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EVALUATION OF VITAMIN CONTENT AND LIPID PEROXIDATION IN THE BLOOD SERUM OF ATHLETES WITH SCOLIOSIS AND IRON-DEFICIENCY ANEMIA

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Aim. The paper aims to assess vitamin (A, C, carotene) and iron content, as well as peroxidation activity in the blood serum of athletes with scoliosis and anemia. **Materials and methods.** 620 adolescents aged from 13 to 18 were randomly selected. All participants were under clinical supervision at a medical and physical education clinic in Veliky Novgorod. Of these adolescents, 3 groups were formed for further analysis: 1st group – apparently healthy adolescents (n = 20), 2nd group – adolescents with iron-deficiency anemia (n = 20), 3rd group – athletes with scoliosis and iron-deficiency anemia (n = 10). Blood test results were evaluated. The serum levels of vitamin A, C, carotene, iron and malondialdehyde were measured. Vitamin C content was determined in the urine samples. ECG indicators were analyzed before and after exercise. **Results.** It has been found that athletes with both scoliosis and anemia demonstrate significant changes in terms of vitamin A and C levels, which trigger the processes that result in oxidative stress. These changes can be one of the causes of frequent (in 50% of cases) ECG changes under exercise in this group of athletes (extrasystole, transient SA block II degree). **Conclusion.** Iron-deficiency anemia is mostly identified for the first time during a routine examination. Athletes with scoliosis and iron deficiency anemia are advised for further medical examination and operational monitoring of regulatory mechanisms, including vitamin content in blood serum, due to hypoxia and lipid peroxidation.

Keywords: *athletes, iron-deficiency anemia, scoliosis, flat feet, vitamin content, vitamin A, vitamin C, carotene, malondialdehyde.*

Introduction. Diseases of the musculoskeletal system (scoliosis) are the most common pathology in athletes. According to O. Goncharova [8], there is an increasing number of children with musculoskeletal disorders [28]. Therefore, the issue of musculoskeletal system diseases is a priority for modern medicine. The pathology of the musculoskeletal system in children is formed by hereditary and social factors [11]. Musculoskeletal system diseases among children are closely associated with dysplastic processes, which are mainly presented by scoliosis and flat feet [12]. Scoliosis also leads to changes in the spinal configuration with the local overload of its segments, which results in limb disorders [4]. Joint hypermobility and active training with asymmetric load on the spine of adolescent athletes provoke the so-called "sports scoliosis" [24].

As a result of scoliosis progression, the deformation of the chest occurs, which leads to negative changes in the cardiorespiratory system [7]. Hypoxia development is associated with iron-deficiency anemia (IDA). Therefore, IDA progression occurs among adolescent athletes from 5 to 7.5 %.

Hypoxia is accompanied by the development of oxidative stress, which leads to damage of cell membranes and the emergence of pathological conditions. A stable secondary product of lipid peroxidation is malondialdehyde, which is determined in blood serum.

Antioxidants are non-enzymatic factors such as vitamin A, C, carotene.

Regular sports activity increases the need for vitamins. Studies of blood vitamin levels indicate a combined vitamin deficiency in most children [15].

According to other researchers, vitamin concentration in the blood serum of athletes can be either reduced or increased, depending on the age and the type of sport [2, 19].

Currently, there is insufficient information

on athletes with iron-deficiency anemia and scoliosis, namely about their level of vitamins A, C, carotene, iron content and antioxidant status. The presence of the abovementioned diseases in an athlete contributes to pathological processes, which result in performance worsening.

The paper aims to assess vitamin (A, C, carotene) and iron content, as well as peroxidation activity in the blood serum of athletes with scoliosis and anemia.

Materials and methods. 620 adolescents aged from 13 to 18 were randomly selected. All participants were under clinical supervision at a medical and physical education clinic in Veliky Novgorod. Preventive examinations of athletes are carried out constantly twice a year. The annual report and medical documents of adolescent athletes (110 – powerlifting, 210 – freestyle wrestling, 168 – volleyball, 132 – rowing, sports ranks from the III youth to I adult categories and candidates for master of sport) were studied. The study was conducted in the spring during the training period.

For the purpose of the study, 3 groups were formed: 1st group – apparently healthy adolescents (n = 20), 2nd group – with iron-deficiency anemia (n = 20), 3rd group – athletes with scoliosis and iron-deficiency anemia (n = 10). All adolescents did not take any vitamins and nutritional supplements in the month before the experiment.

The following blood indices were measured: hemoglobin, hematocrit, erythrocyte count, mean corpuscular hemoglobin (MCH), mean corpuscular hemoglobin concentration (MCHC) and red cell distribution width (RDW), which reflects the degree of anisocytosis. 5 ml of blood samples were taken in the morning on an empty stomach from the peripheral vein.

Iron in blood serum was measured using bathophenanthroline, which gives a color reaction with ferrous ions recorded with spectrocolorimeter.

Vitamin A and carotene content in the blood serum was measured by the Bessey method as modified by L. Anisimova [21].

Ascorbic acid in serum and urine was measured by the Tillmans method [21]. The intensity of lipid peroxidation was studied by the content of malondialdehyde in blood plasma. The MDA content in the fraction of TBA-active products was studied in the reaction with thiobarbituric acid [23].

The following data were also measured for the purpose of the study: body height, body weight, blood pressure, ECG before and immediately after exercise, health status (based on the report on comprehensive health examination).

Data processing was carried out using the Statistica for Windows 6.0 statistical software package. All data are provided as means with standard deviation in M ± m. The significance of differences was evaluated using Student's t-test for independent variables. The significance level was at $p < 0.05$.

Results. According to the clinical report for 2018, diseases of the musculoskeletal system are on the first place in the structure of adolescent morbidity: 40 % – flat feet, 27 % – scoliosis. For instance, iron deficiency anemia and cardiac arrhythmias are 5 %.

A special group included 10 adolescents (7 females and 3 males) aged from 13 to 18 with iron deficiency anemia and scoliosis. Among them, there are 6 volleyball players, 3 wrestlers, and 1 rower.

In the blood samples of the 1st group, erythron values did not exceed the reference values, in the 2nd and 3rd groups – hemoglobin concentration and the hematocrit index were significantly reduced ($p < 0.05$). Table 1 shows average indexes of the erythron system in athletes of the studied groups.

Anemia in athletes was revealed during an examination routine. At the same time, adolescents did not have any complaints. The most common type of anemia was microcytic (MCV data) and hypochromic (MCH and MCHC). Anisocytosis (RDW) was also found.

The IDA diagnosis in patients was verified based on a decrease in serum iron (Table 1).

Heart rate variability was measured in all studied groups. ECG in athletes before exercise showed sinus arrhythmia and sinus bradyarrhythmia, as well as incomplete right bundle branch block and early repolarization syndrome. In the third group, in all athletes, heart rate variability was monitored. The difference in the frequency of heart rate variabiility was normally significant between the first and third groups ($p < 0.05$).

Adolescents of the second and third groups demonstrated transient sinoatrial block II degree or extrasystole during ECG recording. However, in the third group, such ECG changes were more common than in the second (10 % and 50%, respectively). In apparently healthy adolescents, there were no similar changes ($p < 0.05$ between the first and third groups).

Table 1

The erythron system and serum iron among adolescent athletes (M ± m)

Indices	Apparently healthy adolescents n = 20	Athletes with anemia (group II) n = 20	Athletes with scoliosis and anemia (group III) n = 10
Red blood cell count	4.39 ± 0.13	4.06 ± 0.14	4.00 ± 0.15
Hemoglobin (Hb), g/l	132.5 ± 2.24	114.9 ± 2.26*	114.0 ± 2.27*
Hematocrit (Ht), %	37.1 ± 0.32	35.0 ± 0.37*	34.7 ± 0.35*
MCV, fl	86.44 ± 2.89	77.26 ± 2.71	77.25 ± 2.69
MCH, pg	28.51 ± 1.49	24.91 ± 1.32	24.95 ± 1.4
MCHC, g/l	322.95 ± 1.79	316.7 ± 1.96	316.56 ± 1.81
RDW, %	13.49 ± 0.12	14.0 ± 0.12	14.2 ± 0.31
Iron, μmol/L	14.7 ± 0.76	8.6 ± 0.71*	8.4 ± 0.72*

*$p < 0.05$ changes are significant for athletes under normal conditions.

Vitamin (A, C, carotene) content in blood serum and urine vitamin C were measured (Table 2).

Vitamin A content in adolescents of the first and second groups was within lower reference range (0.3–0.8 μg/ml). In the third group, the concentration was significantly reduced compared to apparently healthy adolescents. Carotene indices (Table 2) in all groups were also recorded within lower reference range (0.8–2.38 μg/ml). Vitamin C content in adolescents over 13 years of age is normally 4–20 μg/ml. In our studies, vitamin C content, especially in the second and third groups, fluctuated at the lower level of reference values.

Urinary excretion of vitamin C in apparently healthy athletes and adolescents of the second group was within normal levels. However, in the third group, low levels were recorded (0.4 mg / h) that significantly differed from the results of the first group.

Malondialdehyde content in blood serum was measured as a marker of oxidative stress.

Table 3 reveals that malondialdehyde levels in group II and III were significantly reduced compared with apparently healthy adolescents.

Discussion. Iron-deficiency anemia was diagnosed in 5 % of adolescents. Our data verify results of other researchers. Athletes are at increased risk of reduced iron content due to a decrease in its absorption [9, 22].

In a well-trained athlete, sinus bradycardia and respiratory sinus arrhythmia can be recorded due to an increase in the tone of the vagus nerve [10, 13]. Athletes with scoliosis, compared with athletes without scoliosis, can have low exercise tolerance and a longer recovery period of the cardiovascular system [1].

ECG extrasystole (during exercise) in athletes of the third group requires further examina-

Table 2

Vitamin (A, C, carotene) content in blood serum and urine vitamin C in athletes

Indicator	Apparently healthy adolescents n = 20	Athletes with anemia (group II) n = 20	Athletes with scoliosis and anemia (group III) n = 10
Vitamin A, μg/ml	0.36 ± 0.02	0.34 ± 0.03	0.28 ± 0.03*
Carotene, μg/ml	0.80 ± 0.08	0.79 ± 0.07	0.79 ± 0.07
Ascorbic acid, μg/ml (serum)	5.40 ± 0.05	4.80 ± 0.06	4.80 ± 0.05
Ascorbic acid, mg/hour (urine)	0.64 ± 0.05	0.54 ± 0.05	0.45 ± 0.05**

*$p < 0.05$ changes are significant for athletes under normal conditions; **$p < 0.02$.

Table 3

Serum malondialdehyde levels in adolescents

Indicator (μmol/L)	Apparently healthy adolescents n = 20	Athletes with anemia (group II) n = 20	Athletes with scoliosis and anemia (group III) n = 10
Malondialdehyde	2.75 ± 0.23	3.1 ± 0.24*	3.29 ± 0.29*

*changes are significant for athletes under normal conditions.

tion to exclude connective tissue dysplasia, which may also be accompanied by arrhythmias and mitral valve prolapse [12, 14]. The presence of anemia in such athletes enhances regional microcirculation disorders in various areas.

Under these conditions, increased physical activity changes biochemical processes in the anaerobic zone and activates lipid peroxidation. This leads to the accumulation of lactic acid, metabolic acidosis, damage of the cell membrane, disruption of the enzymes and an even greater decrease in efficiency due to impaired neuromuscular interaction [6, 20, 26]. The levels of vitamin A in serum in all groups of our subjects were recorded at lower normal values. There was a significant difference between the retinol levels in the serum of the first and third groups of athletes ($p > 0.05$). The same tendency in terms of content and a significant difference between the groups was also noted for vitamin C excretion in urine, which indicates possible vitamin C deficiency [16]. Vitamin A, especially in athletes, has a compensatory effect on lipid peroxidation after strenuous exercise [17]. Vitamin C is a water-soluble antioxidant and can reduce the adverse effects of reactive oxygen species caused by exercise, including muscle damage [3, 5]. These indices are especially important for the third group, where hypoxia is accompanied by activation of lipid peroxidation.

Carotene is an antioxidant. Its content in the blood serum of athletes was at the lower level of reference values. The effect of carotene on exercise tolerance has not been fully studied [18].

One of the side effects of lipid peroxidation is the formation of malondialdehyde. Its rise indicates that lipid-protein complexes are formed in the body. Thus, when anemia is detected, athletes, especially the third group, need to monitor their diet and consume foods enriched with vitamins (B, C and E), which are necessary for the normal synthesis of collagen and antioxidants [25, 27]. It is advisable to use vitamin and mineral complexes on a daily basis and in a dosage calculated by a doctor.

Conclusion. Iron-deficiency anemia can be identified for the first time during a routine examination. In order to propose adequate physical training, iron-deficiency anemia and scoliosis should be smoothly detected. More specific examination and operational monitoring are necessary, including measuring vitamin content in blood serum that affects hypoxia and oxidative stress.

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ОЦЕНКА СОДЕРЖАНИЯ ВИТАМИНОВ И АКТИВНОСТИ ПЕРЕКИСНОГО ОКИСЛЕНИЯ ЛИПИДОВ В СЫВОРОТКЕ КРОВИ У СПОРТСМЕНОВ СО СКОЛИОЗОМ И ЖЕЛЕЗОДЕФИЦИТНОЙ АНЕМИЕЙ

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Цель – оценить содержание витаминов А, С, каротина, железа и активность перекисного окисления в сыворотке крови спортсменов со сколиозом и анемией. **Материалы и методы.** Случайным образом отобраны 620 подростков в возрасте от 13 до 18 лет, находящихся под диспансерным наблюдением во врачебно-физкультурном диспансере Великого Новгорода. Из их числа для дальнейшего анализа были выделены 3 группы: 1-я группа – здоровые подростки (20 человек), 2-я – имеющие железодефицитную анемию (20 человек), 3-я группа – спортсмены, у которых диагностированы одновременно сколиоз и железодефицитная анемия (10 человек). Оценивались результаты общего анализа крови, содержание в сыворотке крови витаминов А, С, каротина, железа, малонового диальдегида. Концентрация витамина С определялась в моче. Анализировались показатели ЭКГ до и после нагрузки. **Результаты.** Установлено, что у спортсменов с сочетанием сколиоза и анемии развиваются значительные изменения в содержании витаминов А и С, происходит активация процессов, приводящих к оксидативному стрессу. Эти изменения, вероятно, служат одной из причин часто выявляемых в этой группе спортсменов (в 50 % случаев) изменений ЭКГ при физической нагрузке (экстрасистолия, транзиторная сино-атриальная блокада II степени). **Заключение.** Железодефицитная анемия часто выявляется впервые на профилактическом осмотре. Спортсменам, имеющим сколиоз и железодефицитную анемию, необходимо более тщательное обследование, оперативный контроль за состоянием регуляторных механизмов, в том числе определение содержания витаминов в сыворотке крови, учитывая то, что в организме развивается гипоксия и активизируются процессы перекисного окисления липидов.

Ключевые слова: *спортсмены, железодефицитная анемия, сколиоз, плоскостопие, витамины А, С, каротин, малоновый диальдегид.*

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