Short Communication

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# Fresh View on Sport's PSM-Systems

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**ABSTRACT**

The syndrome of heart chronic physical overstrain is the condition of functional disadaptation, which a coach must diagnosis by himself. If he misses the development of this condition (especially for juniors) then subsequent training or competitive activities may cause development of hypertrophic cardiomyopathy and increase the risk of sudden cardiac death. The syndrome of heart chronic physical overstrain is the main reason of «professional sports aging».

**Keywords:** Sport; Cardiomyopathy; Heart Rate; Monitoring; Athlete's Readines

## Introduction

Physiological state monitoring (PSM-systems) is an IT system used to record various physiological parameters of the human body. The purpose of the PSM-systems is to monitor the viability/viability of a person in extreme conditions (diseases, injuries, extreme physical exertion, etc.). It is generally accepted that the degree of the person's efficiency in the terms of specific intensity and tension (sports of high achievements, fighting actions, extreme activities, etc.) is determined by complex interactions of the following components:

1) Health
2) Physical (athletic) shape
3) Technical (special) education
4) Psychological motivation (morally volitional qualities).

For the clear understanding interactions of these components in athletic pedagogy, the term «Athlete's Functional Readiness» is used.

### Athlete's Functional Readiness

In 2014, a group of scientists-physiologists and engineers from Bauman Moscow State Technical University created a methodological guide for Russian Ice Hockey Federation, dedicated for national teams' coaches, called: «General and special functional readiness of ice hockey players» [1].

Following relevant issues were reviewed and summarized in the manual:

1) Biochemical regulation of energy supply processes during specific work on the ice;
2) Physiological mechanisms of controlling ice hockey players' functional readiness;
3) New specific methods of functional testing during training camps and international competitions.

The concept of «athlete's functional readiness» has a very complex and multifaceted context. Functional readiness may be defined as «a relatively settled state of the organism, determined by the level of development of key functions required for the certain sport, as well as their specialized properties that directly or indirectly determine the effectiveness of the competitive activity». Physical education and sports theory distinguish technical, tactical, physical and psychological readiness. All functional components of the functional readiness develop in one way: muscle exercise, organized in a certain way within the specific biomechanical structure. Physical exercises used in training classes and sports game are very often

aimed only at developing the motor component of functional training. However, an athlete's effectiveness in sport and adaptation to specific sports activities may be greatly enhanced by targeted additional methods of influence on all functional components of preparedness.

In 2015 Bauman Moscow State Technical University jointly with The University of Al-abama (USA) carried out research «A study of applicability of a breathing sensor PACT2.0 in determination of aerobic-anaerobic potential of professional athletes (junior ice hockey player) ». This study has been approved by the Institutional Review Board for the protection of human subject request for approval of research involving human sub-jects (National Institutes of Health, USA). The purpose of the proposed study is disclosure of correlations between the dynamics of the Respiration Rate (RR) and Heart Rate (HR) when performing the intermittent operation at maximum power on a cycle ergometer. The study will be conducted to determine aerobic-anaerobic capacity of sportsmen in the framework of their functional prepared-ness and to evaluate feasibility of developing a non-medical methodology for assessing the state of chronical over-exertion.

The necessity for this research was determined by current requirements of the strategical item for a coach the information about how professional athletes in team kinds of sport (hockey, football, handball, basketball, etc.) match each other in speed-strength qualities, as well as a determination of a possibility for their mutual substitution without loss of a game quality during competitive cycles. Developed during this study the specific PSM-system named RheoCaR see (Figure 1). RheoCaR solves the global problem in the determination of the individual dynamic of changes in the levels of functional readiness of each sports team member, it allows effectively to maintain high levels of team efficiency in the whole during a competitive macro-cycle. The convenience of this sports functional testing is that it is held directly in the conditions of a stadium without involving any complex diagnostic medical equipment.

**Figure 1:** RheoCardioMonitor with modulus of functional readiness (RheoCaR).

**Physiological Basis of Work RheoCaR**

Heart rate (HR) is most often used as a load intensity evaluation criterion in sports. There is a linear relationship between heart rate and training intensity. To lead the most useful endurance training, it should be performed on the certain intensity level, when the entire oxygen-transport system is activated, i.e. in a so-called aerobic-anaerobic zone. When you have such intensity, the accumulation of lactate (lactic acid) does not occur [2]. Often, endurance trainings (aerobic exercises) are performed by the athletes at the heart rate of about 180 beats per minute (bpm). For many athletes, this heart

rate significantly exceeds the aerobic-anaerobic transition area. The boundaries of the aerobic-anaerobic transition area vary greatly at different people, but roughly it is between 140 and 180 bpm. To calculate training intensity and monitor an athlete's functional state, the basic heart rates are used: your resting heart rate, maximum heart rate, reserve heart rate and heart rate abnormalities, as well as target heart rate, characterizing the beyond of the aerobic-anaerobic zone. Maximum heart rate (HRmax) is the maximum number of contractions that the heart may be made within 1 min. After 20 years, HRmax gradually begins to decline by about 1 beat per year. So HRmax is calculated by the following formula [3]:

$$HR\max = 220 - TheAge(years) \quad (1)$$

For the calculation of the load intensity is also used the method of heart rate reserve (HRR), which was developed by Finnish scientists Karvonen. HRR is the difference be-tween HRmax and HR rest (HR0):

$$HRR = HR\max - HR0 \quad (2)$$

Knowing the HR reserve, you can calculate the target of the heart rate (HRM). Target heart rate (HRM) is the optimal heart rate, which does not allow going beyond the aerobic-anaerobic zone during the intensity of the performed exercise M (%):

$$HRM = HR0 + M \times HRR \quad (3)$$

At the same time, knowing HR0 and HRmax, according to the Karvonen's formula, it is possible to calculate with what intensity (M) the athlete performs the exercise:

$$M = (HRduringexercise - HR0)/(HR\max - HR0) \times 100\% \quad (4)$$

Thus,

$$M = (HRduringexercise - HR0)/(220 - Age - HR0) \times 100\% \quad (5)$$

**The Algorithm of the Execution of the Sports Standard Rheocar**

The sports standard RheoCaR was designed for functional testing of the professional athletes during training camps and competitions. The basis of this functional testing is registration of the biometric (blood pressure, pulse rate and breath rate) and anthropometric (height and weight) indicators with the further complex of the mathematical processing. The test consists of two parts:

1) Performing of the daily functional observations (DFO) using the program DiVa-S;

2) Performing of the stage complex examination (SCE) using RheoCardioMonitor with modulus of functional readiness.

DFO are performed during training camps for the operational control of health and dynamics of adaptation of the athletes' bodies to training loads, and during the competitive period with the aim of increasing of the correction efficiency of the pharmacological protective individual schemes in extreme conditions (see (Figure 2) (Table 1).

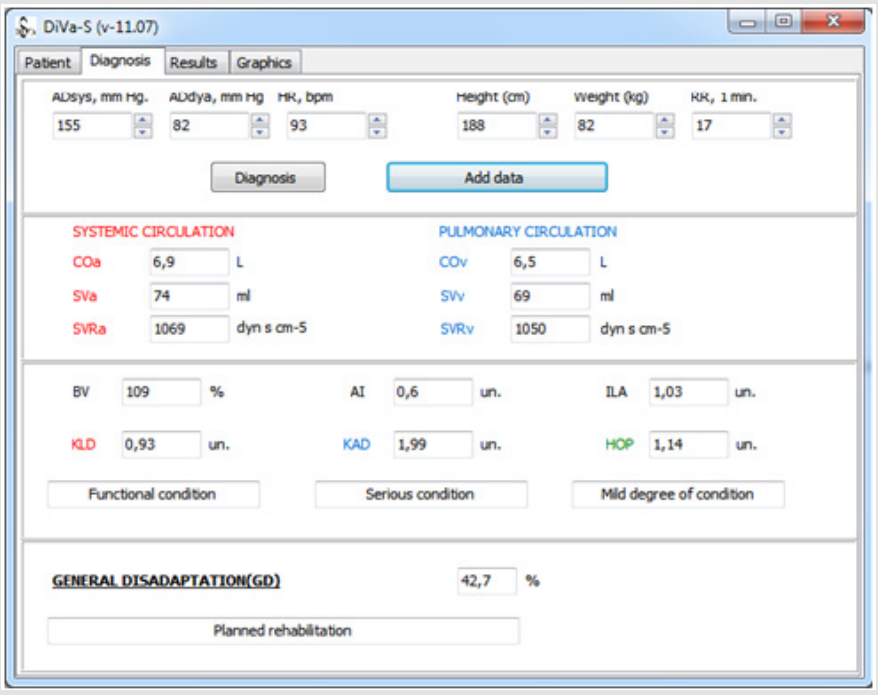



**Figure 2:** Software DiVa-S.

**Table 1:** Physiological characteristics and prognostic coefficients.

| Abbreviation | Full name | Units |
|---|---|---|
| ADsys | Systolic component of arterial tension | mm Hg |
| ADdya | Diastolic component of arterial tension | mm Hg |
| HR | Heart rate | bpm |
| Height | Body height | centimeter |
| Weight | Body weight | kg |
| RR | Breath rate | rpm |
| COa | Cardiac output of left ventricle of heart | liter per minute |
| COv | Cardiac output of right ventricle of heart | liter per minute |
| SVa | Stroke volume of left ventricle of heart | ml |
| SVv | Stroke volume of right ventricle of heart | ml |
| SVRa | Systemic vascular resistance | dyn·s·cm-5 |
| SVRv | Pulmonary vascular resistance | dyn·s·cm-5 |
| BV | Blood volume | % of body weight |
| ILA | Index of pulmonary adaptation | dimensionless |
| AI | Algever's index | dimensionless |
| KLD | Coefficient of latent disadaptation | dimensionless |
| KAD | Coefficient of apparent disadaptation | dimensionless |
| MD (HOP) | Metabolic dysfunction | dimensionless |
| GD | General disadaptation | % |
| IH | The level of individual health | dimensionless |

DFO aims, implemented with the help of the sports standard RheoCaR:

**1)** Individualization and effectiveness increasing of the educational training process and recovery;

**2)** Determination of the functional readiness level, making of the correction in the individual training plans;

**3)** Prescription of the recommendations to improve adaptive capacity, the implementation of preventive, therapeutic and rehabilitation measures; (Figure 3)

**4)** Determination for a sportsman's health admission to the training sessions and competitions.

**5)** The stage complex examination (SCE) are usually performed twice (at the beginning and at the end of the educational training camp) to determine the levels of the functional readiness and athletes' adaptation to the special work.

**6)** During SCE, a load test on the Bicycle Ergometer is conducted, in which an individual intensity (power) of the performed exercise (M, %) and target heart rate (HRM) for each athlete are received, as well as objective information on the indicators (on a five-point scale):

**7)** Total energy capacity (the capacity of the ATP-system);

**8)** Aerobic system (oxygen system readiness);

**9)** Anaerobic system (lactate system);

**10)** General adaptation of the blood circulation system.

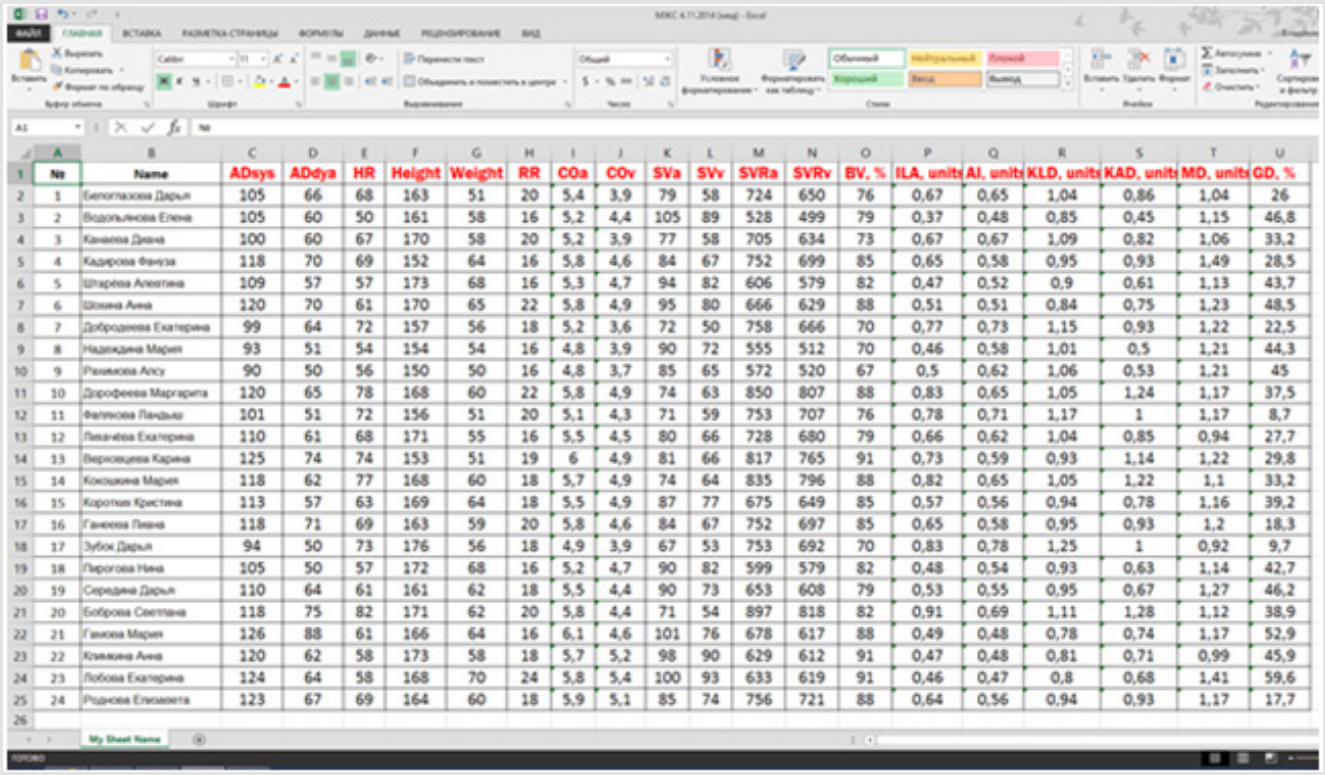
**11)** Based on results of the sports standard RheoCaR, make an individual biomedical program, including recommendations, is composed:

**12)** Additional work or rest during educational training camp;

**13)** Preventive measures;

**14)** Using of the selective methods of restoring the functions of ATP-system, Aerobic-system and Anaerobic-system;

**15)** Plan correction of a medical and biological providing and a pharmacological protection in extreme sport's conditions.



| № | Name | ADsys | ADdya | HR | Height | Weight | RR | COa | COv | SVa | SVv | SVRa | SVRv | BV, % | ILA, units | AI, units | KLD, units | KAD, units | MD, units | GD, % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Белоглазова Дарья | 105 | 66 | 68 | 163 | 51 | 20 | 5,4 | 3,9 | 79 | 58 | 724 | 650 | 76 | 0,67 | 0,65 | 1,04 | 0,86 | 1,04 | 26 |
| 2 | Водольянова Елена | 105 | 60 | 50 | 161 | 58 | 16 | 5,2 | 4,4 | 105 | 89 | 528 | 499 | 79 | 0,37 | 0,48 | 0,85 | 0,45 | 1,15 | 46,8 |
| 3 | Канаева Диана | 100 | 60 | 67 | 170 | 58 | 20 | 5,2 | 3,9 | 77 | 58 | 705 | 634 | 73 | 0,67 | 0,67 | 1,09 | 0,82 | 1,06 | 33,2 |
| 4 | Кадирова Фануза | 118 | 70 | 69 | 152 | 64 | 16 | 5,8 | 4,6 | 84 | 67 | 752 | 699 | 85 | 0,65 | 0,58 | 0,95 | 0,93 | 1,49 | 28,5 |
| 5 | Шарева Алевтина | 109 | 57 | 57 | 173 | 68 | 16 | 5,3 | 4,7 | 94 | 82 | 606 | 579 | 82 | 0,47 | 0,52 | 0,9 | 0,61 | 1,13 | 43,7 |
| 6 | Шохина Анна | 120 | 70 | 61 | 170 | 65 | 22 | 5,8 | 4,9 | 95 | 80 | 666 | 629 | 88 | 0,51 | 0,51 | 0,84 | 0,75 | 1,23 | 48,5 |
| 7 | Добродеева Екатерина | 99 | 64 | 72 | 157 | 56 | 18 | 5,2 | 3,6 | 72 | 50 | 758 | 666 | 70 | 0,77 | 0,73 | 1,15 | 0,93 | 1,22 | 22,5 |
| 8 | Надеждина Мария | 93 | 51 | 54 | 154 | 54 | 16 | 4,8 | 3,9 | 90 | 72 | 555 | 512 | 70 | 0,46 | 0,58 | 1,01 | 0,5 | 1,21 | 44,3 |
| 9 | Разикова Алсу | 90 | 50 | 56 | 150 | 50 | 16 | 4,8 | 3,7 | 85 | 65 | 572 | 520 | 67 | 0,5 | 0,62 | 1,06 | 0,53 | 1,21 | 45 |
| 10 | Дорофеева Маргарита | 120 | 65 | 78 | 168 | 60 | 22 | 5,8 | 4,9 | 74 | 63 | 850 | 807 | 88 | 0,83 | 0,65 | 1,05 | 1,24 | 1,17 | 37,5 |
| 11 | Фалякова Пандыш | 101 | 51 | 72 | 156 | 51 | 20 | 5,1 | 4,3 | 71 | 59 | 753 | 707 | 76 | 0,78 | 0,71 | 1,17 | 1 | 1,17 | 8,7 |
| 12 | Лиханева Екатерина | 110 | 61 | 68 | 171 | 55 | 16 | 5,5 | 4,5 | 80 | 66 | 728 | 680 | 79 | 0,66 | 0,62 | 1,04 | 0,85 | 0,94 | 27,7 |
| 13 | Верхощева Карина | 125 | 74 | 74 | 153 | 51 | 19 | 6 | 4,9 | 81 | 66 | 817 | 765 | 91 | 0,73 | 0,59 | 0,93 | 1,14 | 1,22 | 29,8 |
| 14 | Конощина Мария | 118 | 62 | 77 | 168 | 60 | 18 | 5,7 | 4,9 | 74 | 64 | 835 | 796 | 88 | 0,82 | 0,65 | 1,05 | 1,22 | 1,1 | 33,2 |
| 15 | Коротких Кристина | 113 | 57 | 63 | 169 | 64 | 18 | 5,5 | 4,9 | 87 | 77 | 675 | 649 | 85 | 0,57 | 0,56 | 0,94 | 0,78 | 1,16 | 39,2 |
| 16 | Ганеева Лиана | 118 | 71 | 69 | 163 | 59 | 20 | 5,8 | 4,6 | 84 | 67 | 752 | 697 | 85 | 0,65 | 0,58 | 0,95 | 0,93 | 1,2 | 18,3 |
| 17 | Зубок Дарья | 94 | 50 | 73 | 176 | 56 | 18 | 4,9 | 3,9 | 67 | 53 | 753 | 692 | 70 | 0,83 | 0,78 | 1,25 | 1 | 0,92 | 9,7 |
| 18 | Пирогова Нина | 105 | 50 | 57 | 172 | 68 | 16 | 5,2 | 4,7 | 90 | 82 | 599 | 579 | 82 | 0,48 | 0,54 | 0,93 | 0,63 | 1,14 | 42,7 |
| 19 | Середина Дарья | 110 | 64 | 61 | 161 | 62 | 18 | 5,5 | 4,4 | 90 | 73 | 653 | 608 | 79 | 0,53 | 0,55 | 0,95 | 0,67 | 1,27 | 46,2 |
| 20 | Боброва Светлана | 118 | 75 | 82 | 171 | 62 | 20 | 5,8 | 4,4 | 71 | 54 | 897 | 818 | 82 | 0,91 | 0,69 | 1,11 | 1,28 | 1,12 | 38,9 |
| 21 | Ганиева Мария | 126 | 88 | 61 | 166 | 64 | 16 | 6,1 | 4,6 | 101 | 76 | 678 | 617 | 88 | 0,49 | 0,48 | 0,78 | 0,74 | 1,17 | 52,9 |
| 22 | Климина Анна | 120 | 62 | 58 | 173 | 58 | 18 | 5,7 | 5,2 | 98 | 90 | 629 | 612 | 91 | 0,47 | 0,48 | 0,81 | 0,71 | 0,99 | 45,9 |
| 23 | Лобова Екатерина | 124 | 64 | 58 | 168 | 70 | 24 | 5,8 | 5,4 | 100 | 93 | 633 | 619 | 91 | 0,46 | 0,47 | 0,8 | 0,68 | 1,41 | 59,6 |
| 24 | Роднова Елизавета | 123 | 67 | 69 | 164 | 60 | 18 | 5,9 | 5,1 | 85 | 74 | 756 | 721 | 88 | 0,64 | 0,56 | 0,94 | 0,93 | 1,17 | 17,7 |

**Figure 3:** Physiological characteristics and prognostic coefficients (software DiVa-S).

**Pedagogical Interpretation of the Results**

The results of the implementation of the sports standard Rheo-CaR allow to realize pedagogical monitoring of the levels of both general and special functional readiness of sportsmen in accordance with the characteristics of S.V. Fomin's model (1984) [4] (see (Figure 4), where

1) M (%) – the intensity of the performed exercise. It characterizes the condition of the neurodynamical component of the control system and the powering component of implementation system.

2) HR0 (bpm) – pre-start HR. It characterizes the condition of the neurodynamical component of the control system.

3) HRmax (bpm) – maximum HR achieved by the athlete performing a load test. It characterizes the condition of the neurodynamical component of the control system and the powering component of implementation system.

4) HRM (bpm) – the target HR at which the athlete moves from the mixed zone of energy supply purely in the anaerobic zone. It characterizes the condition of the powering com-ponent of implementation system.

5) Time (s) – time to run a load test by an athlete. It characterizes the condition of the driving component of implementation system.

The level of athlete's functional readiness (units) shows the athlete's work effectiveness during performing a load test regarding the state of her physical health, skills and psycho-logical motivation (on (Figure 4) for ice hockey players (women) levels of athlete's functional readiness are presenting the adaptation to Special Ice Work).

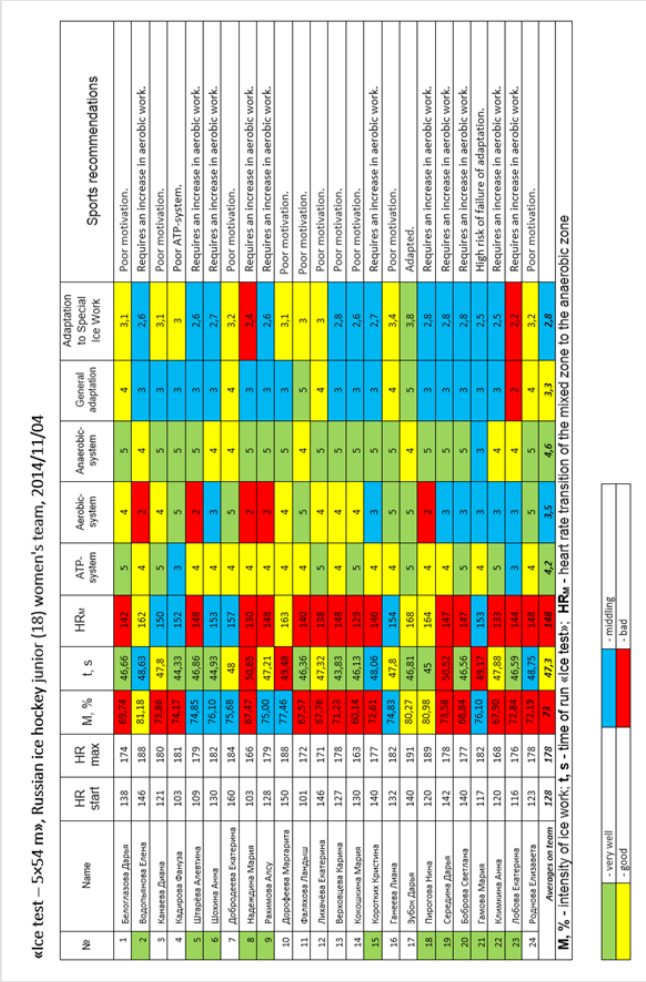



**Figure 4:** Pedagogical interpretation of the sports standard RheoCaR results.

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