# A Smart Mobile System for Monitoring and Assessing Sportsman's Physiological Reserves During Training

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***Abstract*—This article describes a smart system that monitors and assesses Sportsman's level of physiological reserves while doing sport activities, applied in sports medicine and in high performance sports. The system was proposed for monitoring of the health status of the sportsman during the training process. The development of the system bases on metabolism and energy mechanism under the impact of physical activity on human organ systems. A series of human physiological indicators are formed characterizing the response of organs by exercise levels. This smart system records biosignals and physical activity signal, processes, analyzes, and wirelessly transmits information to other components of the system to ensure continuous data recording and provide timely information on Sportsman's physiological reserves level during training process. Structure of a smart mobile system for registration of a complex of biomedical parameters and method of assessing the diagnostically significant parameters of a Sportsman's body physiological reserves are developed.**

***Keywords—Smart Mobile system; physiological reserves; sportsman; complex of parameters; intergral parameter; biomedical signals***

## I. INTRODUCTION

Training professional Sportsman in Top Sports always needs an optimal plan and an appropriate training program. In order to make a good exercise plan for them, apart from the annual physical and clinical tests, the monitoring and evaluation of sports physiology are also very important.

Sports physiology is an individual characteristic in sport, expressed through the physiology, metabolism and energy for Sportsman under the impact of physical activity (PA). Identifying the true nature of metabolic and energy processes in training will greatly impact the training effectiveness of the lesson plan as well as the next training plan. In addition, the timely evaluation also prevents all overtraining signs, fatigue symptoms in training under practical conditions such as stadiums, training areas with lacking means of support, and predict training results.

During the training process, a comprehensive evaluation of Sportsman's physiological reserves (PhR) will correctly predict the physical recovery, as well as the level of PA for the next training plan. Different from the previously proposed methods (for example, subjective estimation of intensity, training duration by lactic acid threshold, percent of VO2max or percent of maximum heart rate (HRmax), as demonstrated in [1-6], we consider the comprehensive level of PhR through parameters of the organ systems: Cardiovascular, Respiratory and Nervous system under the influence of PA.

Therefore, the development of smart system for comprehensively monitoring and assessing Sportsman's PhR in training is an urgent issue of sports medicine as well as in training professional Sportsman.

## II. FORMATION OF COMPLEX OF PARAMETERS OF PHYSIOLOGICAL RESERVES

During PA, the human organs work continuously so that the metabolic processes timely ensure energy for activities and provide oxygen for active muscles and conserve blood for vital organs. Glucose oxidation for energy generation takes place in skeletal muscle cells, which require continuous oxygen. At this time, the cardiovascular system and respiratory system ensure continuous process to pump oxygen in the blood throughout the body. Therefore, when the level of PA (ie: intensity and duration) increases, sympathetic activity begins to rise. Heart rate (HR), Breathing Rate (BR), and the Blood Pressure (BP) also increased.

For oxidation takes place continuously in the cells, respiration requires oxygen flow to be dissolved in the blood, so the level blood oxygen saturation (SO2) decreases during intense PA, as demonstrated in [4]. Controlling the SO2 level will avoid situations of fainting and dizziness due to lack of oxygen and exhaustion. Therefore, HR, BP, BR, and SO2 level are very important evaluative parameters in training.

In addition, during PA, the sympathetic nervous system will ensure stimulating the organs, and blood vessel walls, causing an increase of the HR, BP, BR... This variation is influenced by of the nervous system. Therefore, the sign of this process consists of a Heart Rate Variability (HRV), as demonstrated in [7].

Hence, diagnostically significant parameters (DSP) characterized by the organ systems under the impact of PA must be used to assess Sportsman's PhR level in training: Cardiovascular, Respiratory, Nerve systems: HR, BR, BP,

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SO2, the variance of HRV (*dispRR*) and the range of HRV (*dRR*).

## III. Structure of the Mobile System for the Evaluation of Sportsman's Physiological Reserves

Evaluating methods - To comprehensively assess the changes in physiological parameters during training process, it is required to develop a system of smart devices to record biomedical information of the body, and measure the Sportsman's level of PA, according to [8]. This smart system consists of following basic components (Fig.1):

Sportsman's Mobile Device (SpMD): The device is extremely small, can be worn with the Sportsman during the training to record the information and monitoring parameters. The device needs to record signal channels such as Electrocardiogram (ECG) signal, Breathing signal (BS), Photoplethysmogram (PPG) signal as well as Sportsman's performance by using the Accelerometer channel to estimate power consumption. The device should be operated in intelligent mode: In normal condition, all channels are enabled for an overview (channel registration for biosignals and channel measuring of PA), in case of intense PA level (ie, training with increasing intensity), the system needs to disconnect the biomedical channels, to keep only the Accelerometer channel to assess the Sportsman's level of PA. After finishing each training course, the Biomedical channels are automatically turned on to measure, analyze Sportsman physiological reserves. All signals are transmitted wirelessly to the Sportsman's smart devices.

Sportsman's Mobile Computer – SpMC (Smart Phone or Tablet) – Used to receive signals from a mobile device, noise filtering, process, calculate and analyze the established information and send it to the Server of Sports Medicine Center (SMC).

Server of SMC: Store sportsman's information, where doctors, coaches can easily access with their personal computers to check, monitor the health situation and evaluate the PA level of Sportsman.

Coach's Mobile Computer – CoMC (Smart Phone or Tablet): Receive signal via WLAN channel from system server. Based on the activity level, the coach will correlate the results of the exercises. In case of signs of bad health such as overexertion, fatigue, the coach will inform sports medicine doctor through the GMS channel to the Sportsman to make recommendations, join in developing and adjusting the training plan.

Doctor's Mobile Computer – DoMC (Smart Phone or Tablet): Receive signals via WLAN channel. Only in case of excessive decrease sign in the level of physiological reserves, information will be immediately sent to the Doctor of sports medicine to make recommendations and join in developing and adjusting the training plan.

The components of the system must ensure continuous operation, throughout the evaluation period. In its parts, special attention is given to the Sportsman's Mobile Device. To accurately assess the information set above, the mobile device needs to record and receive the channels: ECG channel, PPG channel - (to measure SO2), Breathing channel - (to measure BR), Accelerometer channel - (to assess Sportsman's PA level).

In addition, to measure BP, a blood pressure monitor can be used as soon as the exercise has been completed. As soon as BP results are available, standardized values of the physiological reserve level shall be calculated. This will range from 0-1.0 for each parameter.

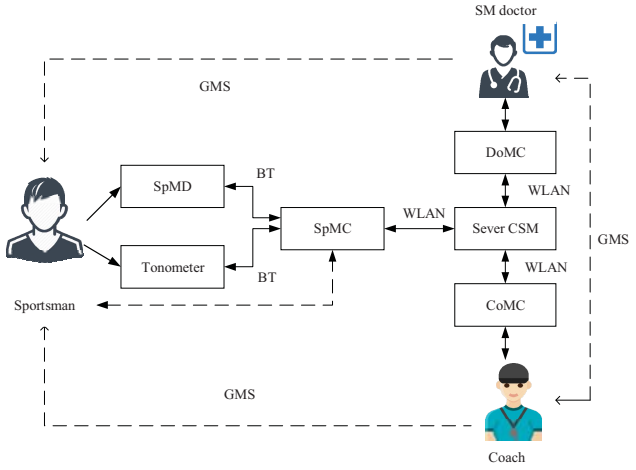


Fig. 1. The Mobile system assesing of sportsman's PhR

## IV. Method of Evaluation of Physiological Reserves

For a comprehensive evaluation of Sportsman's biophysical reserve level, a single integral parameter should be formed, representing the physiological reserve level. The integral parameter will be calculated by relationships between the private parameters. However, for the integral parameter of human physiology is calculated by composition of the private parameters (polygonal area), the value will be affected if some of them are reduced to almost zero. Therefore, to limit this, we propose the following rule: In case of the physiological reserve level of at least one private parameter as of 0, that means the Sportsman's physiological status is in dangerous level, affecting his life, then the system needs to alert him and experts to solve the problem as soon as possible. Only in case of parameters within limit level, the integral value of physiological reserve will be calculated.

For a comprehensive evaluation of all DSP and the dynamics of their change, we propose an N-sector pie chart. Its advantages are due, firstly, to the visibility of the display of N-dimensional space, and secondly, to the simplicity of interpretation of the integral parameter - area parameter. Thirdly, the simplicity of reflection (visualization) of the dynamics of private and integral parameters. A quantitative measure of the PhR integral parameter is the area of the polygon obtained on a pie chart by normalized parameters of important parameters. The integral parameter will be characterized by the area of the N-sector. Then the parameter of the integral parameter of PhR is determined by:

$$S = \frac{1}{2} * \sin(\frac{\pi}{N})(p_1 p_2 + p_2 p_3 + ... + p_N p_1),$$

where π/N is the angle between the sectors, a1...aN are the values of normalized private DSP within 0-1.0. The values normalized private DSP at the current time are determined by:

$$p_i(t) = \frac{P_i(t) - P_i \min}{P_i \max - P_i \min},$$

where $P_i(t)$ is value at the current time in the training process, $P_i$max, $P_i$min are individual upper and lower thresholds of private DSP, set by the SM doctor by empirical.

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In Fig. 2 shows the dynamics of the integral parameter PhR at different levels of the performed PA. On the other hand, the value of the N-sided polygon domain area depends on the order of adjacent edges, which is the private value of the physiological reserve. Therefore, the formation of rules for integral parameter is very important for this problem.

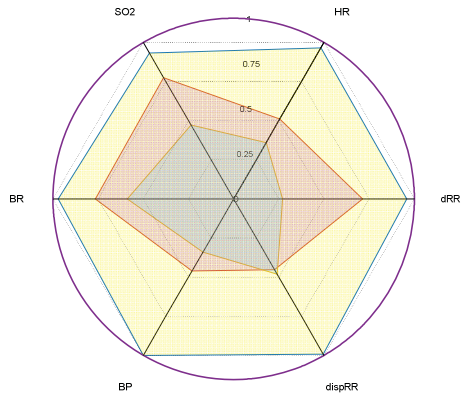


Fig 2. Dynamic of the integral parameter PhR at different levels of PA

Method of forming and assessing the PhR integral parameter:

Step 1 - Pre-processing of BMS and data (smoothing and filtering);

Step 2 – Detection of characteristic points of the received signals (R-waves of the ECG signal, the maximums points of the PPG signal, the maximums points of the BS signal);

Step 3 - Calculation of private values of the current status of health of the Sportsman: HR, HRV, SO2, BR, BP;

Step 4 - Assessment of the current health status of the Sportsman;

Step 5 - Development of the current integral parameter of the Sportsman's PhR;

Step 6 - Comparison of the level of PhR with the level of Sportsman's PA;

Step 7 - Evaluation of dynamics of the Sportsman's PhR;

Step 8 - Elaboration of the conclusion about the PhR status, taking into account the level of the Sportsman's P and the dynamics of the PhR at the previous stages of training.

## V. CONCLUTION

In order to objectively and comprehensively evaluate the Sportsman's ability, it is necessary to assess their physiological reserves, fully record and collect their biomedical signals during training process, consisting of assessing parameters, characterized by the cardiovascular, respiratory and nervous systems of the Sportsman under the impact of PA. Basing on private parameters, a rule for integral parameter of their physiological reserve level is to be established.

Method of forming an integral parameter is proposed to comprehensively standardize and evaluate the system of different parameters about measuring unit as well as values of private parameters.

The proposed smart multi-channel system improves management efficiency, establishes training plans, can be applied to predict sports training results, and convenient in monitoring and assessing the Sportsman's health in actual conditions.

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