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## APPLICATION OF HEART RATE VARIABILITY IN THE RAPID FUNCTIONAL ASSESSMENT OF ATHLETES

The sympathetic type of overtraining manifests itself as level of perceived psychological stress increases and coordination reactions decreases during exercise. Clinically this syndrome is manifested by an increase in heart rate, arterial hypertension with frequent headaches. Moreover, most athletes experience an increase in body temperature with a characteristic increase in metabolism.

The parasympathetic type of overtraining is a phase of “exhaustion” with an indispensable decrease in the body’s performance. According to the founder of the theory of stress Hans Selye “exhaustion phase” is an irreversible reaction of the regulatory system, denoting the “death” of the body.

The study was conducted at the premises of the sports medicine and rehabilitation center at the Akbulak Olympic Center (Almaty region, Republic of Kazakhstan) with the participation of 30 highly qualified athletes involved in Greco-Roman wrestling of the main group and the control group consisting of healthy volunteers comparable exclusively to males aged between 18 and 35 years old.

The sympathetic type of misadaptation is characterized as psychological stress with a typical behavioral and emotional manifestation. A change in autonomic regulation with a predominance of the sympathetic link is an early indication of a breakdown in adaptation with a decrease in performance. With increased sympathetic regulation the athlete’s body is in a condition of constant stress and internal tension, in the future such condition can become a predictor of the occurrence of organic disorders.

**Key words:** athletes, misadaptation, cardiovascular system, heart rate variability.

### Introduction

Huge amounts of training load and high requirements for the level of functional vigor of a high-class athlete cannot always be mastered without costs to the athlete’s health. Since the middle of the last century extensive symptoms of athletes’ illnesses that occur due to intense training loads have been considered. In 1956 at the World Congress on Sports Medicine the Austrian scientist L. Prokop first introduced the term “athletic disease”. According to the author “athletic disease” is a condition that occurs when training loads do not correspond to the adaptive capabilities of the body, due to chronic diseases, poor nutrition, and the impact of mental environmental factors [1].

In 1990 at a multidisciplinary meeting held at Oxford University for the first time the term “unexplained underperformance syndrome” was used, which included an uncorrected performance deficit, despite periods of recovery and rest for the athlete [2]. According to a recent review on the concept of

misadaptation states, overtraining syndrome occurs in two variants, depending on the predominance of sympatic or parasympathetic regulation of the autonomic nervous system [3].

The sympathetic type of overtraining manifests itself as level of perceived psychological stress increases and coordination reactions decreases during exercise. Clinically this syndrome is manifested by an increase in heart rate, arterial hypertension with frequent headaches. Moreover, most athletes experience an increase in body temperature with a characteristic increase in metabolism.

The parasympathetic type of overtraining is a phase of “exhaustion” with an indispensable decrease in the body’s performance. According to the founder of the theory of stress Hans Selye “exhaustion phase” is an irreversible reaction of the regulatory system, denoting the “death” of the body. This condition occurs as a result of a “vicious circle” of a decrease in the concentration of anabolic hormones in the blood and a decrease in the specificity of  $\beta_2$ -adrenergic receptors

for these hormones [4]. Thus, due to the discrepancy between the intensity and duration of exposure of adaptive capabilities of the body to stress factors, 40% of athletes undergo a pathological transformation of body systems from adaptive to misadaptive.

According to the opinion of European and American colleagues a constant study of the mood profile is necessary for the early detection of an inexplicable underperformance. The study of the neuropsychic state of an athlete, his psychological attitude and performance quotient before the competition is one of the main criteria to diagnose and control prepathological and pathological states among athletes [ 5].

To determine the early signs of misadaptation, first of all, it is necessary to focus on the neuropsychic state of an athlete and the features of neurohumoral regulation using indicators of autonomic regulation of cardiac activity [6].

With respect to the above, the purpose of this study is to determine the type of autonomic regulation in highly qualified athletes involved in speed-strength sports.

### Materials and Methods

The study was conducted at the premises of the sports medicine and rehabilitation center at the Akbulak Olympic Center (Almaty region, Republic of Kazakhstan) with the participation of 30 highly qualified athletes involved in Greco-Roman wrestling of the main group and the control group, consisting of healthy volunteers comparable exclusively to males aged between 18 and 35 years old. All the examined athletes underwent a mathematical analysis of RR interval measurements during ECG dynamic records. The results obtained were interpreted in accordance with the HRV standards, which were adopted in 1996 at a joint meeting of the European Society of Cardiology and the North American Society of Electrical Stimulation and Electrophysiology [7].

This study was approved by the ethics committee (Minutes of the Local Ethics Commission No. 3 dated March 13, 2020).

The main indicators of HRV were interpreted as:

- SDNN (ms) – standard deviation of the RR interval and their square root of all heart rate series;
- SI (RU) – stress index characterizing the activity of mechanisms of sympathetic regulation;
- TP (ms<sup>2</sup>) – characterizes the power of heart rate fluctuations in the range from 0.003 to 0.4 Hz and is an integral indicator of heart rate activity under neurohumoral influence and includes the total percentage of indicators: LF% and HF%, as well as VLF%;
- LF (ms<sup>2</sup>) – displays the power of oscillations in the range between 0.04 and 0.15 Hz at low frequencies and characterizes the sympathetic type of regulation;
- HF (ms<sup>2</sup>) – indicates the power of heart rate fluctuations at a high frequency level in the range from 0.15 to 0.4 Hz and indicates the predominance of vagal control over the heart rhythm, and also has a relationship with respiratory rate;
- VLF (ms<sup>2</sup>) – represents the power of heart rate fluctuations at very low frequencies within 0.003-0.04 Hz and reflects the work of the renin-angiotensin- aldosterone system and thermoregulation, as well as the level of activity of the higher regulatory systems of the body.

### Results and Discussion

In a comparative analysis of the results of the average HRV values among highly qualified athletes and people not involved in professional sports, significant differences were revealed in the SDNN and SI indicators (Table 1). The SDNN indicator shows the overall total effect of autonomic regulation, and the SI indicator is a stress index of the tension of regulatory systems.

**Table 1** – Comparative characteristics of the results of HRV in athletes and people not involved in professional sports.

HRV indicators	The main group of highly qualified athletes ( n =30 )	Control group ( n =30 )	R
RRNN, ms	934.5±144.6	939.3667±144.6	0.830
SI, arb. unit	103.6 (21.01-606.40)	70.5 (21.01-97.01)	0.045*
SDNN, ms	44.0 (12-91)	61(42-91)	0.003*
RMSSD, ms	41.9±4.6	33.7±7.38	0.673
MxMDn , ms	0.40±0.3	0.4±0.3	0.982
LF, ms <sup>2</sup>	687.2±593.9	669.3±350.1	0.559
TP, ms <sup>2</sup>	1951.7±1585.4	2005.2±1551.6	0.819
LF/HF	1.77±1.3	1.2±0.5	0.181
VLF, ms <sup>2</sup>	1277.9±1343.9	1096.4±714.7	0.767
HF, ms <sup>2</sup>	1473.5±1495.6	1573.6±1444.2	0.088
* – Mann Whitney U test, Me (IQR) (median (interquartile range))			

The two-contour model of heart rate regulation is interpreted according to four groups of autonomic regulation [8].

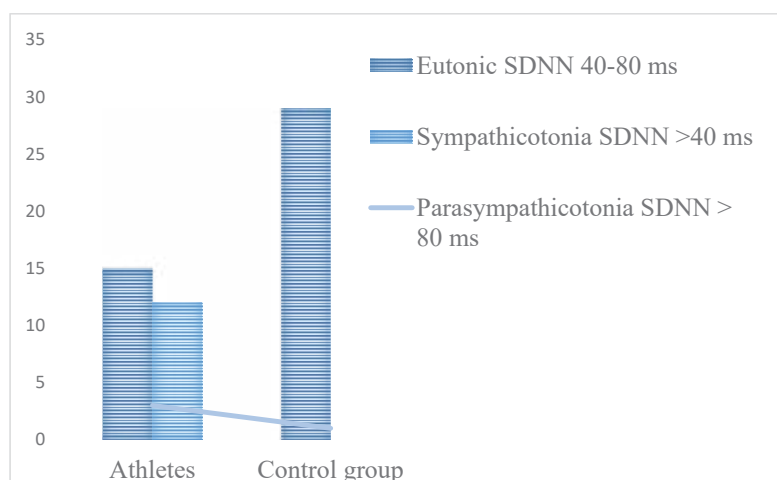
– the first group is characterized by a moderate predominance of central regulation activity and a decrease in the autonomic contour;

– the second group is characterized by autonomic dysfunction with a significant predominance of sympathetic regulation;

– the third group is interpreted as a moderate predominance of autonomous regulation and characterizes the optimal state of regulatory systems;

– the fourth group has a significant predominance of parasympathetic influences over the sympathetic type of regulation.

The above groups were comparable with the sympathetic, eutonic and vagotonic type of autonomic regulation (Diagram 1). Taking into account the dependence of changes in SDNN on increased sympathetic regulation, the stress index SI was studied as an index of the tension of regulatory systems. The results in athletes were interpreted in accordance with the assessment of the functional state of regulatory systems proposed by N.I. Shlyk in 2003 in the form of a rapid assessment of the predominance of the autonomous or central type of heart rate regulation [9].



**Diagram 1** – Types of predominance of autonomic regulation in highly qualified athletes and the control group

In the HRV spectral analysis of 12 athletes the value of the median with the interquartile range of SDNN was within  $23.5 \pm 14$ , which indicated a significant tension in the regulatory systems and signs of misadaptation of autonomic regulation ( $p < 0.05$ ) (diagram 1).

The study found a high value of SI in athletes with a significant predominance of sympathetic regulation of the heart rate 230.08 (122.86-606.40) RU, in comparison with the eutonic type of regulation 44.24 (23.1-186.3) RU, and control group 70.59 (21-97) RU. Thus, this condition may indicate a state of severe fatigue and overtraining or the peak of form.

## Conclusion

Athletes in their professional activities are exposed to various physical and emotional overloads associated with participation in numerous competitions, which can potentiate the risk of developing misadaptive conditions.

The sympathetic type of misadaptation is characterized as psychological stress with a character-

istic behavioral and emotional manifestation [10]. A change in autonomic regulation with a predominance of the sympathetic link is an early indicator of a breakdown in adaptation with underperformance. With increased sympathetic regulation the athlete's body is in a condition of constant stress and internal tension, in the future such condition can become a predictor of organic disorders [11].

When analyzing HRV the most sensitive indicators of the prevalence of the tone of the sympathetic nervous system are VBI (vegetative balance index) and SI (regulatory system stress index), which are determined based on the histogram analysis. SI parameters up to 75 relative units can be considered as normal value. With physical or emotional load this parameter can increase 1.5-2 times. If a person is in constant stress of regulatory systems, the SI can increase up to 400-600 RU [12,13].

Thus, the study of HRV indicators is important in diagnostic terms in the early diagnosis of misadaptation conditions at the prenosological level in comparison with other instrumental studies.

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