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PATENT-PROTECTED TECHNOLOGIES FOR THE DIAGNOSIS AND REHABILITATION OF ATHLETES AFTER COVID-19

G.N. Ter-Akopov, A.V. Abramtsova, S.M. Abutalimova

FSBI “North-Caucasian Federal Research-Clinical Center of Federal Medical and Biological Agency”, Essentuki, Russia

Annotation. The research is devoted to the review of technological solutions created at the level of inventions protected by domestic and foreign patents in the field of technology development and scientific substantiation of methods for diagnosing the condition of athletes, their performance and recovery systems, rehabilitation after COVID-19 and other infections. The study made it possible to identify several subgroups of technical solutions and methods related to the prediction of the infection occurrence, the consequences associated with COVID-19 and the restoration of physical performance. In earlier patented methods, immunological tests are used to assess the prognosis of athletes' health, and during the epidemic of a new coronavirus infection, technical methods are proposed that detect the onset of conditions such as COVID-19 or other respiratory infections by monitoring respiratory rate and heart rate with automatic data processing. The section of recovery and rehabilitation of athletes is represented by documents in which several areas can be distinguished: physiotherapy, nutritional support for athletes, resort factors, hypoxic and cold loads, respiratory rehabilitation.

Keywords: patent, athletes, COVID-19, post-covid period, diagnosis, prognosis, physical performance, recovery, rehabilitation.

Introduction. Large-scale COVID-19 vaccination, which began in 2021, and an emergent tendency to decrease the incidence of a new coronavirus infection at the present time, confirmed by official data from the Rospotrebnadzor website [1], made it possible to reduce social restrictions and resume planned events, which is especially important for athletes whose lives are regulated by training and competition periods throughout the year, including those related to staying at the training camps in middle altitude [2-4]. However, the 3-year period of the SARS-CoV-2 pandemic, which covered all categories of the population, affected the established rules for the training of athletes infected with this virus. All diagnostic, therapeutic and rehabilitation measures of people infected with COVID-19 are regulated by international and domestic clinical recommendations. In the field of sports medicine, criteria are additionally used that determine the gradual return of athletes to intense physical and professional activity after COVID-19 and other infections [5-7]. Nevertheless, the issues of the condition of athletes who have returned to training

remain insufficiently covered, and an analysis of methodological approaches for their recovery after intensive physical activity exertion is also required. Therefore, it is relevant to evaluate existing materials on methods and technical solutions for medical control of athletes who have resumed training and have a history of infectious diseases, including COVID-19.

The aim of the study is to analyze the technical level and results of patent-protected technologies for diagnosis, physical performance, recovery and rehabilitation of athletes who had COVID-19 and other infections.

Methods and organization. The object of patent research was the problem of approaches to the diagnosis of conditions, recovery and rehabilitation of athletes who had COVID-19 and train in the middle altitude conditions. Individual keywords: diagnosis and prediction of health after COVID-19 and infectious diseases; methods for recovering patients and athletes after inflammatory diseases and coronavirus; respiratory rehabilitation; recovery of athletes by oxygen administration, hypoxia, middle altitude (in Russian and in English).

The patent information search was made in electronic patent databases of the Federal service for intellectual property (Rospatent, www.fips.ru), Yandex Patents, Google patents, search for patents and inventions of the Russian Federation and the USSR (<http://www.findpatent.ru/>), electronic databases of the European Patent Office (<https://worldwide.espacenet.com>), the United States Patent and Trademark Office, (<https://globaldossier.uspto.gov/>). The depth of the search was not limited, all the protection documents found for the search object under study were analyzed.

Results and discussion. The patent search was conducted in accordance with GOST P.15.011-96 "System for the development and production of products. Patent research. The content and procedure". According to the results of the search for methods, medical technologies and technical solutions, created at the

level of inventions and protected by domestic and foreign patents, 89 security documents were found that meet the specified criteria for the subject: diagnosis and prognosis of health after COVID-19 and infectious diseases (in Russian) – 18; diagnosis and prognosis of health after COVID-19 and infectious diseases (in English) – 4; rehabilitation, recovery, performance of athletes after COVID-19 (in Russian) – 21; methods for recovering patients and athletes after inflammatory diseases and coronavirus (in English) – 8; respiratory rehabilitation (in Russian) – 11; respiratory rehabilitation (in English) – 2; recovery of athletes by oxygen administration, hypoxia, middle altitude (in Russian) – 13; recovery of athletes by oxygen administration, hypoxia, middle altitude (in English) – 12 (fig. 1).

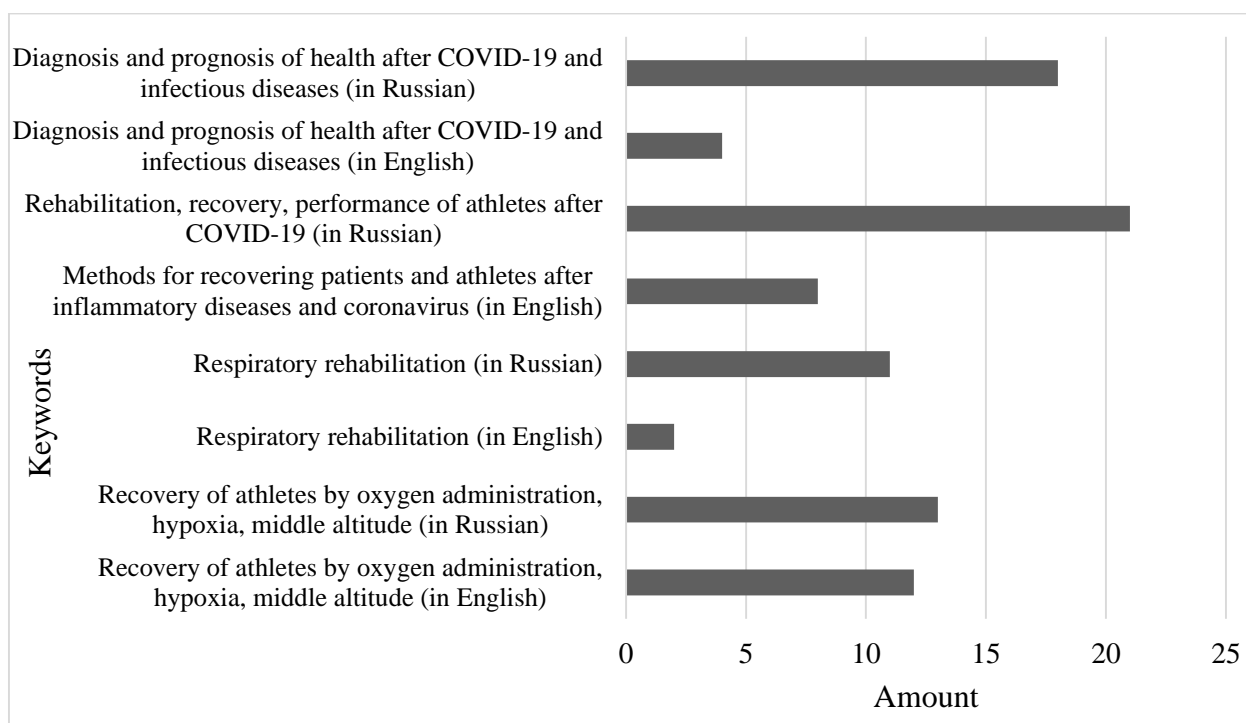


Fig. 1. Distribution of the number of patents by keywords (components) of the search object (keywords are shown in the figure on the Y axis)

The number of patents found for the keywords "rehabilitation", "recovery", "performance of athletes after COVID-19 and other infections", including the subsections "respira-

tory rehabilitation", "recovery of athletes by oxygen administration, hypoxia, middle altitude" in Russian and English prevails over the number of documents, related to the diagnosis of the

condition of athletes. However, the choice of methods and approaches for assessing the condition of athletes who have resumed training, their reactions to physical activity and performance will depend on the direction of new technologies and methods being developed for the recovery of athletes after COVID-19.

The documents found under the section “diagnosis and prognosis of health after COVID-19 and infectious diseases” (both in Russian and in English) (fig. 2) were distributed as follows, the earliest – 2, which occurred in 1998 and 1999, then – 6, published during the next 20 years and 12 – in the last two years.

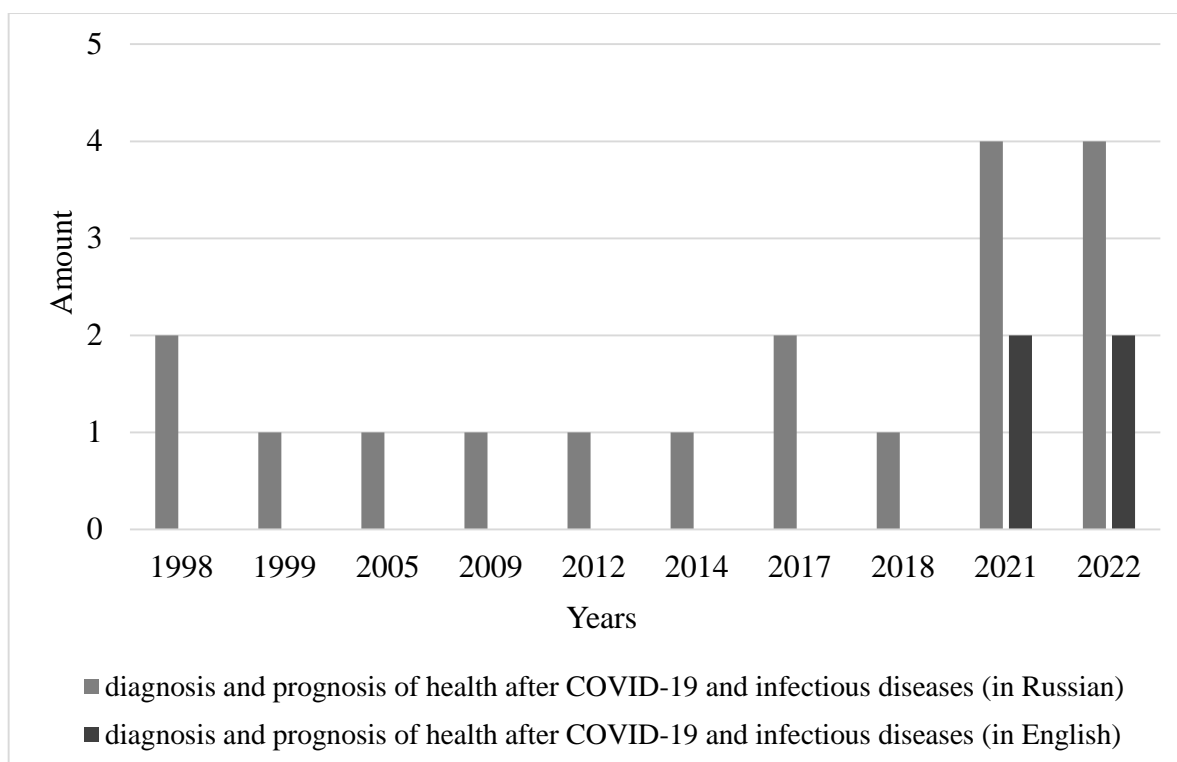


Fig. 2. Distribution of the number of patents by year by keywords “diagnosis and prognosis of health after COVID-19 and infectious diseases” (both in Russian and in English)

The greatest patent activity in this section was noted in 2021 and 2022 (12 patents out of 22). The patent holders are mainly legal entities in the Russian Federation and natural people from the USA and Europe.

An essential point in the diagnosis of athletes' health is the prediction of their condition during training in an epidemiologically unfavorable environment. Therefore, it is possible to distinguish several subgroups of technical solutions and methods related to the prediction of the occurrence of infections, the consequences associated with COVID-19 and the restoration of physical performance. In earlier patented methods, immunological tests are used to assess the prognosis of athletes' health [8], and during the epidemic of a new coronavirus infection,

technical methods are proposed to detect the onset of conditions such as COVID-19 or other respiratory infections by monitoring respiratory rate and heart rate with automatic data processing [9]. In addition, there is a genetic screening, that includes the prognosis of the severity of an infectious disease, COVID-19 in particular [10], as well as the the prognosis of the condition of patients who had COVID-19, for example, by the level of volatile metabolites in exhaled air [11], by the control of endothelial markers [12] or indicators of the coagulation system [13].

Another subgroup of patent-protected documents includes load tests that determine the performance of athletes: according to the state

of oxygen transport and oxygen-releasing systems with a given cyclic load of gradually increasing intensity in the zone of aerobic-anaerobic transition [14]; the conjugacy of cardiohemodynamics and external respiration with the level of oxygen consumption is evaluated [15]; the body's resistance to hypoxia and hypercapnia is identified [16]; by comparing the external respiration and the capacity of the work performed during a bicycle ergometer test, the contribution of anaerobic glycolysis to the energy supply of the work is determined based on the assessment of the effectiveness of the athlete's physical performance [17]. The performance of athletes is determined by the metabolic profile after physical activity [18] or when the maximum load is reached on the bicycle ergometer [19]. Analyzing the list of published inventions over the past 5 years, it can be noted that research teams mainly offer automated non-invasive methods for diagnosing the condition of athletes using functional parameters of various organizational systems, or high-tech genetic tests for gene polymorphism are carried out, determining the functioning of systems both responsible for the immunological protection of

the body, and related to the success of profiling sports activities.

The largest number of patents were found for the following keywords (both in Russian and in English): “methods for recovering patients and athletes after inflammatory diseases and coronavirus” (fig. 3). The earliest document was issued in 1994, the patent holder for it is the Russian Scientific Center for Rehabilitation and Physical Therapy. 12 documents were found for the period from 1996 to 2017. The greatest patent activity was noted starting from 2018 to the current time (2018 – 3 documents, 2020 – 2, 2021 – 6, 2022 – 5). Of the 29 patent holders, 10 are Russian legal entities, 11 are Russian natural people and 8 are foreign natural people. Among Russian and foreign copyright holders, there has been an increase in patent activity over the past 3 years, which is associated with the need to search for new methods of rehabilitation of various population groups, including athletes, given the appearance of SARS-CoV-2 in December 2019 and the following COVID-19 pandemic.

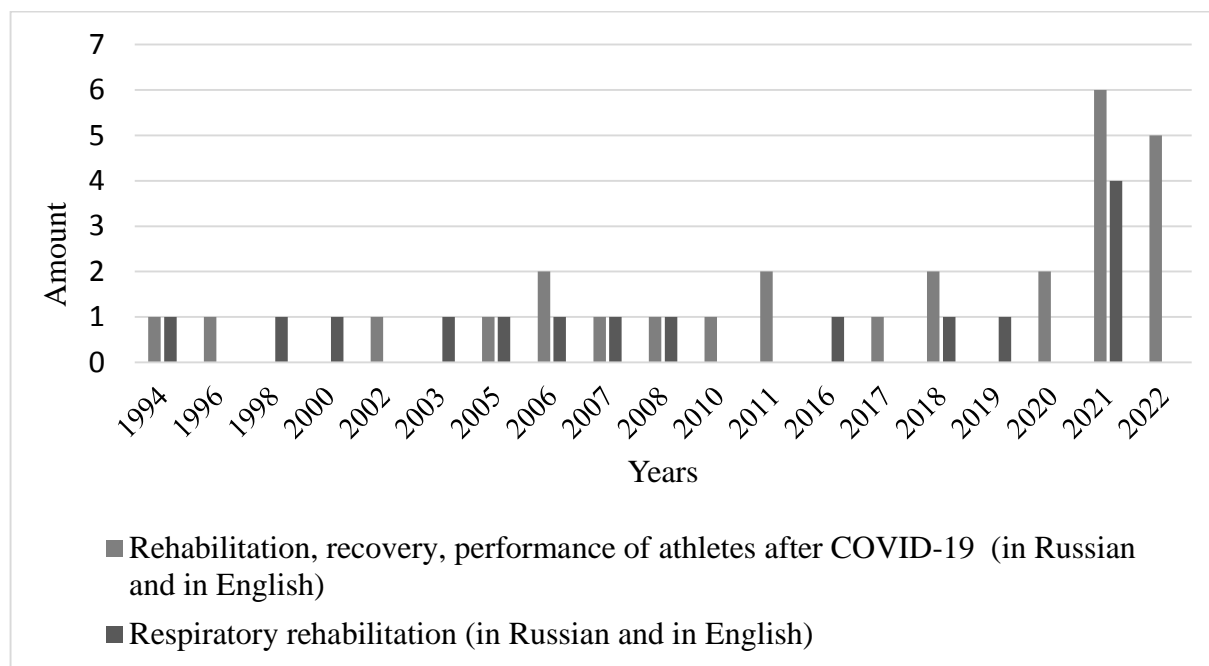


Fig. 3. Distribution of the number of patents by year according to the keywords “rehabilitation, recovery, performance of athletes after COVID-19”, “respiratory rehabilitation” (both in Russian and in English)

According to the search keywords "methods for recovering patients and athletes after inflammatory diseases and coronavirus", 8 documents were found, one each in 2005, 2008, 2017, in 2021 – 3 from the USA, 2018 – 1 international and 2021 – 1 from Great Britain, the patent holders of which are natural people. Separately, a search was made for the rehabilitation subsection "respiratory rehabilitation" (in Russian and in English), which included 11 documents, 9 of them Russian and 2 foreign (1 from the USA and 1 from China).

This subsection is presented by documents, in which several directions can be identified that offer technical solutions for the recovery and rehabilitation of athletes. These are patents, where various methods of physical therapy are mainly used – 15, compositions for nutritional support of athletes – 6, resort factors – 2 and the effect of hypoxic and cold loads – 4, the latter

are designed to increase physical performance and stress resistance. In the section of respiratory rehabilitation, the main ones are the methods with different techniques of respiratory gymnastics performed individually or in combination with kinesiotherapy and physical therapy. Over the past 3 years, the proposed methods of respiratory rehabilitation have been provided by automated control systems, for example, hardware methods of influencing the chest with biological feedback, combined with a certain breathing rhythm, are intended for complex rehabilitation after COVID-19 [20], as well as the intelligent breathing training systems for athletes [21]. Other methods of training and restoring respiration include methods of physical therapy: electric myostimulation of diaphragmal respiration [22], a method using electrostimulation of areas of the vagus nerve [23].

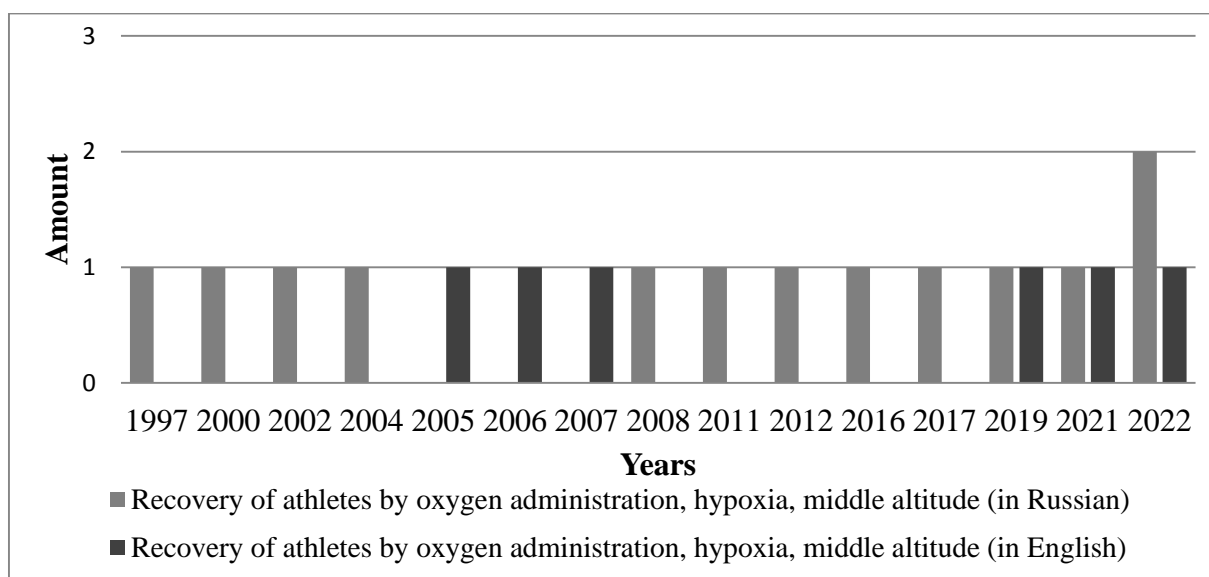


Fig. 4. Distribution of the number of patents by year by keywords "recovery of athletes by oxygen administration in middle altitude" (both in Russian and in English)

Conducting trainings in the middle altitude conditions implies the allocation of a separate section in the patent search, for which the following keywords were used: oxygen administration, hypoxia, middle altitude (both in Russian and in English) (fig. 4). 13 Russian documents were found, 7 of them dated 1997, 2000, 2002, 2004, 2008, 2011, 2012 years, 2 documents – 2016 and 2017, and 4 documents –

from 2019 to 2022. Foreign patents are represented by American, European and Chinese natural people in 6 documents dated 2005, 2006, 2007, 2019, 2021 and 2022. The patent-protected documents present methods of oxygen therapy using various compositions of gas mixtures (xenon and oxygen, oxygen and helium, xenon with helium and oxygen), given in

the proportions of normoxia or hyperoxia. Oxygen therapy is also carried out by the method of hyperbaric oxygenation. The feature of each of the methods is the control of physiological parameters by which dosing is carried out, duration and effectiveness of oxygen therapy is evaluated. [24]. Separately, it is possible to imagine the restorative effect of oxygen dissolved in water for oral administration [25] or in the form of water procedures [26].

Conclusion. The patent analysis demonstrated that scientists and experts are actively engaged in studying the issues that are the object of our research – the development of technologies for the recovery and rehabilitation of athletes after COVID-19.

There are several subgroups of technical solutions and methods related to the prediction of the occurrence of infections, the conse-

quences associated with COVID-19 and the restoration of physical performance. In earlier patented methods, immunological tests are used to assess the prognosis of athletes' health, and during the outbreak of a new coronavirus infection, technical methods are proposed that reveal the onset of conditions such as COVID-19 or other respiratory infections for monitoring respiratory rate and heart rate with automatic data processing.

The section of recovery and rehabilitation of athletes is represented by documents in which several areas can be distinguished: physiotherapy, nutritional support for athletes, resort factors, hypoxic and cold loads. Respiratory rehabilitation is represented by various techniques of respiratory gymnastics, including in combination with kinesiotherapy and physical therapy.

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INFORMATION ABOUT THE AUTHORS:

Gukas Nikolaevich Ter-Akopov – PhD, General Director of the FSBI “North-Caucasian Federal Research-Clinical Center of Federal Medical and Biological Agency”, Essentuki.

Anna Viktorovna Abramtsova – Candidate of Medical Sciences, Senior Researcher of the Center of Biomedical Technologies, FSBI “North-Caucasian Federal Research-Clinical Center of the FMBA of Russia”, Essentuki, e-mail: a.v.abramtsova@skfmba.ru.

Sabina Malikovna Abutalimova – Researcher of the Biomedical Technologies Center, FSBI “North-Caucasian Federal Research-Clinical Center of Federal Medical and Biological Agency”, Essentuki, e-mail: sabina190989@yandex.ru.

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