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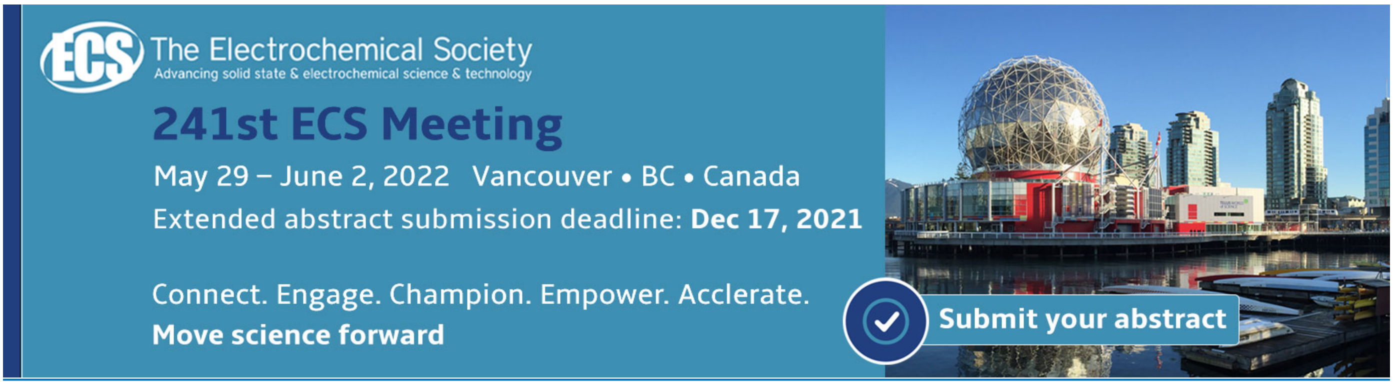

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Medical and Biological Problems in the Control of Therapeutic Exposure Parameters in Sports Medicine and Ways of Their Solution in New Medical Instruments and Systems

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Abstract. High-quality treatment and recovery of athletes-patients depends on reliable informational diagnosis of injuries and diseases, but also on adequate therapeutic effect. In most cases, the question remains of further predicting the condition of the patient-athlete as a result of the treatment. The article discusses the main biomedical problems in monitoring the therapeutic parameters of exposure and ways to solve them in new devices and systems based on thermometric and optoelectronic methods.

1. Existing biomedical problems in healthcare and in sports medicine. The problem in light-laser therapy: registration of the function “exposure - response of the body, i.e. response ”, is becoming particularly relevant. Despite objective and subjective difficulties, one can find ways to solve this problem, based on the isolation of the signal of the photobiological effect. The tasks of implementing these paths are to develop adequate optoelectronic information and metrological techniques as applied to medical technologies.

In general, the problem of determining the set of correlated parameters of the body's response to low-intensity laser exposure is an integral part of the problem, the determination of the functional relationship between the totality of the exposure parameters and the corresponding parameters of the body's response and its use for exposing therapeutic doses of the primary exposure parameters.

In this regard, the proposed: laser plethysmography, laser pulse oximetry and digital precision thermometry are universal methods on which the exposure control of the therapeutic dose will be based on feedback informative links. The development of new biocontrolled methods for monitoring the therapeutic parameters of exposure in electro-light-vacuum-laser therapy is an urgent problem. Carrying out laser-laser therapeutic procedures is always closely related to the concept of compulsory perception of the impact of their bio-object, for example, when conducting electro-laser stimulation, you can use the temperature of the target organ, which is targeted at, allowing you to estimate the amount of electro-laser exposure perceived by a particular organism.

The study of the effects on the human body is the first urgent research problem.

Changes: organ temperature, body blood flow, conductivity, and other factors in the zone of physiotherapeutic exposure can be measured and used to control exposure parameters. However, for these purposes, it is necessary, within 1 ° C to an accuracy of 0.1 ° C, to measure the temperature of the internal organ in hard-to-reach places (urology, andrology, gynecology, etc.). Existing non-invasive radiothermometric and thermal imaging methods do not provide the accuracy required for measuring temperature.

The first research problem was implemented using the contact method of temperature measurement using thermistors with negative TCR, providing in the range + 5 ° C ... + 50 ° C an error of ± 0.1 ° C. Therefore, thermometers (ТМЦП-2) [1] based on thermistors can be classified as precision. Based on the thermometer, it is possible to implement temperature control for biocontrolled thermometry.

The second biomedical problem is the study of the relationships between the therapeutic parameters of exposure to PPG [2], with the help of which it is possible to isolate many therapeutic parameters that can be calculated from it to quantify the reaction of the body [3]. The use in existing single-channel laser plethysmographs (PPG) of a light emitting diode (LED) (920 ... 960 nm) inevitably leads to "physiological interference" when recording a PPG signal by 30%. It is impossible to obtain an acceptable accuracy of less than 5%; the repeatability and adequacy of the PPG signal is impossible with LED PPG. It is necessary to develop a new single-wave laser ($\lambda = 805 \pm 0.75$ nm, P = 0.1 ... 0.2 mW) of two-channel FPG1-2KL [4,5]. The wavelength of the laser diode (LD) 804.25 ... 805.75 nm is the "isobestic point" for oxy- and deoxyhemoglobin. It provides an error of no more than 5% and is not only an information optical-electronic device, but also a device for automated feedback “impact-response”.

The third problem is the biomedical problem associated with the treatment of oxygen in the blood. Using a three-wave two-channel laser pulse oximeter (PSO3-2KL) [6], it is possible to optimize the dose parameters of electro-laser and other quantitative assessment of the body's response, which allows us to consider the positive fulfillment of the third problem.

2. Ways to solve biomedical problems and practical implementation in new medical devices and systems. To solve the posed biomedical problems, new principles, techniques, methods and methods have been developed for constructing optoelectronic devices for healthcare and sports on their basis.

1. The principle of constructing FPG1-2KL [4, 5, 7] taking into account LD in the laser mode with an operating wavelength of $\lambda = 805 \pm 0.75$ nm, which provides:

1) the implementation of a new parameter for registering the PPG signal at the “isobestic point” of 805 nm, in order to eliminate “physiological interference” by 30% compared to the single-channel prototype “Akutest” on an LED (920 ... 960 nm);

2) the use of the second LD-FD channel as a reference and rationing of the optical signal from the first channel relative to the reference error of up to 5% of the registration of the PPG curve;

3) instrumental implementation of FPG1-2KL [4,5,7] accuracy class 2.5, recording not only the parameters of blood flow in hemodynamics, but also allowing the use of PPG as a biological feedback as a corrector of therapeutic parameters in order to eliminate overdose of exposure.

2. The developed method for controlling temperature changes as a biological parameter of the feedback between the action and the temperature reaction of the “target organ” to it allows you to:

1) use the temperature response of organs to physiotherapeutic effects as secondary effects, and adjust the therapeutic parameters of exposure as primary effects;

2) instrumentally implement thermometers precision TMCP-2 [1,7], providing measurement with an accuracy of 0.1 ° C; changes in the temperature of the investigated organ within + 5 ... 50 ° C;

3) adjustment of exposure parameters in accordance with the applicable procedure, including registration of the skin temperature of the patient in the area of the surface sensors of the pulse oximeter.

3. The developed construction principle and instrumentally implemented on its basis PSO3-2KL [6], which records PPG signals with an error of 5% (PSO “Spectrotest” has 10%) from two LD-PDs ($\lambda = 640$ nm, $\lambda = 940$ nm) , instead of one LED-PD optocoupler, and one calibration LD ($\lambda = 805$ nm) in the laser sensor, using the effect of "backscattering" of light from blood and biological tissue, allows you to [8-11]:

1) to identify in the diagnostic local pathology of blood vessels, superficial and deep, simultaneously in different parts of the cardiovascular system with the possibility of early and high-precision assessment of the state of arterial vessels and regional blood flow;

2) the introduction of a third calibration LD with a radiation wavelength $\lambda = 805$ nm, which is the “isobestic point” for the absorption spectra of hemoglobin, oxyhemoglobin and other hemoglobin compounds, into the design of the PSO3-2KL laser sensor [6,7], to ensure the measurement reliability of the patient’s content blood oxygen by 30 percent relative to PIC with sensors on the LED;

3) constructive construction of surface sensors using selected three-axis accelerometers in order to record the magnitude of mechanical acceleration along three mutually perpendicular axes to eliminate the influence of patient movement artifacts and simplify the software PSO3 -2KL [12,13];

4) by introducing into the design of surface sensors a temperature sensor, record the temperature of the patient’s skin surface in the area of the sensors and provide control of the final functional dependence of the output on the thermistor of the power sensor from changes in skin temperature to adjust the treatment process [14,15];

5) confirm the results obtained experimentally and made by theoretical calculation of the optimal location of the LD and PD surface sensors 10 ... 20 mm.

The above characteristics and the principles of constructing new medical devices described above, and on their basis medical automated systems, allow solving current medical and biological problems facing sports medicine.

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