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The Inability to Identify the Top-class Athletes Based on Heart Rate Variability Indices

Key words*: ECG, heart rate variability, top-class athlete*

Annotation: *Goal of study: to evaluate the information content of heart rate variability (HRV) parameters in respect of identification of top-class athletes, according to the ECG. Methods of study: ECG, mathematical modeling. Subjects: athletes of national teams of Russia and Republic of Tatarstan. Main results: the analysis of HRV is suitable for the identification of top-class athletes.*

Introduction

One of the pressing issues of modern sports medicine is the development of methods for the objective identification of athletes of varying skill. Regardless of the method used in the practical work of specialists, there is a need in the application of quantitative and analytical methods. When one selects an object and method of analysis, his choice is based, as a rule, on the simplicity and informative value of the data. We have previously showed that the registration of the number of biochemical laboratory parameters like the content of lactate, red cells sedimentation rate and the value of the color index allows the identification of athletes' class (2). The disadvantage of this approach is the need for venous blood sampling and the long duration of analysis. One of the convenient target objects is the heart and from the not invasive methods of analysis of its functioning is a method of ECG. Heart rhythm is stipulated by the ability of the specialized cells of the conduction system of the heart spontaneously to be activated – it is so-called a property of cardiac automaticity. Regulation of heart rate under physiological conditions is the result of the rhythmic activity of the sinus node pacemakers and the modulating effect of the autonomic and central nervous systems, a number of humoral and reflex actions. Normally, the main modulating effect on heart rate has autonomic nervous system. This stimulates the activity of the sympathetic section of the heart and the parasympathetic oppresses it. The impact of the central nervous system has a modulatory effect on the autonomous operation of the cardiac conduction system. The central nervous system controls the relative levels of activity of the sympathetic and parasympathetic divisions typically through a feedback mechanism. However, the simultaneous activation of both parts of the effects of sympathetic and parasympathetic nervous systems do not develop a simple algebraic method, and theirs interaction effects are not expressed by a linear dependence. In addition, the autonomic innervation of the various parts of heart is heterogeneous and unbalanced. For example, the nodal tissue is dominated by the effects of the parasympathetic system, implemented via the n.vagus, and in the ventricular myocardium influence the sympathetic division expressed significantly stronger than the parasympathetic. Effects on the heart of the left and right n.vagus nerve are different. Right n.vagus fibers innervate mainly sinoatrial node; the left n.vagus fibers are suitable mainly to the atrioventricular node. As a result, the right n.vagus affects mainly on heart rate, and the left - on the atrioventricular conduction. Accordingly, in the stimulation of the right n.vagus is more pronounced negative chronotropic effect (slowing of heart rate), and for stimulation of the left - negative dromotropic (slowing atrioventricular conduction).

The key structures of the heart, which are available for research are elements of muscle, and its system of innervation - cardiac conduction system.

Some researchers focus on the analysis of heart rate variability (HRV), measured by ECG. Data analysis is brought to practical use (1) as a computerized technology with the use of instruments of industrial production like “ Poly-spectrum-CM”, “VNS-rhythm”,” VNS-Micro” ('Neurosoft', Ivanovo, Russia). Currently, technologies of HRV analysis are adapted to the bracelet for registration of HRV via smartphones and tablet computer. The technology requires a combination of these devices via Bluetooth Smart or ANT + (6,7).

HRV allows assessing the overall condition of the athlete, and the proportion of selective influence of the parasympathetic and sympathetic nervous system, humoral-metabolic and central ergotropic components. As a result, 6 classes of rate regime are allocated in descending order from 1 (highest functionality of the athlete’s heart) to 6 (extreme case of failure of the autonomic regulation of the heart rate) class, i.e. to identify the state of fatigue athlete) (4) or the recovery after exercise as well (9).

Based on the fact that according to the HRV is possible to distinguish the athlete from healthy young people, we decided to check whether it is possible according the HRV parameters also identify athletes of top-class.

Purpose of the study: check the possibility of the identification of high-class athletes based on HRV parameters, according to the ECG.

Methods and organization of study

The study was conducted at the Center of sports training of the Ministry of Youth, Sports and Tourism of the Republic of Tatarstan.

The object of study: the athletes of national teams of Russia and Tatarstan, 103 people, including 48 women, 55 men, average age - 19.6 years. The distribution of athletes in sports (number): athletics (38), rowing (5), swimming (7), basketball (4) cross-country skiing (10), judo (6), fencing (11), trap-shooting (8) boxing (3), wrestling (4), badminton (3), cycling (3), gymnastics (1). Athletes were divided by the level of sportsmanship into two groups: 1.Sportsmen of top-class, 16 persons: honored master of sports - (4), the master of sports of international class - (12). 2. Athletes are not of top-class, 87: master of sports - (23), a candidate for master of sports - (39), winner of the 1st category - (25).

Methods: Heart rate variability analysis; the study was conducted with the help of ambulatory electrocardiographic system "Polispektr 8 / EX" ("Neurosoft"). We used the following tests: 1) supine position of the patient during the recording, 2) orthostatic test - vertical position of the athlete. The recording time of the heart rate was 6 minutes (360 s).

The following standard HRV parameters were recorded (1): HR, TP, VLF, LF, HF of spectra, the indices LF / HF, VLF (%), LF (%), HF (%), RRmin, RRmax, SDNN.

Statistical analysis. The software package Statistica 6.0 was used: the modified Kolmogorov–Smirnov test was used for testing for normality of the parameters distributions, calculated MD ± SD, comparison of the two groups was carried out by T-test, calculated the correlation coefficient Pearson, considered as a statistically significant p-value <0.05. Identification of the sportsmen class was performed by discriminant analysis, quality of the model was evaluated by the values of Wilks' λ, $\chi 2$.

In today are adopted a set of standards for the HRV values used in the clinic, which offered by the Task Force of the European Society of Cardiology and North American Society of Pacing Electrophysiology (3,10). For the purpose of sports medicine, such standards are none. In sports medicine, even a 5-minute interval stabilization period before registration of HRV begins already regarded as too long. Evidence that is sufficient even 1 minute is presented (6). Reliable results for the identification of athletes according to HRV is impossible with use of descriptive analysis (Table 1).

Table 1. HRV of athletes of different classes.

№	Parameter	Supine position		Orthostatic-test					
		Sportsmen		Sportsmen					
		top-class	non top-class	top-class			non top-class		
1	Heart rate	57,8±9,5	63,1±10	81±9	22±9*	26,83± 10,3**	86,2 ±14	22 ±13	26,5 ± 18
2	TP, ms^2	5685±2542	5391±4924	6288±10159			6328±15417		
3	VLF, ms^2	2828±1680	1712±1670	1997±2443			2042±3592		
4	LF, ms^2	1114±877	1264±1232	2347±2855			2279±4789		
5	HF, ms^2	1741±1448	2384±3118	1942±5034			2007±9119		
6	LF/HF	1,44±2,04	0,97±1,0	5,2±4,4			6,2±5,15		
7	VLF%	48±19	35±17,6	40,23±10,74			39,9±19,0		
8	LF%	22±13	24,7±12,2	44,5±11,7			42,8±15,3		

9	HF%	29±18	39,6±18,5	15,2±12,4	17,1±16,47
10	RRmin, ms	825±138	763±168	558±158	556,2±155
11	RRmax, ms	1270±233	1239±573	1116±645	953±514
12	RRNN, ms	1066±185	978±154	752±100	720±121,0
13	SDNN, ms	75,1±30,3	72,9±48,4	65,7±52,4	81,95±137.87

Note: * - increase in heart rate in absolute terms ** - in %. Comparison of means of groups, p = 0,09-0,965.

Parametres of the investigated sportsmen were characterised by normal distribution.The correlation coefficients are very low, they do not exceed in the module value 0.246 and not statistically significant, p> 0.05 (Table2).

Pearson’s correlation coefficient,(class of athlete– parameter (r, (p)) Table 2

Test	Parameter													
	Heart rate (HR)	↑ HR	TP	VLF	LF	HF	LF/HF	VLF%	LF%	HF%	RR_{min}	RR_{max}	RRNN	SDNN
Supine position	-0,097 (0,337)	–	0,014 (0,891)	0,160 (0,111)	-0,037 (0,715)	-0,092 (0,368)	0,069 (0,536)	0,142 (0,199)	-0,030 (0,785)	-0,150 (0,171)	0,106 (0,294)	0,022 (0,829)	0,092 (0,361)	-0.024 (0.823)
Orthostatic test	-0,111 (0,272)	-0,074 (0,466)	0,019 (0,851)	0,020 (0,842)	0,047 (0,642)	-0,029 (0,774)	-0,028 (0,803)	0,013 (0,905)	-0,034 (0,751)	-0,018(0,862)	-0,056 (0,584)	0,137 (0,177)	0,101 (0,319)	0,034 (0,736)

In the diagnostic tests is unsuitable approach based on an assessment of the significance of differences of the compared target groups, when assessment of the informative value of studies is reduced to the terms of descriptive statistics: determination of the mean values of the groups, the standard deviation, the difference between the two means, correlation coefficients, determination of sensitivity or specificity of the test.

The most appropriate approach in the mathematical analysis in order to identify a causal relationship, comparability of the target parameter study is the regression analysis(8), in our study of his particular case, discriminant analysis, which was used by us to identify the top-class athletes.

The target data of the present study were the results of discriminant analysis. These models for the identification of top class athletes indicate that there are no statistically significant differences between the athletes in groups (Wilk's λ <1), for supine position test sample λ = 0.843, and for orthostatic one λ = 0.915, $\chi 2$ value is not high (11.84 (p = 0.375) and 6.69 (p = 0.877), respectively). This result is explained by the fact that the HRV is highly variable and individual index. It is used to analyze the current state of the dynamics of the state , determining the signs of fatigue , assessment of adaptation options.

Conclusion. Analysis of HRV as in the supine, and in orthostatic test is not suitable for identification of top -class athletes.

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