

Determinacy of pre-competitive heart rate regulation processes by personal characteristics of athletes

Belova Evgenia Lyudvigovna
Associate Professor, Department of
Physical Culture, Sports and Adaptive
Physical Education, Institute of
Pedagogics, Psychology and Physical
Education
Vologda State University
Vologda, Russia
lab_ffk@mail.ru
0000-0001-6980-7070

Rumiantseva Natalia Valerievna
Associate Professor, Department of
Physical Culture, Sports and Adaptive
Physical Education, Institute of
Pedagogics, Psychology and Physical
Education
Vologda State University
Vologda, Russia
nvrurn_skitur@mail.ru
0000-003-2871-899X

Melentieva Natalia Nikolaevna
Associate Professor, Department of
Physical Culture, Sports and Adaptive
Physical Education, Institute of
Pedagogics, Psychology and Physical
Education
Vologda State University
Vologda, Russia
nataliyamelenteva@mail.ru
0000-0002-7415-7380

Abstract. *The purpose of the article is to study the features of heart rate regulation in the pre-competitive period, depending on personal characteristics. Materials and methods: qualified and highly qualified athletes of various specializations (n = 50) participated in the study. The parameters of autonomic regulation were evaluated using the method of heart rate variability (HRV), carried out under pre-competitive stress conditions before city, regional and national competitions. The experiment was conducted according to the following scheme: the first measurement - recording HRV and personal characteristics on the day of rest (relative physiological rest), the second measurement - one hour before competitions (stress). The personal characteristics of the athletes were determined using the 16PF Cattell's questionnaire (form C) and the Spielberger's Test Anxiety Inventory. Results: the paper shows two types of HRV response to precompetitive stress in athletes, depending on the initial status of the body. The correlations between the personal characteristics of athletes with HRV indicators in the pre-competitive period are established. Conclusion The personal characteristics of athletes participate in the formation of the specifics of the response of autonomic regulation to cardiac activity in the pre-competitive period.*

Key words - *pre-competitive period, autonomic nervous system, heart rate variability, athlete's personal characteristics.*

I. INTRODUCTION

An important role in achieving a successful result in competitions is played by the pre-competitive status. It stimulates increased mental stress and affects athletes' behavior and effectiveness [5, 7-8]. The autonomic nervous system (ANS) plays a leading role in adapting the body to the upcoming stress [12] and, as a consequence, implementing pre-launch conditions [2]. Autonomic regulation at relative physiological rest is largely determined by the individual characteristics of a person. However, data on the presence of such correlations and their intensity in stress and anxiety before competitions is not enough.

An effective method of assessment, allowing to determine the state of the mechanisms regulating physiological functions in the human body, is heart rate

variability [4, 9, 13]. This method reflects the adaptive reaction of the whole organism based on the study of the relationships of three regulatory units: neurohumoral regulation of the heart, sympathetic and parasympathetic tone of the autonomic nervous system, which change their activity under stressful conditions [1, 6, 11]. This study is aimed at establishing the features of heart rate regulation in the pre-competitive period, depending on personal characteristics,

II. MATERIALS AND METHODS

Qualified and highly qualified athletes of various specializations (n = 50) participated in the study. The parameters of autonomic regulation were evaluated using the method of heart rate variability under conditions of pre-competitive stress before city, regional and national competitions. The personal characteristics of the athletes were determined using the 16PF Cattell's questionnaire (form C) and the Spielberger's Test Anxiety Inventory.

The experiment was conducted according to the following scheme: the first measurement - recording HRV and personal characteristics at relative physiological rest on the day of rest (rest), the second measurement - one hour before competitions (stress).

Statistical data processing was performed in the Statistica 6.0. software.

III. RESULTS AND DISCUSSION

In response to stress, adaptive systemic responses occur that are compensatory in nature. Analyzing the results obtained, significant changes in the parameters of heart rate in the pre-competitive period were found. All recorded cases of adaptive responses were divided into two groups (I and II) with an antagonistic change in a number of parameters (Table 1).

TABLE. 1. HRV INDICATORS IN ATHLETES AT REST AND BEFORE COMPETITIONS (M ± d)

Parameter	Group I	Group II
SDNN, ms	72.58±36.6 92.08±35.6**	95.92±32.2 73±33.3**
CV%	7.37±3.2 9.92±3.4**	9.4±2.8 7.79±2.8**
RMSSD, ms	69.79±48.9 80.58±48.9	92.31±33.1 66.27±38.4**
pNN50, 50%	33.82±23.1 39.53±22.9	51.93±17.1 35.13±23.8**
VB, s	0.41±0.2 0.51±0.1**	0.52±0.2 0.41±0.2**
AMo,%	34.52±14.1 26.56±10.9**	26.58±7.4 34.06±12.9**
IVB, c.u.	121.66±118.4 61.95±43.4**	59.6±31.9 108.04±80.9**
RPAI, c.u.	35.98±15.6 30.2±13.8**	26.95±9.9 39.43±19.3**
SI, c.u.	63.29±58.5 35.17±24.7**	30.47±18 64.61±54.2**
VRI, c.u.	3.16±1.7 2.4±0.8*	2.17±0.79 3.29±1.8**
HR, bpm	62.71±9.1 66.92±7.9*	79.62±94.8 67.81±10.5
TP, ms ²	6201.5±5245.7 9869.96±6388.4**	9503.77±5770.1 6316.31±4948.2**
VLF, ms ²	1863.08±1654.8 3474.29±3568.3**	3239.5±2426 2211.19±2382.4*
LF, ms ²	1925.84±2033.5 2914.04±2457.3*	2895.6±2859.5 1824.35±1431.8*
HF, ms ²	2412.69±3084.7 3481.5±4020.4*	3368.73±2205.5 2280.72±2342.2**

at $p \leq 0.05$ *, at $p \leq 0.01$ **, in the numerator - data at "rest", in the denominator data at "stress"

The reaction of group I (n = 24) consisted in an increase in SDNN, RMSSD, pNN50%, CV% and an increase in vegetative balance (VB). AMo%, the index of vegetative balance (IVB), the regulatory processes adequacy index (RPAI), the vegetative rhythm index (VRI), and the stress index (SI) changed in the opposite direction. In athletes of group II (n = 26), these indicators changed oppositely. Such changes indicate an increase in the tone of the sympathetic system in athletes of group II and an increase in parasympathetic control in the regulation of the cardiac activity in athletes of group I.

Group I demonstrated a statistically significant increase in the total spectrum power by 60% due to an increase in all spectral components in absolute terms (VLF - 86%; LF - 51%; HF - 44%). No statistically significant changes in the ratio of spectral components were found, the 38:32:30 ratio indicated the dominance of the metabolic component in heart rate regulation. In group II, a change in the wave structure in response to pre-competitive stress was expressed by a statistically significant decrease in the total spectrum power by 34% and the absolute power of the spectral components (VLF - 44%; LF - 37%; HF - 32%). Changes in the ratio of the spectral components VLF and HF in the total spectrum power did not reach a statistically significant level ($p > 0.05$), the contribution of the LF component increased ($p \leq 0.05$). The power distribution of the spectral components in a ratio of 35:32:34 indicates a mixed type of autonomic regulation.

In the pre-competitive period, group I is characterized by a statistically significant increase in heart rate by 7%, and

group II - by a decrease of 1% that did not reach the significance level.

Opposite responses to competitive stress can be primarily associated with different initial levels of autonomic support. This conclusion is based on significant intergroup differences in some background indicators of heart rate and spectral characteristics. Persons characterized by a reduced energy of spectral parameters, as well as a reduced variability of the RR-intervals and an increased stress index at relative physiological rest, respond to competitive stress by an overactive adaptive response. On the contrary, those with sufficient functional reserves (low SI, high CV and SDNN at rest), according to the literature, adequately respond to the load.

The analysis of the personality profile revealed that athletes have a variety of individual characteristics, which is confirmed by a wide range of values within one scale (Table 2).

The most pronounced among athletes were the following personal characteristics: dutiful, staid (7.3 ± 2.2 G-scale), socially bold, venturesome (7.8 ± 2.9 H-scale), practical, rigid (3.6 ± 2.4 J-scale). Also, athletes are distinguished by an increased sociability and dependence on the group (3.3 ± 2.1 Q2-scale) and patience, relaxation (3.3 ± 2.4 Q4-scale). The indicators on the other scales had average values. No significant differences between groups I and II were revealed for any of the factors in the personality questionnaire ($p > 0.05$).

To reveal the features of the responses of autonomic regulation to cardiac activity in the pre-competitive period, a correlation analysis was performed between HRV indicators, personal characteristics of athletes and characteristics of the psycho-emotional status of those registered in the pre-competitive period in a clinostatic position.

It has been established that in the formation of an autonomic profile in the pre-competitive period, personal characteristics related to the emotional-volitional and communicative block are involved. No reliable relationships with factors of the intellectual block were revealed ($p > 0.05$).

The P-factor (prudence - impulsivity) has a negative relationship with indicators: RRNN ($r = -0.32$ at $p < 0.05$), SDNN ($r = -0.34$ at $p < 0.05$), pNN50% ($r = -0.38$ at $p < 0.01$), TP ($r = -0.32$ at $p < 0.05$), VLF ($r = -0.29$ at $p < 0.05$), HF ($r = -0.32$ at $p < 0.05$), Mo ($r = -0.42$ at $p < 0.01$), VB ($r = -0.31$ at $p < 0.05$). Positive relationships for this factor were revealed with HR ($r = 0.32$ at $p < 0.05$), AMo ($r = 0.33$ at $p < 0.05$), IVB ($r = 0.34$ at $p < 0.05$), RPAI ($r = 0.38$ at $p < 0.01$), VRI ($r = 0.41$ at $p < 0.015$), SI ($r = 0.38$ at $p < 0.01$). The obtained relationships suggest that athletes characterized by emotionality, impulsivity, cheerfulness, talkativeness and a high number of points on the P-scale demonstrate a tendency to increased sympathetic tone in the regulation of cardiac activity before competitions. On the contrary, an increase in volitional control of emotions was associated with an increase in parasympathetic influences.

The C-factor (emotionally stable - reactive) is characterized by the correlations with the following parameters: LFnorm ($r = 0.35$ at $p < 0.05$), LF / HF ($r = 0.35$

at $p < 0.05$), $pNN50\%$ ($r = -0.28$ at $p < 0.05$), HF_{norm} ($r = -0.35$ at $p < 0.05$), $\%HF$ ($r = -0.35$ at $p < 0.05$). The data obtained indicates an increased reactivity of the sympathetic nervous system before competitions in emotionally mature and realistic-minded persons. Fatigable, emotionally labile, irritable persons tend to respond to competitive stress by increasing parasympathetic tone.

The relationship between the E-factor (accommodation-independence) and the following indicators was established: HR ($r = 0.32$ at $p < 0.05$), RPAI ($r = 0.29$ at $p < 0.05$), RRNN ($r = -0.31$ at $p < 0.05$), Mo ($r = -0.37$ at $p < 0.01$). The data obtained indicate an increase in the shift of sympathetic-parasympathetic balance towards sympathy among independent, self-confident, stubborn persons, and, on the contrary, a tendency toward a parasympathetic shift in more dependent, anxious, and, to some extent, passive athletes.

The H-factor (shy-bold) correlated with HR ($r = 0.37$ at $p < 0.01$), VRI ($r = 0.3$ at $p < 0.05$), RRNN ($r = -0.36$ at $p < 0.05$), Mo ($r = -0.43$ at $p < 0.01$). The correlations revealed indicate that more active, courageous athletes sensitive to changes in the current situation, have a stronger tone of sympathetic activity before competitions. Athletes who are timider, prefer to be in the shade, are characterized by increased sense of threat and increase in the tone of parasympathetic activity in response to orthostatic test before competitions.

The g-factor (expedient – rule-conscious) had a relationship with the parameters: LF_{norm} ($r = 0.29$ at $p < 0.05$), LF / HF ($r = 0.29$ at $p < 0.05$), HF_{norm} ($r = 0.29$ at $p < 0.05$). More mature, responsible athletes are characterized by an increase in the tone of the sympathetic system, on the contrary, unorganized individuals are prone to increased parasympathetic influences.

The O-factor (self-assured – apprehensive) correlated with LF ($r = -0.31$ at $p < 0.05$).

The Q4 factor (relaxed-tense) correlated with AP_{diast} ($r = -0.29$ at $p < 0.05$). In people with increased anxiety, sympathetic activity decreases in response to competitive stress.

The Q2 factor (self-reliant – group-oriented) had correlations with HR ($r = 0.31$ at $p < 0.05$) and RRNN ($r = -0.32$ at $p < 0.05$).

The study of psycho-emotional status revealed moderate personal anxiety in 77.6% of the athletes from the sample and situational anxiety - in 34.7%; 22.4% and 51% of athletes showed a high level of personal and situational anxiety, respectively, and 14.3% of the athletes in the sample showed low situational anxiety. The indicator of situational anxiety correlates with the following parameters: RRNN ($r = 0.34$ at $p < 0.05$), Mo ($r = 0.38$ at $p < 0.01$), VB ($r = 0.33$ at $p < 0.05$), HR ($r = -0.35$ at $p < 0.05$), RPAI ($r = -0.37$ at $p < 0.01$). It can be concluded that athletes with increased situational anxiety before competitions show a tendency to vagotonia, athletes with lower values of situational anxiety tend to be sympathetic. We attribute the obtained data to a compensatory increase in the activity of the parasympathetic system in response to the activation of its sympathetic link as a result of stress exposure. Some authors see this mechanism as a phenomenon of “protective inhibition” that occurs in subjects with strong mental stress [10].

IV. CONCLUSION

The personal characteristics of athletes take part in the features of the response of autonomic regulation to cardiac activity before competitions.

Athletes responding to competitive stress by an overactive adaptive reaction (group I) are characterized by volitional control of emotions, fatigue, a tendency to emotional lability, irritability, dependence on others, anxiety, timidity, and sensitivity to threats. On the contrary, athletes who adequately respond to pre-competitive stress (group II) are characterized by emotionality, impulsiveness, cheerfulness, talkativeness, emotional maturity, independence, self-confidence, an active lifestyle and a realistic attitude to the current situation.

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