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EVALUATION OF THE EFFECTIVENESS OF AN IMMUNOSTIMULATING PRODUCT BASED ON LOW-MOLECULAR-WEIGHT PEPTIDES DERIVED FROM MARE'S AND CAMEL'S MILK

The study aimed to develop and evaluate the effectiveness of a specialized immunostimulating product based on low-molecular-weight peptides isolated from mare's and camel's milk. The product was additionally enriched with biologically active compounds possessing antioxidant and immunomodulatory properties. The clinical study involved 20 volunteers aged 30-45 years divided into control and experimental groups. Participants consumed 90 g/day of the product for 20 days under conditions of daily physical activity. Humoral and cellular immunity parameters (IgG, IgA, IgM, T- and B-lymphocytes), lipid peroxidation markers (MDA, diene conjugates), and antioxidant defense indicators (catalase, superoxide dismutase, total antioxidant activity, vitamins A, E, and C) were assessed.

The results demonstrated that physical exercise in the control group led to decreased immunoglobulin levels and signs of secondary immunodeficiency, along with increased oxidative stress markers. In contrast, administration of the specialized product resulted in a significant increase in IgG, IgA, and IgM levels, enhancement of T- and B-lymphocyte counts, reduction of lipid peroxidation products, and activation of antioxidant defense enzymes. The product stabilized humoral and cellular immunity and improved antioxidant status during physical stress.

The findings confirm the pronounced immunostimulatory and antioxidant effects of low-molecular-weight peptides from mare's and camel's milk and support their use in the development of functional and preventive nutrition products.

Keywords: mare's milk, camel milk, low-molecular-weight peptides, immunostimulation, antioxidant activity, lipid peroxidation, physical exercise, functional nutrition.

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Бие және түйе сүтінен алынған төмен молекулалы пептидтер негізіндегі иммуностимуляциялық өнімнің тиімділігін бағалау

Зерттеудің мақсаты – бие және түйе сүтінен бөлініп алынған төмен молекулалы пептидтер негізінде иммуностимуляциялық қасиеті бар арнайы өнім әзірлеу және оның тиімділігін бағалау. Өнім антиоксиданттық және иммуномодуляциялық әсері бар биологиялық белсенді компоненттермен байытылды. Клиникалық зерттеуге 30-45 жас аралығындағы 20 ерікті қатысты, олар бақылау және тәжірибелік топтарға бөлінді. Қатысушылар 20 күн бойы тәулігіне 90 г өнім қабылдап, тұрақты физикалық жүктеме орындады. Гуморальдық және жасушалық иммунитет көрсеткіштері (IgG, IgA, IgM, Т- және В-лимфоциттер), липидтердің асқын тотығу өнімдері (МДА, диендік конъюгаттар) және антиоксиданттық қорғаныс жүйесінің белсенділігі (каталаза, супероксиддисмутаза, жалпы антиоксиданттық белсенділік, А, Е, С витаминдері) анықталды.

Нәтижелер физикалық жүктеме бақылау тобында иммуноглобулиндердің төмендеуіне және тотығу стрессінің күшеюіне алып келгенін көрсетті. Ал тәжірибелік топта арнайы өнімді қолдану IgG, IgA және IgM деңгейлерінің жоғарылауына, Т- және В-лимфоциттер санының артуына, липидтердің асқын тотығу өнімдерінің төмендеуіне және антиоксиданттық ферменттердің белсенуіне ықпал етті.

Алынған нәтижелер бие және түйе сүтінен алынған төмен молекулалы пептидтердің айқын иммуностимуляциялық және антиоксиданттық әсерін дәлелдейді және оларды функционалдық және профилактикалық тағам өнімдерін әзірлеуде қолданудың ғылыми негізін қалыптастырады.

Түйін сөздер: бие сүті, түйе сүті, төмен молекулалы пептидтер, иммуностимуляция, антиоксиданттық белсенділік, липидтердің асқын тотығуы, физикалық жүктеме, функционалдық тағам.

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Оценка эффективности иммуностимулирующего продукта на основе низкомолекулярных пептидов из кобыльего и верблюжьего молока

Целью настоящего исследования являлась разработка и оценка эффективности специализированного иммуностимулирующего продукта на основе низкомолекулярных пептидов, выделенных из кобыльего и верблюжьего молока. Продукт дополнительно обогащён биологически активными компонентами с антиоксидантными и иммуномодулирующими свойствами. В клиническом исследовании приняли участие 20 добровольцев в возрасте 30-45 лет, разделённых на контрольную и экспериментальную группы. Испытуемые в течение 20 дней принимали по 90 г продукта в сутки на фоне ежедневных физических нагрузок. Оценивали показатели гуморального и клеточного иммунитета (IgG, IgA, IgM, Т- и В-лимфоциты), маркеры перекисного окисления липидов (малоновый диальдегид, диеновые конъюгаты), а также параметры антиоксидантной защиты (каталаза, супероксиддисмутаза, общая антиоксидантная активность, витамины А, Е, С).

Установлено, что физическая нагрузка в контрольной группе сопровождалась снижением уровней иммуноглобулинов G и A, признаками вторичного иммунодефицита и усилением оксидативного стресса. В экспериментальной группе при применении разработанного продукта отмечено достоверное повышение уровней IgG, IgA и IgM, увеличение количества Т- и В-лимфоцитов, снижение концентрации продуктов перекисного окисления липидов и активация ферментов антиоксидантной системы.

Полученные результаты свидетельствуют о выраженном иммуностимулирующем и антиоксидантном действии низкомолекулярных пептидов кобыльего и верблюжьего молока и подтверждают целесообразность их использования при создании функциональных продуктов профилактической направленности.

Ключевые слова: кобылье молоко, верблюжье молоко, низкомолекулярные пептиды, иммуностимуляция, антиоксидантная защита, перекисное окисление липидов, физическая нагрузка, функциональное питание.

Introduction

Given the impact of adverse environmental factors, as well as physical and neuro-emotional stress, supporting the body's defenses through both pharmaceuticals and nutritional supplements is becoming increasingly important.

In this context, the development and evaluation of the effectiveness of immunostimulant products based on both traditional and non-traditional raw materials is of particular interest.

Given national and ethnic dietary patterns, mare's and camel's milk, as well as products made from them and their unique chemical composition, have recently become particularly popular due to their proven therapeutic and preventative properties (Kanareikina & Kanareikin, 2016).

Scientific literature on the role of mare's and camel's milk primarily discusses the presence of factors such as PUFAs, vitamins, antioxidant substances, lysozyme, and a number of macro- and microelements in milk that influence certain physiological and biochemical parameters of the body and, accordingly, its health (Simonenko et al., 2021).

It should be noted that there is virtually no information in the scientific literature on the role and significance of low-molecular-weight peptides isolated from mare's and camel's milk in regulating the body's immune and antioxidant properties.

Existing scientific data on the role of mare's milk peptides in enhancing physical activity and performance in experimental animals confirms their uniqueness and significance and substantiates the potential for their use as a basis for the development

of new specialized food products (Sarsembayev, 2021; Sinyavskiy, 2017).

Taking into account the above, the aim of this study was to develop a new specialized product with targeted immunostimulating and antioxidant properties using low molecular weight peptides from mare's and camel's milk based on traditional and non-traditional raw materials.

Materials and methods

1. Evaluation of the Immunostimulating Properties of the Product

To evaluate the immunostimulating properties of the product, studies were conducted on 20 volunteers aged 30-45 years. Ten volunteers received the immunostimulating product at a dose of 90 g per day (30 g three times during the main meal) and 10 control subjects received a product with targeted preventive properties and increased biological value, also at a dose of 90 g per day for 20 days. The control product, with targeted preventative properties and increased biological value, contained turmeric, soy isoflavones, β-glucans from higher fungi, resveratrol, dry lactic acid bacteria strains, coenzyme Q10, lycopene, red root, plant sterols, omega-3 fatty acids, and a vitamin and mineral complex (thiamine, vitamin D_3, B_{12}, B_2, B_6, biotin, folic acid, niacin, pantothenic acid, and calcium).

Patients receiving the immunostimulant product and the control product underwent two hours of daily physical exercise, including treadmill running and cycle ergometer exercise.

After 20 days of supplementation, humoral and cellular immune system parameters were assessed in blood serum samples. In addition, lipid peroxidation indices were evaluated, including the levels of end and intermediate lipid peroxidation products (malondialdehyde, MDA, and diene conjugates, DC), as well as the activity of antioxidant enzymes, namely superoxide dismutase and catalase (Valgimigli, 2023). The content of diene conjugates was determined according to the method described by Ayala et al. (2014). Lipid hydroperoxides and diene structures were assessed in serum lipid extracts obtained using a heptane–isopropanol mixture (1:1, v/v). Briefly, serum samples were mixed with the extraction solvent, centrifuged to achieve phase separation, and the heptane phase containing lipid extracts was collected. Optical density was measured spectrophotometrically at a wavelength of 233 nm.

2. Humoral Immunity Assessment

To assess humoral immunity in blood serum, globulin fractions (IgG, IgA, and IgM) were analyzed using enzyme immunoassay kits from Vector Best (Russia). To assess the antioxidant system in the serum, catalase activity and malondialdehyde (MDA) levels were determined. Catalase activity was determined colorimetrically (Del Rio et al., 2005). The method is based on the ability of hydrogen peroxide to form a stable, colored complex with ammonium molybdate, with an absorption maximum at 410 nm. MDA content was determined colorimetrically with thiobarbituric acid. At high temperatures in an acidic environment, MDA reacts with 2-thiobarbituric acid to form a colored trimethine complex with an absorption maximum at 532 nm (Ternovskaya et al., 2010).

3. Determination of superoxide dismutase activity

Superoxide dismutase (SOD) activity was determined using kits from Boehringer Mannheim GmbH (Germany). The activity of the antioxidant defense system was assessed by total antioxidant activity (TAA) and thiol status (TS) using kits from Cayman Chemical and Immundiagnostik AG (Germany). The concentration of antioxidant vitamins A, E, and C was determined using high-performance liquid chromatography (HPLC) with fluorescence detection on an Agilent 1260 Infinity instrument from Agilent Technologies Inc. (USA).

4. Isolation of Low-Molecular-Weight Peptides

Low-molecular-weight peptides from mare's and camel's milk were obtained according to the method described in *(Rouhana-Toubi et al., 2009)* Skim milk, previously fermented with kumiss starter for 20 hours, was used. 0.5 g of pancreatin was then added to the fermented milk product, the mixture was fermented for 4 hours, then 300 g of Sephadex G-25 was added, and the mixture was thoroughly mixed for 10-15 minutes. The mixture was then centrifuged at 3000 rpm for 20 minutes. The supernatant was removed, the swollen gel was eluted with distilled water, and the mixture was then centrifuged again at 3000 rpm for 20 minutes. The resulting liquid fractions were filtered through fine-pored filters with a pore diameter of 0.2 μm. Approximately 100 ml of a fraction containing low-molecular-weight peptides with molecular weights ranging from 3,000 to 15,000 Da was obtained from one liter of fermented mare's milk. The proposed method for isolating low-molecular-weight peptides from fermented mare's milk allows for the extraction of primarily peptides with molecular weights ranging from 3,000 to 14,000 Da, with a predominance of peptides with molecular weights ranging from 3,000 to 8,000 Da.

5. Statistical Analysis

Statistical analysis was performed using the mean (M) and standard deviation (SD). The significance of differences between mean values was assessed using the Student's t-test. Differences were considered significant ($p \leq 0.05$) at a significance level of 95%.

Results and discussion

Formulation Development and Justification of the Use of Food Ingredients in the Design of a Specialized Product.

Resveratrol, turmeric, Lion's Mane, Turkey Tail, Cordyceps, dry lactic acid bacteria strains, red root, omega-3 fatty acids, vitamin E, vitamin A, vitamin C, and low-molecular-weight peptides from mare's milk and camel milk were used as raw materials for the creation of this new specialized product.

The included of higher mushrooms – Lion's Mane, Turkey Tail, and Cordyceps – are sources of high-molecular-weight glucans, glycans, and heteropolysaccharides, which have the ability to inhibit tumor growth by stimulating various parts of the body's immune system, help prolong life and enhance the body's defenses (Wasser, 2010; Wasser, 2014). Turkey tail mushroom and the polysaccharides it contains are essential components of all body cells and primarily nourish the immune system. It promotes performance, reduces the risk of malignant cell growth, boosts immunity, and increases the chances of survival for individuals with various types of cancer undergoing chemoradiation therapy by stimulating the immune system.

Cordyceps has a powerful immunostimulatory effect, prevents the development of Alzheimer's disease, reduces the risk of malignant tumors, and improves performance and endurance.

Hericium erinaceus is a unique mushroom used in China to treat cancer. In Japan, it is taken to enhance cognitive function and reduce the risk of neurodegenerative diseases, including Alzheimer's disease and dementia. It improves brain function, restores impaired nerve impulse transmission, and the superoxide dismutase found in this mushroom slows the aging of any cell, including enhancing antioxidant properties and boosting immunity (Wasser, 2014).

Resveratrol, a natural biologically active substance in the product, is a polyphenol isolated from dark grapes and grape seeds. It has anti-carcinogenic, immunostimulatory, and anti-inflammatory properties. Resveratrol can be used in treatment regimens for a wide range of pathological conditions, including cancer, autoimmune diseases, and damage to the central nervous system and cardiovascular system. (Baur & Sinclair, 2006; Drabikova et al., 2012).

The presence of turmeric in the product is due to the presence of curcumin, which can make up 2 to 5% of the total mass. Curcumin is present in plant extracts. Curcuminoids are responsible for the yellow color of turmeric and curry, and are known for their anti-inflammatory, antioxidant, immunostimulant, antibacterial, and antifungal properties. Curcumin is a universal inhibitor of many pro-inflammatory cellular signal transduction cascades and is widely used in the prevention and treatment of many chronic human diseases as a natural antiphlogistic agent (Goel et al., 2008; Jurenka, 2009; Vareed et al., 2008).

The antioxidants (vitamins A, E, and C) contained in the product enhance antioxidant protection, reduce free radicals formed as a result of exposure to foreign compounds, stress, and negative environmental factors, prevent the development of cancer, heart disease, and neurodegenerative diseases, and enhance the body's defenses.

Omega-3 fatty acids have an anti-inflammatory effect, lower blood triglyceride levels, and are recommended for patients with heart failure. Japanese studies have found that omega-3 fatty acids reduce the risk of coronary heart disease and recurrent strokes.

Recent studies have shown that higher omega-3 fatty acid intake reduces the risk of breast cancer in obese women.

Red root contains tannins, xanthone hedisaride, triterpene saponins, coumarins, flavonoids, and free amino acids. The underground part of the red root contains large quantities (11 to 34% of the air-dry mass) of condensed oligomeric catechins, which are classified as bioflavonoids. Red root catechins possess high P-vitamin activity (they strengthen and restore capillary walls), remove heavy metals from the body, have antioxidant activity (neutralize free radicals), and also stimulate the immune system.

It is believed that supplementing the body with beneficial bacteria (probiotics), such as those of the Lactobacillus family, can help restore the proper balance of intestinal microflora.

Low molecular weight peptides isolated from mare's and camel's milk have a powerful immunostimulatory effect and are primarily aimed at regulating the body's defenses and reducing the risk of developing diseases such as diabetes, coronary heart disease, and stroke.

The preparation process for this specialized immune-boosting product is as follows: resveratrol, turmeric, dried mushroom powders (trametes, lion's mane, and cordyceps), red root powder, soy isoflavones, dried lactic acid bacteria strains, omega-3 fatty acids, vitamins A, E, and C, low-molecular-weight peptides from mare's and camel's milk, and filler (up to 100% by weight) are weighed into a container according to the recipe.

All ingredients are thoroughly mixed and blended until smooth. The product is then sent for packaging.

The product recipe is provided below in Table 1.

Table 1
The product recipe

Ingredient	Quantity
Resveratrol	5.0-5.5
Turmeric	4.0-5.0
Hericium erinaceus powder	1.0-1.5
Trametes powder	1.0-1.5
Cordyceps powder	0.5-1.0
Dry lactic acid bacteria strains	0.5-1.0
Red root powder	1.0-1.5
Omega-3 fatty acids	0.3-0.5
Vitamin E	0.10-0.15
Vitamin A	0.010-0.015
Vitamin C	0.20-0.25
Low molecular weight peptides from mare's milk	0.10-0.15
Low molecular weight peptides from camel milk	0.10-0.15
Filler (starch)	the rest up to 100.00 mass.

Thus, taking into account the raw materials and biologically active additives used, an immunostimulating specialized product with specified medical and biological properties was developed.

Effect of a specialized product on immunological and biochemical parameters of subjects.

It was found that, compared to the control group, serum levels of IgG and IgA immunoglobulins increased with the specialized product. This could be due to increased synthesis or decreased degradation. (Table 2) The decrease in immunoglobulin levels in the control group during product administration could have been due to impaired synthesis of one or all classes of immunoglobulins and insufficient availability of material for their synthesis.

As can be seen from the presented data, humoral immunity is affected by physical activity, which was manifested by a decrease in serum immunoglobulins G and A in the control group. Physical activity led to more pronounced impairments in humoral immunity and the development of secondary immunodeficiency. Meanwhile, immunoglobulin M levels did not change significantly and remained within normal limits. It should be noted that, in contrast, the specialized immunostimulating product increased humoral immunity indicators, including an increase in all immunoglobulin classes.

Thus, IgG levels after physical activity in the control group decreased by an average of 12.06%, while in the experimental group this indicator increased by 10.7%. IgA levels after exercise in the control group decreased by 18.75%, while in the experimental group this indicator increased by 7.6% respectively.

IgM levels in the experimental group increased by 10.8% compared to baseline. The observed changes indicate increased activity of the humoral immune system following the use of a specialized immunostimulating product.

Table 2
Assessment of humoral immunity parameters in the control and experimental groups (Mean ± SD)

Indicators, g/L	Control group		Experimental group	
	Before intervention	After 20 days	Before intervention	After 20 days
IgG	5.97 ±0.56	5.25±0.62	5.60±0.50	6.20±0.70
IgA	0.96±0.07	0.78±0.08	1.05±0.10	1.13±0.11
IgM	0.85±0.06	0.83±0.09	0.74±0.05	0.820±0.051

The concentration of immunoglobulins in the blood serum reflects the established balance between their synthesis and breakdown.

IgM are antibodies of the acute phase of the immune response, synthesized by plasma cells upon initial contact with a specific pathogen. In our case, there was no significant increase in their levels following the administration of the immunostimulant, while in the control group, this level decreased slightly.

IgG are late-phase antibodies of the immune response. They are more specific than IgM, which begin to be synthesized after the predominant adaptation period. In our case, an increase in these immunoglobulins was observed following the administration of the immunostimulant compared to individuals receiving the prototype.

The observed slight decrease in IgA concentration in the serum of control patients indicates a deficiency of humoral and local immunity, impaired synthesis or increased IgA catabolism, and its adsorption to immune complexes. In this case, an increase in serum IgA was observed following the administration of the immunostimulant, compared to the control group. Evaluation of the spontaneous NBT (nitroblue tetrazolium) test allowed us to assess the oxygen-dependent bactericidal mechanism of blood neutrophils in vitro. This test characterized the state and degree of activation of the intracellular NADPH oxidase antibacterial system. In our case, a slight increase in the spontaneous NBT test was observed in the group of individuals receiving the immunostimulant, indicating enhanced immune function following the administration of the new product.

A decrease in the absolute T-lymphocyte count in the blood indicated a deficiency of cellular immunity, while an increase in T-lymphocyte count was a favorable sign. In our case, individuals receiving the immunostimulating product showed an increase in serum T-lymphocyte levels (T-helper and T-cytotoxic lymphocytes) by an average of 20.8% compared to individuals in the control group. (Table 3)

An increased T-lymphocyte count indicates immune hyperactivity.

A decrease in the absolute T-lymphocyte count of 7.7% in the control group indicates a deficiency of cellular immunity, specifically inhibition of the cellular component of the immune system.

A decrease in B-lymphocyte count is observed when the body's defenses are inactivated and the immune system is impaired.

An increase indicates an increase in the body's defenses and normalization of the immune system.

In this case, a 16.6% decrease in B-lymphocyte levels was observed in the control group after exercise, while in the experimental group, this indicator increased by 15% compared to pre-exercise levels.

Table 3
Changes in cellular immunity indicators (Mean ± SD)

Lymphocyte subpopulation	Control group		Experimental group	
	Before intervention	After 20 days	Before intervention	After 20 days
T lymphocytes	1.30±0.12	1.20±0.10	1.35±0.10	1.45±0.12
B lymphocytes	0.18±0.02	0.15±0.02	0.20±0.03	0.23±0.03

Studies have shown that physical activity leads to significant changes in humoral immunity, manifested by decreased concentrations of IgG, IgA, and IgM immunoglobulin fractions, which is one of the signs of developing secondary immunodeficiency. Increasing the intensity of physical activity leads to more pronounced impairment of humoral immunity, with an increasing number of individuals experiencing more severe hypogamoglobulinemia, and blood immunoglobulin concentrations in some individuals reaching critically low levels. Heavy physical activity leads to a disruption of the antioxidant defense system. Excessive levels of lipid peroxidation products (MDA) and peroxides appear in the blood, as evidenced by increased catalase activity.

The study found that taking a special product in individuals in the experimental group slowed the progression of immunodeficiency and led to the stabilization of the body's antioxidant system. The data obtained allow us to recommend the use of this special product to support humoral immunity and the body's antioxidant system during periods of physical and psycho-emotional stress, as well as to prevent diseases caused by secondary immunodeficien-

cies. The mechanism underlying this phenomenon requires careful study.

Analysis of the LPO-AOP system indicates that during adequate physical activity, MDA concentrations exceeded the normal level in 25.0% of subjects. This value reached 2.8±0.9 μmol/L, compared to a normal value of 1.5±0.6 μmol/L. With increased physical activity, the frequency of elevated MDA concentrations in subjects in the control group increased to 45.0%. In the experimental group, elevated MDA concentrations were observed 2.0 times less frequently, occurring in 15.0% of subjects. This value reached 1.8±0.1 μmol/L.

During physical activity, an increase in diene conjugate levels was observed in the control group, while a 12.5% decrease in diene conjugate levels was observed in the experimental group compared to baseline values. Moreover, the level of diene conjugates in the experimental group decreased significantly compared to the control group.

During physical activity, catalase activity was 30.0±2.8 kU/L in 25.0% of control group subjects, exceeding the upper limit of the reference range by 1.7-2.3 times, reaching 46-67 kU/L. With increasing physical activity, a tendency toward increased enzyme activity was observed in the control group.

In contrast, a significant decrease in enzyme activity was observed in the experimental group, with catalase activity reaching 23.2±2.5 μmol/L at the end of the study 20 days later.

Furthermore, prophylactic use of the special product contributed to a significant increase in total antioxidant activity (TAA) by 1.7 times, while in the control group, total antioxidant activity increased only 1.1 times, with the differences remaining significant.

Regarding changes in superoxide dismutase activity during physical exercise and the effect of a specialized immunostimulant product, it should be noted that SOD activity in the control group during physical exercise decreased by an average of 15% compared to the experimental group. Consumption of the specialized product had a beneficial effect on superoxide dismutase activity, and its serum level increased by 22.3% compared to the control group.

An assessment of serum antioxidant vitamin levels in the control and experimental groups revealed no significant changes. By the end of the experimental period, the control group showed a slight increase in vitamin A, E, and C levels. Vitamin A levels increased by 7.6%, vitamin E by 8.3%, and vitamin C by 13.0%, compared to baseline. In the experimental group, vitamin A levels increased by 15.6%, vitamin E by 16.6%, and vitamin C by 27.0%, compared to baseline.

The observed changes in the experimental group were most likely related to the additional enrichment of the product with a complex of antioxidant vitamins, which undoubtedly contributed to the improved antioxidant status of the subjects and increased serum antioxidant vitamin levels. In addition, taking a specialized product could not help but affect overall physical activity and performance against the background of normalization of humoral immunity indicators and the state of the LPO-AOP system.

Conclusion

As a result of this study, an immunostimulating product with targeted protective and antioxidant properties was developed. The antioxidant properties and the product's effect on immune parameters during physical exercise were assessed.

It was found that humoral immunity was affected by physical exercise, manifested by a decrease in serum levels of primarily immunoglobulins G and A in the control group. Physical exercise led to more pronounced impairments in humoral immunity and the development of secondary immunodeficiency. Meanwhile, immunoglobulins M did not change significantly and remained within normal limits. It should be noted that, in contrast, the use of the specialized immunostimulating product resulted in an increase in humoral immunity parameters, including an increase in all immunoglobulin classes.

A decrease in the absolute number of T-lymphocytes in the blood indicated a deficiency in cellular immunity, while an increase in the number of T-lymphocytes was a favorable sign. In our case, individuals receiving the immunostimulant product showed an average 20.8% increase in serum T-lymphocyte levels (T-helper and T-cytotoxic lymphocytes) compared to those in the control group, indicating immune hyperactivity.

A 7.7% decrease in the absolute T-lymphocyte count in the control group indicated a deficiency in cellular immunity, specifically, inhibition of the cellular component of the immune system.

In this case, a 16.6% decrease in B-lymphocyte levels was observed in the control group after exercise, while in the experimental group, this indicator increased by 15% compared to pre-exercise levels, indicating enhanced immune defenses and normalization of the immune system.

The study revealed decreased performance and fatigue in participants undergoing physical exercise,

a significant increase in the blood concentration of lipid peroxidation (LP) end products and intermediates, and a decrease in total antioxidant activity. It was found that taking the immunostimulant product at a dose of 90 grams per day, 30 grams divided into three doses, for 20 days resulted in a decrease in serum MDA and diene conjugate levels and an increase in the activity of the antioxidant defense system, demonstrating the effectiveness of this preventative course of treatment.

Thus, the conducted studies on immune parameters and the LPO-AOP system demonstrated the immunostimulatory and antioxidant effects of the new product, based on low-molecular-weight peptides from mare's and camel's milk.

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