



# The approach of incremental adjustment, guided by heart rate variability metrics, in the coaching of elite swimmers

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## Abstract

**Objective of the study** was to assess the effectiveness of the Varicard system in optimizing the training regimen for elite swimmers.

**Methods and structure of the study.** 30 qualified athletes took part in the observation: 10 masters of sports, 14 international masters of sports, 6 honored masters of sports. The task was to use HRV indicators in training management over a selected period, the same for the control and experimental groups. The study used the VARICARD complex and the ISCIM6 program.

**Results and conclusions.** The findings of the research demonstrated the success of the «sitting position» scenario in accordance with the outlined monitoring procedure. The significance of the data collected enables the creation of a more precise training program.

**Keywords:** heart rate variability, stress index (SI), elite swimmers, microcycle, progress indicator.

**Introduction.** Solving the problem of reliable interpretation of HRV indicators during training will allow achieving tangible progress in competitive activities [8, 12]. To assess the state of the regulatory systems of the athletes' body, it is important to have accessible and simple measurement methods. The main thing in these cases will be the dynamics of changes and the repetition of control measurements. In the analysis of HRV indicators, it is important to select digital indicators that will reliably correlate with each other [7]. On the way to a sports result, a balance is needed between additional resources of the body and the maintenance of natural homeostasis [8, 11].

To monitor the current state, it is necessary to use, including in different directions, various functional tests and make minor but important changes to the training program [9]. It is noted that, in general, for the most effective impact on strength endurance, as a developing quality, training should be built in aerobic zones. (V. S. Gorozhanin, 1984, Avdienko V. B., So-

loпов I. N., 2019, Avdienko V. B., 2021, V. M. Volkov, 1990). For correct reproduction of the research results, a similar qualification level of athletes, a number of measurements and suitable standard conditions are required [6]. The whole range of control measures will help to avoid premature intensification of the training process. (A. G. Dembo, 1980; P. P. Ozolin, 1984). It is necessary to create conditions for the realization of a high training potential. A higher training level is ensured on the basis of a high level of development of aerobic endurance (V. N. Platonov, 1998; V. B. Avdienko et al., 2005, I. N. Solopov) [2]. Control over the activity of adaptation mechanisms is carried out along two contours. Minimal participation of the central circuit provides the underlying regulatory systems with a large number of degrees of freedom and helps to achieve a functional optimum (V.V. Parin, R.M. Bae-vsky) [6].

HRV indicators have certain differences associated with the characteristics of different sports. For

our study, the differences in the indicators of the total power of the spectral waves TP were very important [4].

**Objective of the study** was to assess the effectiveness of the Varicard system in optimizing the training regimen for elite swimmers.

**Methods and structure of the study.** The research work was conducted over two years during the preparation of swimmers of the Russian national team at year-round centralized training events. The observation involved 30 qualified athletes: 10 masters of sports, 14 masters of sports of international class, 6 honored masters of sports.

The task was to use the HRV indicators in training management during the selected period, the same for the control and experimental groups.

The conditions for the experiment, confirming the equivalence of the two groups, were: swimming specialization - distances up to 200 meters, WA (World Aquatics - former FINA) score level of at least 800 points, mixed groups - men and women, performance at the same competitions at the same time.

The study used the VARICARD complex and the IS-CIM6 program. The standard scenario of «sitting position» at rest was used. Athletes visited the treatment room in the evening, after the training day, strictly according to an individual schedule. The minimum number of measurements according to the regulations is twice a week. The following HRV indices were used: TI – tension index, TP – index of total spectral wave power, HR, PARS – index of regulatory systems activity, PAPR – index of regulation process activity, pNN50, MxMDn – variation range. Individual dynamics of

Table 1. Interdependence of HRV indicators

Indicators	Criterion	Notes
TI + TP	-0,895	Inverse correlation
pNN50 + TI	-0,838	Inverse correlation
PAPR + TI	0,949	Direct dependence
TP + MxMDn	0,928	Direct dependence

Table 2. Criteria for HRV indicators

Indicators	Norm	Correction
TP	1100 - 5000	Work in any zones
TI	20 - 170	
PARS	1-4	
<b>Indicators</b>	<b>Norm</b>	<b>Correction</b>
TP	<1100	Work in compensatory zones
TI	>300	
PARS	5-7	
<b>Indicators</b>	<b>Norm</b>	<b>Correction</b>
TP	>6000	Work in zones A1 and A2
TI	>200	
PARS	8-10	

changes in the listed indices were taken into account. With the help of the above-mentioned HRV indices, practical changes were made to the training plan of the weekly microcycle. The experimental group used the method of minor correction taking into account the obtained criterion assessments and pedagogical interpretation of the data. The control group did not

Table 3. Example of individual changes in HRV

		TP																				
Спортсмен		Ж.П.	С. А.	Ч. Е.	Ж. А.	Д. М.	З. Н.	С. П.	К. К.	В. М.	К. А.	О. А.	Л. К.	Т. Д.	Г. Н.	Р. Е.	Р. В.	Д. Е.	П. П.	Ж. Д.	Б. Т.	С. В.
Нагрузка																						
ПАНО		1872	2747	2675	2098	1906	1448	4990	2788	2604	3019	4574	2517	1895	4157	4043	781	2146	2925	2118	1572	4791
МПК		840	487	710	434	771	497	981	406	892	1819	1149	1090	472	2028	1318	188	343	759	548	668	958
Гликолиз		1339	1556	910	1102	3862	824	1263	1144	6523	6939	2967	1485	769	9928	1675	497	608	8166	1149	927	1141

		ИИ																				
Спортсмен		Ж.П.	С. А.	Ч. Е.	Ж. А.	Д. М.	З. Н.	С. П.	К. К.	В. М.	К. А.	О. А.	Л. К.	Т. Д.	Г. Н.	Р. Е.	Р. В.	Д. Е.	П. П.	Ж. Д.	Б. Т.	С. В.
Нагрузка																						
ПАНО		156	88	66	110	171	116	83	21	75	102	94	82	148	35	41	320	145	102	171	259	38
МПК		271	323	328	641	328	295	338	632	192	163	225	183	848	132	147	1390	707	356	281	214	160
Гликолиз		186	173	462	137	125	205	270	215	31	48	130	175	340	67	148	296	326	21	295	149	192

		ПАРС																				
Спортсмен		Ж.П.	С. А.	Ч. Е.	Ж. А.	Д. М.	З. Н.	С. П.	К. К.	В. М.	К. А.	О. А.	Л. К.	Т. Д.	Г. Н.	Р. Е.	Р. В.	Д. Е.	П. П.	Ж. Д.	Б. Т.	С. В.
Нагрузка																						
ПАНО		3	3	4	2	3	1	6	6	2	6	6	5	4	3	7	6	3	4	7	5	5
МПК		6	5	6	9	8	3	7	4	5	8	4	5	7	2	1	10	8	8	4	6	3
Гликолиз		4	5	6	5	4	1	8	2	7	7	4	5	6	4	2	6	5	7	8	6	3

make any changes to the training at different stages of preparation, receiving data.

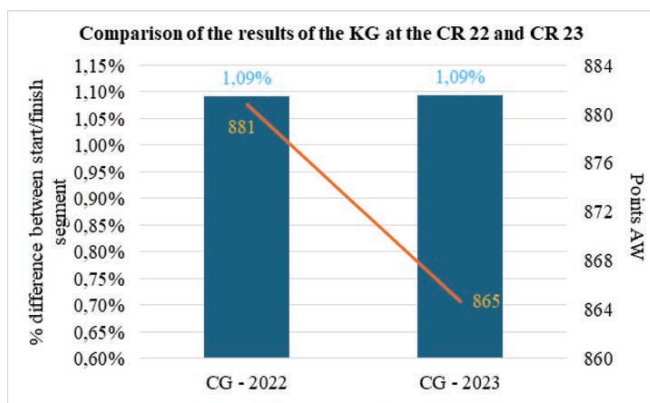
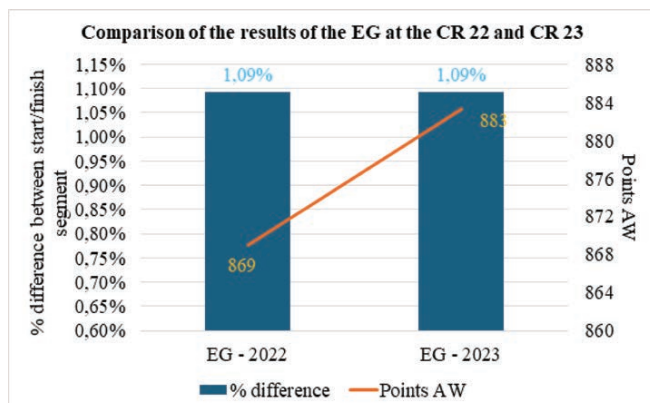
**Results of the study and discussion.** During the observation period, 3820 measurements of highly qualified swimmers were taken under the conditions of training events held by the Russian Swimming Federation at the Olympic base «Lake Krugloe». The proposed training format allows observing changes in the functional state of athletes. The interdependence of the used HRV indicators is determined by the method of mathematical statistics. Table 1 shows the values.

It is worth noting that the MxDMn variation range indicators are used by us to determine the pathological condition and a reactive change above 650 ms [14] can serve as a basis for additional consultation with the team doctor. The PARS indicators, although they have program criteria, were developed by Baevsky R. M. not for athletes and in assessing the state of regulatory systems have a reliable connection mainly with high point scores - 1-2 (physiological norm zone). Table 2 shows the criteria for indicators developed during the experiment that are most dependent on the state of the body after training work – TP, pNN50, Tension Index.

Table 3 shows the HRV indices in swimmers after training in the PAN, Glycolysis, and maximum anaerobic power zones.

In the case where the indicators of the tension of the regulatory systems had a pronounced centralization (PAPR), the other taken into account indicators of the HRV changed interdependently. The pedagogical interpretation of the results was expressed in reducing the load on the next day, maintaining the planned work and, in rare cases, increasing the load. The task of the coaches was to make a moderate adjustment to the training program of the next training day. The changes mostly concerned a decrease in intensity. A similar scheme in training management was used at each stage of preparation. After the experiment, the results shown at the competitions by the observed athletes were assessed using the SPLIT SMASH MANAGER electronic system. The results of the comparison of the control and experimental groups at the Russian Championships in 2022 and 2023 are shown. The figure shows the percentage of deterioration in the speed of the starting 50-meter and finishing 50-meter segments for each swimmer who participated in the study (see figure).

**Conclusions.** The problem of effective control over the management of an athlete's training will always be one of the key tasks of growth and improvement of sports skills. A promising direction for this will be control over the course of adaptation processes of the athletes' body. The presence of athletes in a group whose hardware measurement indicators will correlate with available non-invasive methods for determining their current state will simplify the problem of current control by the coach. This, in turn, will help avoid methodological errors when planning the training process.



Start/Finish Segment Deterioration Percentage

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