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The Interdependency of Elemental and Amino Acid Composition of Blood Serum Among the Physically Challenged Athletes

Marshinskaia O. V.
Federal Research Center for Biological Systems and Agrotechnologies of the Russian Academy of Sciences
Orenburg, Russia
m.olja2013@yandex.ru

Kiyaeva E. V.
Federal Research Center for Biological Systems and Agrotechnologies of the Russian Academy of Sciences
Orenburg, Russia
m.olja2013@yandex.ru

Notova S. V.
Federal Research Center for Biological Systems and Agrotechnologies of the Russian Academy of Sciences
Orenburg, Russia
inhip@mail.ru

Kazakova T. V.
Federal Research Center for Biological Systems and Agrotechnologies of the Russian Academy of Sciences
Orenburg, Russia
m.olja2013@yandex.ru

Gedulianova N. S.
Federal State Institution Research Institute of the Federal Penitentiary Service Russia
Moscow, Russia
m.olja2013@yandex.ru

***Abstract* — The aim of research was to study the interdependency between the elemental and amino acid composition of blood serum among the sledge hockey athletes. Determination of the elemental and amino acid composition of blood was performed using an Elan 9000 mass spectrometer and an Optima 2000 V atomic emission spectrometer. The data processing was performed using the Mann-Whitney U-test. The interdependency between the parameters were estimated using the Spearman rank correlation method. An increase in the content of Fe, Zn, α-aminobutyric acid, taurine and lower values of Mg, methionine and tyrosine has been established.**

Keywords* — *blood, amino acid composition, athletes, Mann-Whitney U-test, taurine, tyrosine

I. INTRODUCTION

The number of participants in the Paralympic Winter Games is constantly increasing. During the first Paralympic Winter Games of 1976, 17 countries participated, and in 2018 there were more than 500 athletes from 49 different countries [1]. Popularizing Paralympic sports is related to the fact that playing sports brings a social recognition, a sense of individuality, increases a self-esteem, improves the physical and emotional state of physically challenged people [2, 3]. However, in the reports of the Paralympics, a high percentage of sportsmen's complaints about their health is recorded [4-7]. In this connection, the issue of the development of sports medicine for Paralympians and their adaptation to training activities becomes more relevant.

One of the sports of the Winter Paralympic program is a sledge hockey. This sport is a modified version of the general hockey with a similar equipment, rules, strategy and the degree of contact of players. This sport is designed for the athletes with physical disabilities of the lower body. The adaptive device, special sleds are used, in which the player remains seated during the competition [8].

Microelements are the participants in hundreds of important biological processes associated with the sports activities [9]. Sport, primarily at the professional level, can have a significant impact on the metabolism of microelements in the body. On the one hand, regular physical activity can lead to the activation of the exchange of chemical elements, which is associated with the intensification of metabolic processes and the general improvement of the body [10]. On the other hand, extreme physical exertion leads to the change in the content of physiologically important microelements. A number of modern studies confirm that intense exercise leads to the imbalance of microelements in the body [11-16]. The nature of such changes is diverse and depends on the concrete sport and personal physiological characteristics of an athlete [17].

Amino acids along with the microelements are important natural regulators of metabolism and vital activity of the human body. During the intense sports exercises there are multidirectional changes in the protein content. Despite the fact that amino acids have a small share of energy consumption during the prolonged muscular exercises, this proportion increases up to 5-10% [18]. Amino acid-based preparations are

quite often used by athletes, which once again underlines their important role in providing sports activities [19-22].

By comparing the amino acid and elemental composition of the blood, it is possible to obtain new ideas about the patterns of metabolic processes that will expand the concepts of norm and pathology.

II. RESEARCH OBJECTIVE

Identify the interdependency between the elemental and amino acid composition of blood serum among the sledge hockey athletes.

III. MATERIALS AND METHODS

The athletes of the Orenburg sledge hockey club (n=15) took part in the research. The average age of team members was 34 years, which corresponds to the I period of maturity according to the age periodization of human ontogenesis. All the athletes have a case of amputation of the lower extremities for various injuries and diseases. The participants lived for 5 years in the city of Orenburg.

The research was conducted in accordance with the Helsinki Declaration and the principles of the Good Laboratory Practice. All the participants gave informed consent for their inclusion in the research program. To study the elemental and amino acid status, the blood serum was used as a biosubstrate. Sampling of athletes was carried out during the training camp. Analytical studies were conducted in the laboratory of IIS “Center for Biotic Medicine” (Moscow), using the atomic emission analysis devices (“Optima 2000DV”, “PerkinElmer Corp.”, USA) and the mass spectral devices (“Elan 9000”, “PerkinElmer Corp.”, USA) with inductively coupled plasma. The own results on the content of chemical elements and amino acids in the blood serum of sledge hockey players compared with the reference values.

Processing of the obtained data was carried out using the methods of variation statistics using the statistical package StatSoft STATISTICA 6.1.478. The storage of the obtained data results and the initial processing of the material was carried out in the original database “Microsoft Excel 2010”. The compliance of the obtained data with the normal distribution law was checked using the Kolmogorov's criterion of consent. The hypothesis of data belonging to the normal distribution was rejected in all cases with a probability of 95%, which justified the use of the non-parametric procedures for processing statistical aggregates (Mann – Whitney U-test). The obtained data are presented in the form of the median (Me) and quarters of 25–75 (q25 – q75). The interdependency between the parameters was estimated using the Spearman rank correlation method. To determine the interdependency between the studied characteristics, the correlation coefficient (r) was calculated. The correlation coefficients were estimated as follows: less than 0.3 - weak dependency, from 0.3 up to 0.5 - moderate, from 0.5 up to 0.7 - significant, from 0.7 up to 0.9 - strong, and more than 0.9 dependency was considered very strong.

IV. RESULT AND DISCUSSION

During the study, it was revealed that the serum elements content in the serum of the hockey players was within the normal range (Table 1), with the exception of the iron level (the q75 value exceeded the recommended 1.15 times). When examining the individual tests, it was found that 46% of the examined athletes had an increased Fe content, 13% - an increased Zn content, and 26% - lowered Mg level.

TABLE I. THE ELEMENTAL COMPOSITION OF BLOOD SERUM OF SLEDGE HOCKEY PLAYERS ME (Q25 – Q75), (MCG/ML)

Element	The actual content of elements of sledge hockey players, Me (q25–q75)	Normal range
Ca	109 (107.5–110.5)	90–120
K	200 (195–204)	150–285
Mg	21.7 (20.2–22.3)	20–25
Co	0.0005 (0.0005–0.0006)	0.00045–0.001
Cu	1.13 (0.9–1.2)	0.75–1.5
Fe	1.92 (1.7–2.3)	0.65–2
I	0.05 (0.05–0.06)	0.05–0.1
Mn	0.001 (0.001–0.002)	0.0015–0.004
Se	0.09 (0.09–0.1)	0.07–0.12
Zn	1.2(1.1–1.2)	0.75–1.5
Ni	0.001 (0.001–0.002)	0–0.01
V	0.000085 (0.000085–0.00015)	0–0.01
Al	0.01 (0.01–0.01)	0–0.04
As	0.001 (0.001–0.002)	0–0.01
Cd	0.00006 (0.00006–0.00006)	0–0.00015

TABLE II. AMINO ACID COMPOSITION OF BLOOD SERUM OF SLEDGE HOCKEY PLAYERS, ME (Q25 – Q75), (MCG/ML)

Amino acid	The actual content of amino acid of sledge hockey players, Me (q25–q75)	Normal range
α-aminobutyric acid	36.6 (33.1-42,6)	9-35
Alanine	449 (386.5-482.7)	200-600
Arginine	58.8 (52.5-86.9)	40-120
Asparagine	52.4 (49-54.8)	40-100
Aspartic acid	13.4 (10.7-17.1)	10-30
Glutamic acid	109.2 (102.5-118.2)	25-120
Glycine	317.3 (290.2-340.9)	250-500
Histidine	50.5 (43.7-63.9)	35-100
Hydroxyproline	8.0 (6.5-9.5)	6-35
Methionine	24.5 (20.5-27.7)	45-65
Serine	88.4 (62.9-107.4)	60-110
Taurine	97.4 (92.3-102.05)	50-100
Threonine	93.2 (88.3-106.3)	80-200
Tyrosine	35.7 (27.3-45.9)	50-120
Valine	165.4 (146.3-178.7)	95-225

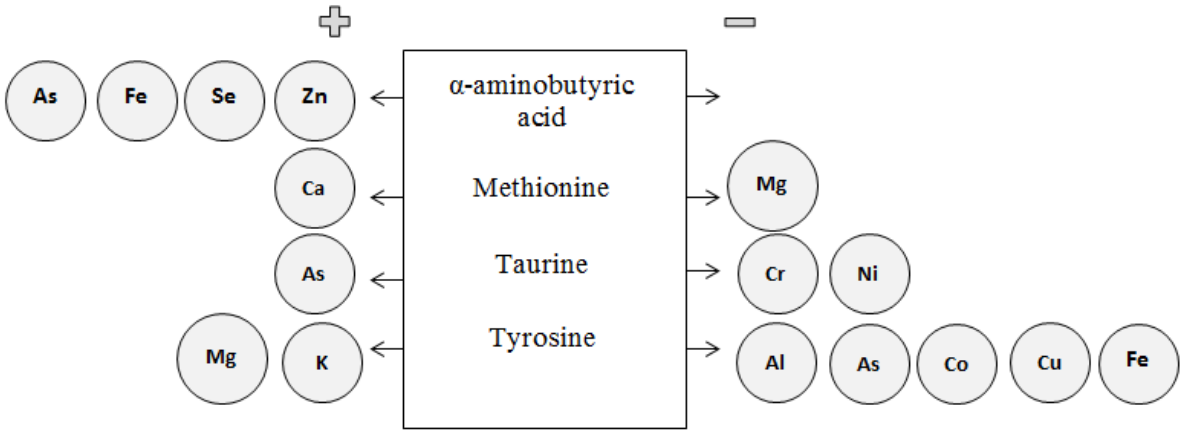

Fig. 1. Correlation of amino acids with trace elements

When studying the amino acid composition of the blood, a decrease in methionine and tyrosine was found (q75 values were lower than those recommended in 1.6 and 1.1, respectively). Minor increases were observed in terms of α-aminobutyric acid and taurine (q75 values exceeded those recommended in 1.2 and 1.02, respectively). The remaining amino acids were within the normal values (Table 2).

In the course of the correlation analysis between the elemental and amino acid composition of serum, the following results were obtained (Figure 1). The reduced level of methionine is associated with Ca (r = 0.42), Mg (r = 0.36), and tyrosine with Al (r = 0.37), with As (r = 0.31), Co (r = 0.41), Cu (r = 0.48), Fe (r = 0.52), K (r = 0.42), Mg (r = 0.4). Elevated levels of α-aminobutyric acid are bound As (r = 0.52), Fe (r = 0.53), Se (r = 0.43), Zn (r = 0.39), and taurine with As (r = 0.33), Cr (r = 0.32), Ni (r = 0.33).

As a result of the study, the peculiarities of the content of microelements in the serum were identified. In most cases, the professional athletes are at risk of developing iron deficiency [10, 23]. However, our results indicate an excess of this element in the serum of almost half of the athletes. Iron is very important for the athletes because of its role in the metabolism of energy production and oxygen transport [24-26]. For normal physiology, the excess iron is toxic because it can accelerate the reaction which generates the active oxygen species and seriously damages cells and tissues of a body [27, 28]. Systemic regulation of iron is mediated by the liver hormone hepcidin [29], the synthesis of which is disturbed when the liver function changes, resulting in the accumulation of iron in the body [27]. The revealed high values of iron can be the result of taking multivitamin complexes containing iron (from 20% to 30% of the daily norm) or damage to the liver, due to the chemotherapy.

Magnesium is the essential element that is included in more than 300 metabolic reactions in the body. This element helps to maintain a normal function of the nervous system and muscles, heart rate, blood pressure, the immune system, the integrity of bones and the level of glucose in the blood and promotes the absorption of calcium [30]. A reduced magnesium content among 26% of sledge hockey players may be a result of its increased expenditure during the physical exertion and insufficient consumption with food [10]. Magnesium deficiency can significantly limit the physical activity of an athlete.

The revealed elevated zinc content among 13% of athletes is probably due to the presence of such diseases as osteosarcoma and osteomyelitis [31]. On the other hand, an increase of the zinc content in the blood may not be due to the availability of zinc to the body, but a reflection of the fact of its mobilization from the depot [10]. For example, the researchers from Spain found that the concentration of zinc in the blood serum increased depending on the type of training. The greatest changes of the zinc content were observed among the athletes performing anaerobic exercises [32].

When analyzing the results of the amino acid composition of the blood, the methionine deficiency was detected, which is an essential proteinogenic amino acid. Methionine occupies a key position in the initial stages of protein biosynthesis, serves in the body as a donor of methyl groups in the biosynthesis of choline, adrenaline and many other biologically important substances [18]. A deficiency of methyl groups is a risk factor for the development of neurodegenerative diseases [33]. The liver plays a central role in the metabolism of methionine [34]; therefore, a deficiency of this amino acid in the blood is probably associated with the presence of a liver dysfunction among the sledge hockey players.

Along with methionine, the tyrosine deficiency was revealed also, which is an interchangeable proteinogenic amino acid. This amino acid is part of the structural proteins, enzymes, it is a precursor of catecholamines, thyroxin and melanin. In most cases, during exercise, the athletes have increased levels of tyrosine in the blood, which is associated with an increase in energy consumption in the body [18, 35]. However, the results that we obtained have the opposite side, the athletes had a lower content of this amino acid.

A slight increase was observed in terms of α-aminobutyric acid and taurine. Japanese scientists from Kyoto University experimentally found that with a lack of magnesium in the body, an increase in taurine is observed [36], which is similar to the results of our study.

V. CONCLUSIONS

The obtained multidirectional changes in the content of microelements and amino acids in the blood serum of athletes show their role in the formation of normal metabolism during the intense exercises. Adjustment of the microelement and amino acid status of Paralympians can have a beneficial effect on the health of athletes and their athletic achievements.

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