrite in all schoolchildren compared to controls. An increase in $H_2S$ content in the oral fluid was also found in girls (by 25.6% compared to the values of the control group). The level of oxidative processes is higher in younger schoolchildren (ages 6-11). With age, the intensity of oxidative stress decreases, but changes in the NO metabolism system increase, especially for girls (cytotoxic peroxynitrite and $H_2S$ accumulate in the oral fluid). Therefore, it is possible to assert a high probability of the development of nitroso-oxidative stress in the conditions of a combination of iron and iodine deficiency already at the stage of preclinical changes, which can increase the risks of developing dental pathology.*

*Key words: nitric oxide stress; oral fluid; latent iron deficiency; mild iodine deficiency.*

## INTRODUCTION

The issue of the high prevalence of dental pathology in school-age children remains a priority, encouraging the earlier diagnosis of pathological processes and the thorough prevention of dental health problems [1]. There is a strong correlation between somatic pathology, particularly in comorbid conditions, and alterations in biochemical composition of the oral fluid [2]. In addition to lesions of the dental hard tissues, there has been a notable increase in the diagnosis of inflammatory-dystrophic diseases of the periodontal tissues in children, particularly during puberty [3].

It is of great importance for a child's body to have an adequate intake of micro- and macronutrients, which are involved in numerous physiological processes and ensure the formation of a hormonal profile. Among the bioelements, iron and iodine merit special attention, as their deficiency has a significant impact on children's health. The physiological importance of iron lies in its participation in the processes of tissue respiration [4]. Additionally, the trace element is a component of iodide peroxidase, catalysing the oxidation of iodine during the synthesis of thyroid hormones. Consequently, iron deficiency can diminish the functional

capacity of the thyroid gland and negatively impact the metabolism of thyroid hormones. It is established that a reduction in serum ferritin (SF) levels results in a decrease in the secretion of free thyroxine [5]. SF is a valuable diagnostic marker for iron deficiency. The combination of iron and iodine deficiency can result in a potentiated pathogenic effect on not only the thyroid profile but also the dental status, which subsequently alters the remineralizing function of oral fluid. It has been demonstrated in scientific studies that hypothyroidism is a contributing factor to the severity and prevalence of dental caries, stomatitis, gingivitis and periodontitis, particularly in the inhabitants residing in endemic regions. Additionally, there is a negative correlation between SF levels and bone mineral density [6, 8]. Oxidative stress plays a significant role in the pathogenesis of these diseases, which develops as a result of an imbalance between the pro- and antioxidant systems, leading to the onset of a local inflammatory process. In such circumstances, pro-inflammatory enzymes (NO-synthases and cyclooxygenases) are activated, accompanied by an increase in the content of oxygen radicals, peroxynitrite, as well as pro-inflammatory cytokines and toxic metabolic products. This exacerbates the development of nitroso-oxidative stress [9-12].

The aim of the study was to ascertain the extent of nitroso-oxidative processes in the oral fluid of schoolchildren exhibiting combined latent iron and mild iodine deficiency.

## METHODS

A clinical-laboratory examination was performed with 67 children of primary and school-age (boys and girls aged 6-11 and young men and girls aged 12-18). The schoolchildren were divided into two groups. Group 1 (control) comprised children with adequate iron metabolism and iodine intake (16 girls and 17 boys). Group 2 consisted of schoolchildren with latent iron deficiency and mild iodine deficiency (16 girls and 18 boys). The studies were performed following the ethical, moral and legal requirements outlined in the Order of the Ministry of Health of Ukraine No. 66 from 13.02.2006.

In order to characterise iron metabolism, a series of tests were conducted on serum iron (SI), SF, total serum iron binding capacity (TSIBC), transferrin saturation with iron (TSI), and haemoglobin (Hb) in capillary blood [13]. The determination of the aforementioned indices was performed using reagent kits manufactured by “Cormay” (Poland) and “DRG” (Germany). The diagnosis of latent iron deficiency was made according to the following criteria: SF - less than 30 μg/l (normal range: 32-68 μg/l), SI - less than 12 μmol/l (normal range: 12-22 μmol/l), TSIBC - more than 58.0 μmol/l (normal range: 44.6-56.8 μmol/l), TSI - less than 17% (normal range: 17-20%) at reference values of Hb in capillary blood (for children aged 6-11 years: 115 g/l and above; 12-18 years: 120 g/l and above) [13].

The assessment of thyroid homeostasis was performed through the analysis of hormonal status and urinary iodine concentration. The content of free triiodothyronine (fT3) and thyroxine (fT4), as well as the adenohypophysis thyroid stimulating hormone (TSH), were determined in the blood serum using “DRG” test kits from Germany. Thereafter, the fT3/fT4, TSH/fT4, and integral thyroid index (ITI) indices were calculated [14]. To evaluate the body’s iodine status, the urinary iodine excretion level was quantified in individual urine samples. A diagnosis of mild iodine deficiency was made when the urinary iodine concentration fell within the range of 50.0-99.0 μg/l [14].

The study of the intensity of oxidative processes in oral fluid was performed through the analysis of indices of protein (POP) and lipid peroxidation (PLO). The state of POP was determined according to the level of products of oxidative modification of proteins (OMP, fraction E430) [15]. The level of PLO was characterised by the accumulation of diene conjugates of unsaturated fatty acids (DC) and thiobarbituric acid – reactive products (TBA – RPs) [15]. The

status of the antioxidant defense system was evaluated by measuring the activity of glutathione peroxidase (GPx) and superoxide dismutase (SOD) in the oral fluid [15]. Furthermore, the activity of arginase, the L-arginine content, the $NO_2^-$ level, the sum of $NO_2^-$ and $NO_3^-$, the concentration of peroxynitrite and hydrogen sulfide ($H_2S$) were also determined in the oral fluid [16]. For the biochemical analysis, pre – frozen oral fluid samples (not subjected to repeated freezing and thawing cycles) were thawed and mixed thoroughly until a homogeneous consistency was achieved.

The digital results obtained were subsequently subjected to statistical processing using the Excel computer program, which forms part of the Microsoft Office 365 ProPlus package. For each sample, the Kolmogorov–Smirnov and Lilliefors tests were employed to ascertain the normality of the distribution of the studied index. The results obtained corresponded to Gauss's law and are represented by the interval M ± m. The reliability of the observed differences in the data within the samples was tested using the parametric Student's t-criterion. The discrepancy in the parameters was deemed statistically significant at a probability level of $P < 0.05$. To determine the strength and direction of the relationship between the indices there was used correlation analysis with the use of the Pearson correlation coefficient r.

## RESULTS AND DISCUSSION

As a result of the study, in primary and senior school-age children of the control group, the indices of iron metabolism in the blood serum were within the reference values (Table 1). In girls with combined iron and iodine deficiency, the Hb content in capillary blood was found to be 11.7% lower than in the control group ($P < 0.05$), SI and SF - at 52.3% ($P < 0.01$) and 69.1% ($P < 0.001$), respectively, against the background of an increase in the TSIBC at 59.8 % ($P < 0.01$). A 72.0% reduction in TSI in girls was observed in comparison to the control data ($P < 0.05$). In boys, the same tendency was observed in the studied parameters, namely: a

**Table 1. Indices of iron metabolism in children aged 6-11 years and 12-18 years with proper iron and iodine metabolism and combined latent iron and mild iodine deficiency (M ± m)**

| Groups of examined | Haemoglobin (Hb), g/l | Serum iron (SI), μmol/l | Total serum iron binding capacity (TSIBC), μmol/l | Serum ferritin (SF), μg/l | Transferrin saturation with iron (TSI), % |
|---|---|---|---|---|---|
| Group 1 (control) | | | | | |
| 6-11 years | | | | | |
| boys | 134.21 ± 5.31 | 21.45 ± 1.94 | 48.90 ± 3.59 | 56.14 ± 8.19 | 42.08 ± 8.63 |
| girls | 130.25 ± 4.21 | 24.33 ± 2.01 | 50.89 ± 5.030 | 51.11 ± 3.12 | 51.69 ± 5.10 |
| 12-18 years | | | | | |
| young men | 145.32 ± 6.37 | 19.04 ± 1.21 | 50.64 ± 4.12 | 53.71 ± 7.45 | 33.01 ± 5.23 |
| girls | 131.60 ± 5.12 | 18.48 ± 1.23 | 56.75 ± 6.41 | 41.45 ± 2.92 | 38.04 ± 3.01 |
| Group 2 (children with latent iron deficiency and mild iodine deficiency) | | | | | |
| 6-11 years | | | | | |
| boys | 115.40 ± 2.32* | 9.95 ± 1.71** | 71.31 ± 5.32** | 22.68 ± 5.21*** | 14.22 ± 3.62* |
| girls | 115.01 ± 2.19* | 11.55 ± 1.95** | 77.46 ± 5.65* | 15.86 ± 3.93** | 14.48 ± 1.80* |
| 12-18 years | | | | | |
| young men | 120.50 ± 1.72** | 10.02 ± 0.97*** | 69.56 ± 4.76 | 27.32 ± 5.01* | 14.64 ± 1.87* |
| girls | 120.10 ± 1.68 | 11.74 ± 1.27** | 68.84 ± 5.19* | 21.61 ± 3.54** | 17.24 ± 2.62** |

Note. Significant difference from the control: *P < 0.05, **P < 0.01, ***P < 0.001.

decrease in Hb content in capillary blood at 14.0% ($P < 0.05$), concentration of SI at 53.6% ($P < 0.01$), and SF at 59.5% ($P < 0.01$), while the content of TSIBC increased at 40.9% ($P < 0.05$) compared to the control group. The TSI in the males within the same group was 66.2% lower than that observed in healthy controls ($P < 0.05$).

A reduction in Hb levels was observed in the capillary blood of girls when compared to the baseline data. However, these changes were not found to be statistically significant. A reduction in the blood serum of girls with combined pathology of SI at 38.4% ($P < 0.01$), SF at 48.0% ($P < 0.01$), and TSI at 54.7% ($P < 0.01$) was observed in comparison to the control data, against the background of an increase of TSIBC at 36.0% ($P < 0.01$). In young men of this group, a statistically significant decrease in the content of Hb in capillary blood was observed, with a reduction of 17.0% ($P < 0.01$), SI at 45.9% ($P < 0.001$), SF at 49.2% ($P < 0.05$) and TSI at 55.8% ($P < 0.05$) of blood serum compared to the control values (see Table 1).

Table 2 presents the thyroid profile indices for the examined children. The thyroid hormone levels were within the reference range [17].

The iodine content in the urine of younger and older schoolchildren of the control group, regardless of gender, corresponded to the literature data on the proper supply of the microelement [17]. Under conditions of combined iron and iodine deficiency, urinary iodine excretion in girls was 29.9% ($P < 0.01$) lower than in the control group, 33.2% ($P < 0.01$) in boys, 30.7% ($P < 0.01$) in girls and 24.6% ($P < 0.01$) in young men, respectively (see Table 2).

Activation of protein peroxidation was found in the oral fluid of primary schoolchildren with latent iron and mild iodine deficiency. In particular, in the girls of group II, the content of OMP products in the oral fluid increased 2.2-fold ($P < 0.001$), in boys - 3.3-fold ($P < 0.001$) compared to the baseline data (Fig. 1A). The multidirectional nature of changes in the studied indices was observed in senior school-age children. Thus, in girls with combined micronutrient deficiencies, a decrease in the content of OMP products in the oral fluid at 87.3% ($P < 0.05$) was found, while

**Table 2. Indices of thyroid status, urine iodine content in children aged 6-11 and 12-18 years with proper iron and iodine metabolism and combined latent iron and mild iodine deficiency (M ± m)**

| Groups of examined | Free triiodothyronine (fT3), pmol/l | Free thyroxine (fT4), pmol/l | Thyroid stimulating hormone (TSH) mMO/l | fT3/fT4, unit | TSH/fT4, unit | fT3 + fT4/ TSH (ITI), unit | Urine iodine content, μg/l |
|---|---|---|---|---|---|---|---|
| Group 1 (control) | | | | | | | |
| 6-11 years | | | | | | | |
| boys | 6.01 ± 0.19 | 27.80 ± 1.23 | 1.56 ± 0.13 | 0.22 ± 0.01 | 0.05 ± 0.01 | 22.31 ± 3.78 | 105.11 ± 2.88 |
| girls | 5.91 ± 0.32 | 25.01 ± 1.21 | 1.44 ± 0.18 | 0.24 ± 0.01 | 0.06 ± 0.01 | 21.50 ± 3.48 | 103.60 ± 2.67 |
| 12-18 years | | | | | | | |
| young men | 5.93 ± 0.25 | 24.61 ± 1.03 | 1.77 ± 0.21 | 0.25 ± 0.01 | 0.07 ± 0.01 | 17.11 ± 2.72 | 103.42 ± 2.71 |
| girls | 5.73 ± 0.36 | 23.41 ± 1.05 | 1.92 ± 0.28 | 0.24 ± 0.01 | 0.08 ± 0.01 | 15.31 ± 1.52 | 104.11 ± 3.61 |
| Group 2 (children with latent iron deficiency and mild iodine deficiency) | | | | | | | |
| 6-11 years | | | | | | | |
| boys | 4.82 ± 0.31* | 21.21 ± 0.94* | 3.83 ± 0.47** | 0.22 ± 0.01 | 0.17 ± 0.03** | 6.96 ± 1.13** | 70.21 ± 6.93** |
| girls | 4.66 ± 0.37* | 22.01 ± 1.02** | 3.94 ± 0.36*** | 0.21 ± 0.01 | 0.18 ± 0.02*** | 6.65 ± 0.82** | 72.61 ± 6.34** |
| 12-18 years | | | | | | | |
| young men | 4.79 ± 0.33* | 20.80 ± 0.98* | 3.33 ± 0.23*** | 0.23 ± 0.01 | 0.16 ± 0.02** | 7.81 ± 1.15* | 78.0 ± 6.68** |
| girls | 4.66 ± 0.72 | 20.31 ± 1.66 | 3.58 ± 0.41** | 0.22 ± 0.02 | 0.17 ± 0.02** | 7.13 ± 1.38** | 72.1 ± 6.34** |

Notes: See Table 1.

in young men, an increase in the studied index at 94.4% ($P < 0.05$) was found compared to the data of healthy peers (Fig. 1B). OMP products are a source of free radicals and signal oxidative tissue damage [18, 19]. It has been scientifically confirmed that they are more stable than DC and TBA – RPs and contribute to a significant depletion of the antioxidant reserve. Analysing the results obtained, we can expect an increased risk of cell membrane destruction and a decrease in antioxidant protection of the oral fluid under conditions of combined trace element imbalance.

The examination of the oral fluid of the children in the study group revealed a notable increase in the intensity of lipid peroxidation processes. In particular, in girls with combined pathology, an increase in the content of DC in the oral fluid 12.4-fold ($P < 0.001$) compared to the values in healthy peers was observed, while the content of TBA – RPs remained within the reference values. In the oral fluid of the boys within the same group, no significant alterations in the DC content were observed compared to the baseline data. However, a notable increase in the TBA – RPs level at 74.5% ($P < 0.01$) was found (see Fig. 1C). In senior schoolchildren, a unidirectional trend of activation of lipoperoxidation processes in the oral fluid was observed, irrespective of gender. Therefore, in girls and young men with combined iron and iodine deficiency, the content of DC in the oral fluid exceeded the baseline data at 50.5% ($P < 0.05$) and 62.7% ($P < 0.001$), while TBA – RPs exceeded the baseline data at 98.1% ($P < 0.01$) and 94.1% ($P < 0.001$), respectively (see Fig. 1D). The results obtained reflect the accumulation of lipoperoxidation products in the oral fluid, which characterizes the development of oxidative stress and increases the risk of cell membrane damage. The observed changes

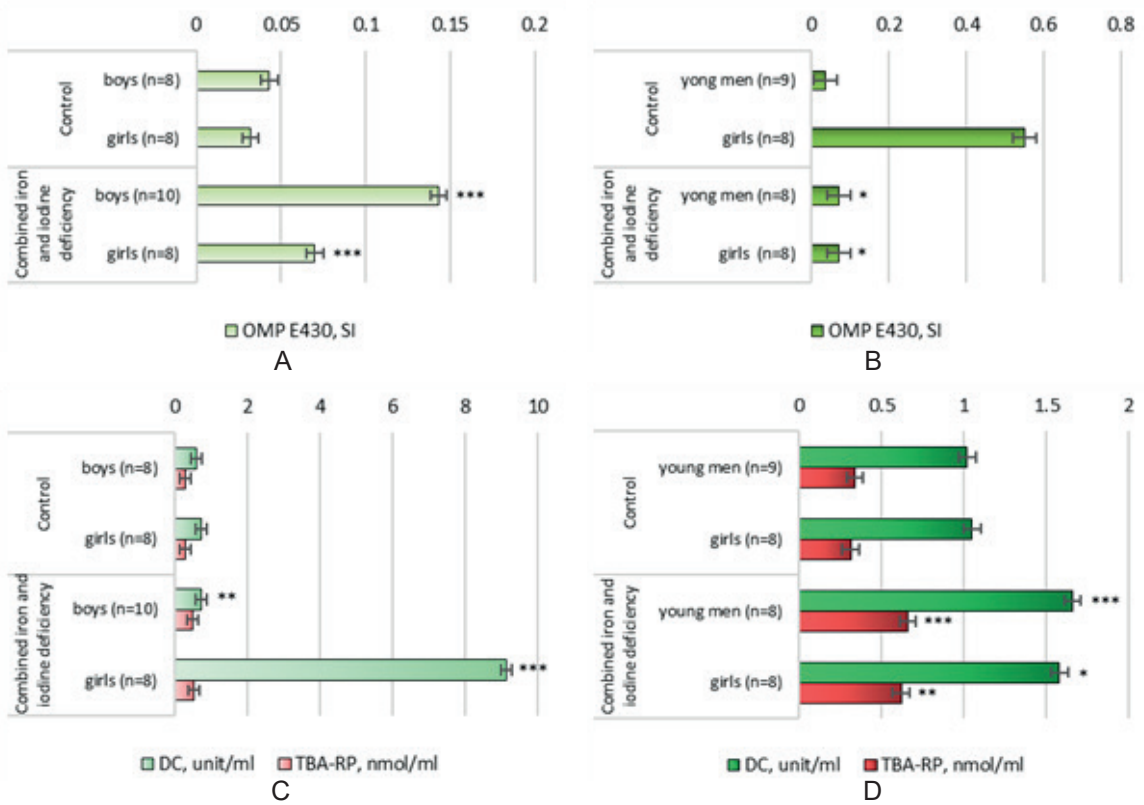


Fig. 1 The content of OMP and POL products in the oral fluid of children aged 6-11 years (A, C) and 12-18 years (B, D) with proper iron and iodine metabolism and combined iron and iodine deficiency (M ± m). *P < 0.05, **P < 0.01, ***P < 0.001

could be regarded as a risk factor for developing dental pathology, given that the activation of protein and lipid peroxidation and the deficiency of certain macro- and microelements lead to the development of gingivitis and generalized periodontitis against the background of reduced capillary resistance of periodontal tissues [18].

Under the conditions of combined pathology, the indices of antioxidant protection in the oral fluid of girls exhibited different dynamics. Therefore, the activity of GPx did not differ significantly from the values observed in healthy control peers, while SOD exceeded the control data at 30.7% ($P < 0.001$) (Fig. 2A). However, in boys, an increase in GPx activity at 92.0% ($P < 0.05$) was observed, while SOD activity decreased at 21.3% ($P < 0.05$) in comparison to the control data. A similar pattern of change in antioxidant protection of the oral fluid was observed in senior schoolchildren. In particular, in girls, the activity of GPx did not differ significantly from the baseline data, while the activity of SOD decreased at 30.7% ($P < 0.01$) in comparison to the control (Fig. 2B). In the oral fluid of young men, the activation of GPx was found to be 93.3% ($P < 0.05$) in comparison to the inhibition of SOD at 20.4% ($P < 0.05$) concerning the reference data. It is of significant importance to note that in the event of an impairment in the body's antioxidant defence, demineralization and subsequent destruction of bone tissue may occur. It can be argued that the development of oxidative stress is contingent upon a reduction in the antioxidant defence of the oral fluid observed in the examined children. This places them in a risk group for the development of inflammatory-dystrophic diseases of periodontal tissues [18, 19].

In recent years, the study of L-arginine metabolism in the context of an imbalance in oxidative processes has been of considerable scientific interest. Unregulated and excessive synthesis of NO contributes to the development of vascular shock, neurodegeneration, and

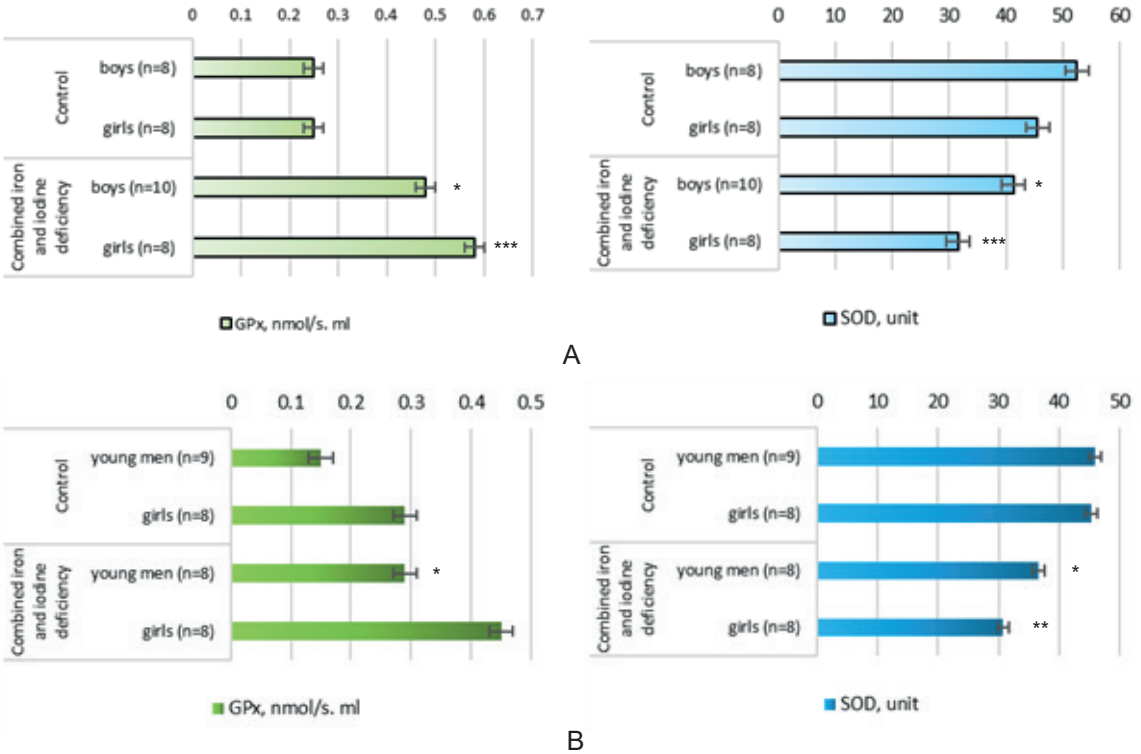


Fig. 2. Activity of GPx and SOD in the oral fluid of children aged 6-11 (A) and 12-18 (B) years, respectively, with proper iron and iodine metabolism and combined iron and iodine deficiency (M ± m). *$P < 0.05$, **$P < 0.01$, ***$P < 0.001$

chronic inflammation. In the oral fluid, the concentration of NO increases in the presence of a severe inflammatory process through the direct activation of inducible NO-synthase (iNOS). It is scientifically proven that high NO concentration inhibits bone resorption [20]. A stable metabolite of the NO gas transmitter is $NO_2^-$, which easily diffuses through cell membranes, where it reacts with target molecules, which can cause cell damage and apoptosis.

It was found that in the oral fluid of primary school children with combined latent iron deficiency and mild iodine deficiency, changes in the L-arginine/arginase system were not pronounced compared to those in the control group. In particular, significant changes in the studied parameters in the oral fluid were found only in boys (inhibition of arginase activity at 33.3%, $P < 0.05$ compared with the baseline values) (Fig. 3A). In the oral fluid of senior schoolchildren with latent iron deficiency against the background of iodine deprivation, no significant changes in the L-arginine/arginase system were found compared to the control data (Fig. 3B).

In the oral fluid of girls with combined iron and iodine deficiency, a tendency towards increased levels of $NO_2^-$ and the sum of $NO_2^-$ and $NO_3^-$ in the oral fluid was observed. However, the results did not exceed the reference values. It is established that NO is a marker of antioxidant homeostasis; however, elevated levels of NO are toxic to the body. L-arginine functions as an agonist of NO synthesis, thereby facilitating the inhibition of NO synthesis at reduced levels [20]. In general, oxidative/nitrosoactive compounds cause an imbalance in antioxidant defence, which results in the disruption of the protective reaction of neutralizing reactive oxygen species. Concurrently, the concentration of peroxynitrite in the girls' oral fluid exhibited a notable increase (2.5-fold, $P < 0.01$ in comparison to the control

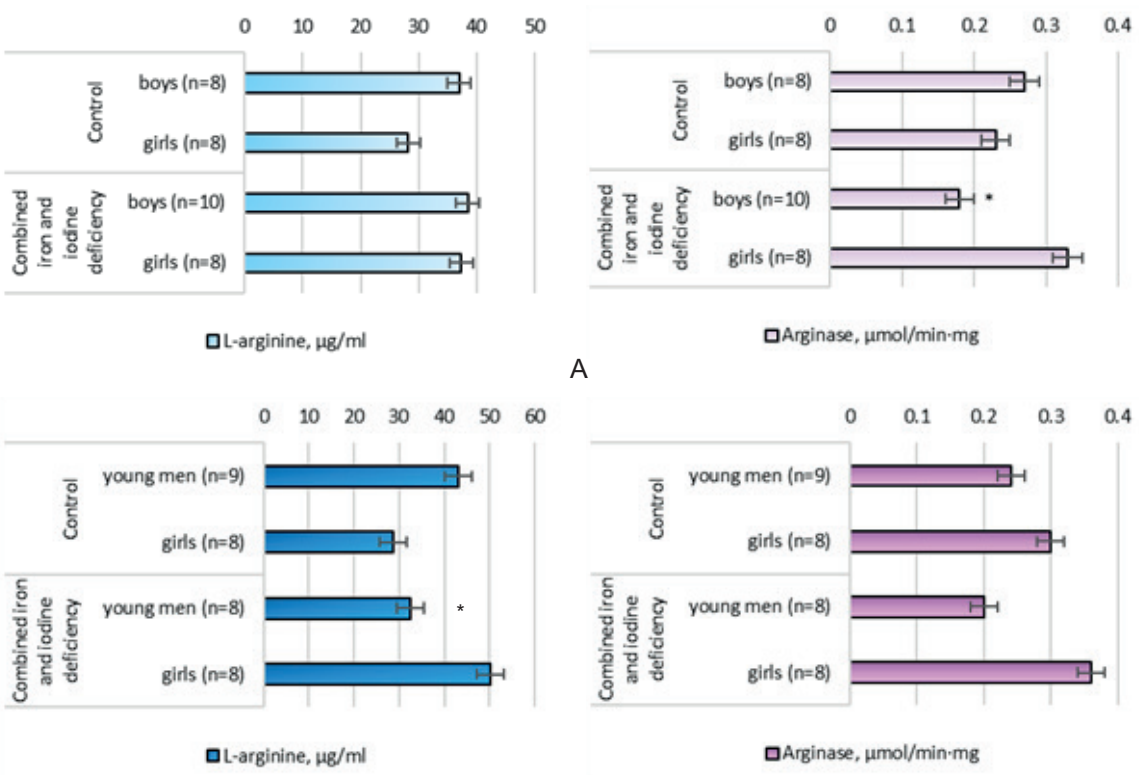


Fig. 3. L-arginine content in oral fluid and arginase activity in children aged 6-11 years (A) and 12-18 years (B) with proper iron and iodine metabolism and combined iron and iodine deficiency (M ± m). *P < 0.05

data). The observed changes in the parameters under study were unidirectional in nature for the boys in this group. Specifically, there was an 8.3-fold increase in $NO_2^-$ content ($P < 0.001$), a 3.3-fold increase in the sum of $NO_2^-$ and $NO_3^-$ ($P < 0.05$), and a 2.8-fold increase in peroxynitrite ($P < 0.01$) (Fig. 4A). It is noteworthy that under hypoxic conditions within the body, elevated concentrations of $NO_2^-$ and $NO_3^-$ can serve as a foundation for an alternative pathway of NO synthesis. In senior schoolchildren with latent iron deficiency and mild iodine deficiency, the values of the aforementioned parameters were consistent with those observed in primary schoolchildren. Therefore, an increase in the concentration of peroxynitrite in the oral fluid of girls and young men in this group was observed to be fourfold ($P < 0.01$) and 11.4-fold ($P < 0.001$), respectively. In contrast, the content of $NO_2^-$, the sum of $NO_2^-$ and $NO_3^-$ in the oral fluid did not exhibit a significant change compared to the data of children in the control group (Fig. 4B).

It seems reasonable to posit that an excessive increase in NO levels contributes to the activation of lipoperoxidation processes and leads to the formation of peroxynitrite, which is a toxic compound of active nitrogen metabolites. It is more reactive than NO and has the potential to damage cellular structures, induce cell apoptosis and inactivate the enzymes SOD and GPx.

The study of another gas neurotransmitter, hydrogen sulfide ($H_2S$), is attracting considerable scientific interest. This mediator is a signaling response molecule that has neuromodulatory and vasodilator effects, and is involved in cytoprotection, apoptosis, inflammation, and regulation of vascular tone. It is established that $H_2S$ displays antioxidant characteristics through its interaction with active radicals. The combined effect of NO and $H_2S$ is vasodilatory, with $H_2S$ catalyzing the release of NO from S-nitrogluta-thione. Oxidative stress initiates a series of reac-tions within the redox-dependent system, wherein $H_2S$ serves to stimulate phosphorylation processes. A deficiency of $H_2S$, occurring concurrently with elevated levels of free radicals and exhaustion of antioxidant defences, results in alterations to the local blood supply and the emergence of tissue hypoxia with impaired endothelial function. The utilization of donors of $H_2S$ synthesis has been demonstrated to exert a beneficial influence upon the course of inflammatory reactions in the digestive system [21].

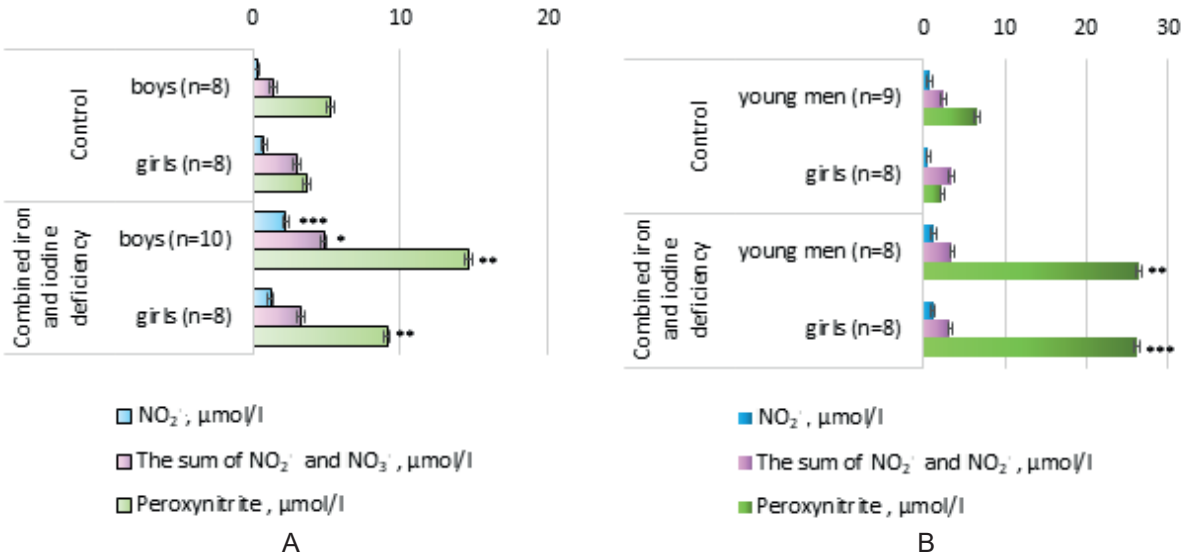


Fig. 4. The content of $NO_2^-$, the sum of $NO_2^-$ and $NO_3^-$ and peroxynitrite in the oral fluid of children aged 6-11 years (A) and 12-18 years (B) with proper iron and iodine metabolism and combined iron and iodine deficiency (M ± m). *$P < 0.05$, **$P < 0.01$, ***$P < 0.001$

The study demonstrated that the concentration of $H_2S$ in the oral fluid of primary (irrespective of gender) and senior schoolchildren was not statistically significant and aligned with the reference values. However, an increase in the concentration of $H_2S$ in the oral fluid of females at 25.6% ($P < 0.01$) was observed in comparison to the results obtained from healthy peers. Such alterations may be conditioned by an imbalance between pro-/antioxidants, or the onset of an inflammatory process within the oral cavity. This may occur at the preclinical stage of trace element imbalance.

Close correlations were found between arginase activity and fT3 ($r = 0.78$, $P < 0.05$) and TSH ($r = -0.77$, $P < 0.05$); concentration of L-arginine and SI ($r = 0.87$, $P < 0.05$). The level of TSH significantly affects the concentration of $NO2^-$ in the oral fluid ($r = -0.89$, $P < 0.05$). The sum of $NO_2^-$ and $NO_3^-$ of oral fluid with a high probability depends on the SF ($r = -0.73$, $P < 0.05$), TSIBC ($r = 0.80$, $P < 0.05$), fT3 ($r = 0.72$, $P < 0.05$) and fT4 ($r = 0.84$, $P < 0.05$). A strong direct correlation was found between the TSIBC and the concentration of peroxynitrite in the oral fluid ($r = 0.77$, $P < 0.05$).

## CONCLUSIONS

Under the conditions of latent iron and mild iodine deficiency in the oral fluid of schoolchildren, the processes of protein peroxidation are activated (the concentration of protein peroxidation products increases at 87.3% – 3.3-fold, $P < 0, 05$) and lipids (the level of DC increases at 62.7% – 12.4-fold, $P < 0.001$) against the background of an imbalance of the antiradical reserve (inhibition of SOD activity at 20.4-30.7%, $P < 0.05$ and activation of GPx by 92.0-93.3%, $P < 0.05$) compared to healthy peers. The level of oxidative processes is higher in younger pupils (aged 6-11 years). As children grow older, the intensity of oxidative stress tends to decrease. However, changes in the NO metabolism system, particularly in girls (cytotoxic peroxynitrite $H_2S$ accumulate in the oral fluid), become more pronounced. The activation of nitroso-oxidative processes in the context of preclinical micronutrient imbalance may serve as a potential trigger for dental pathology in school-aged children.

*The authors of this study confirm that the research and publication of the results were not associated with any conflicts regarding commercial or financial relations, relations with organizations and/or individuals who may have been related to the study, and interrelations of co-authors of the article.*

**О.В. Заяць, Н.М. Воронич-Семченко, Т.П. Кривенький**

## ІНТЕНСИВНІСТЬ НІТРОЗО-ОКСИДАТИВНИХ ПРОЦЕСІВ У РОТОВІЙ РІДИНІ ДІТЕЙ З ПОЄДНАННЯМ ЛАТЕНТНОГО ЗАЛІЗО- ТА ЛЕГКОГО ЙОДОДЕФІЦИТУ

*Івано-Франківський національний медичний університет; e-mail: ozayats@ifnmu.edu.ua*

Належне забезпечення біоелементами, що беруть участь у фізіологічних процесах, є особливо важливим у дитячому віці, адже суттєво впливає на становлення гормонального профілю. Поширеність стоматологічної патології серед школярів відображає пріоритетність ранньої діагностики та ретельної профілактики патологічних процесів. Для з'ясування ризиків порушення стоматологічного здоров'я досліджували інтенсивність нітрозо-оксидативних процесів у ротовій рідині дітей (хлопчиків і дівчаток 6–11 та юнаків і дівчат 12–18 років) з поєднаним латентним залізо- і легким йододефіцитом та за умов достатнього надходження мікроелементів (контрольна група). У результаті дослідження встановили активацію процесів пероксидації білків (зростає вміст продуктів окиснювальної модифікації білків на 87,3% – у 3,3 раза) і ліпідів (збільшується вміст дієнових кон'югатів на 62,7% – у 12,4 раза) на тлі дисбалансу антиоксидантного захисту ротової рідини (пригнічення СОД на 20,4–30,7 %, активація глутатіонпероксидази на 92,0–93,3 %) щодо значень у здорових однолітків. Розвиток залізо- та йододефіциту супроводжується збільшенням вмісту $NO_2^-$ у 8,3 раза, суми $NO_2^-$ і $NO_3^-$ – у 3,3 раза у ротовій рідині хлопчиків та інтенсивним зростанням концентрації пероксинітриту у 2,5–11,4 раза у всіх школярів щодо контролю. У дівчат встановлено також збільшення у ротовій рідині вмісту $H_2S$ (на 25,6% щодо контролю). Рівень оксидативних процесів вищий у молодших школярів (6–11 років). З віком інтенсивність оксидативного стресу знижується, проте наростають зміни в системі метаболізму NO, особливо у дівчат (у ротовій рідині накопичується цитотоксичний

пероксинітрит і $H_2S$). Тому можна стверджувати про високу ймовірність розвитку нітрозо-оксидативного стресу за умов поєднання залізо- та йододефіциту вже на стадії доклінічних змін, що може збільшувати ризики розвитку стоматологічної патології.

Ключові слова: нітрозо-оксидативний стрес; ротова рідина; латентний залізодефіцит; легкий йододефіцит.

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