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Vegetative support of functional reserves in the post-stress recovery period

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Abstract. The aim of the article is to study the vegetative nervous system of wrestlers in the post-stress period. The analysis of the adaptative abilities and peculiarities of the leading systems of the athletes' body in reaction to systematic muscular loads in the post-stress period allows physiologists and specialists in sports medicine to influence the training process for achieving high results. Heart rate variability (HRV) analysis provides important data about the tension of regulation mechanisms, allows taking corresponding measures while planning training loads and controlling the athlete's body. It is known that periodical changes in heart rate demonstrate the state of the vegetative nervous system, which is an important component, able to ensure adaptation reactions of the body. At the same time, a change in the baseline vegetative status may show not only the development of the positive adaptive reaction but also the beginning of donozological states. Obtaining valuable data about the state of regulatory systems is possible when using dosed muscular load, which allows getting the idea about the functional reserves of the body. HRV analysis under the influence of the cycle ergometer load allows revealing significant changes in the values of spectral components and tension index, which gives the opportunity to monitor the alteration of vegetative regulation. As a result, the baseline status of regulatory mechanisms changes greatly. As follows from the analysis of mean group values of heart rate in wrestlers and non-trained volunteers, the instability of heart rate is revealed in the conditions of the cycle ergometer load and in the post-stress recovery period. The revealed changes of HRV parameters prove the activation of the sympathetic nervous system and the intensification of centralization of heart rate after load.

Key words – muscular loads, athletes, adaptation, post-stress period, recovery, heart rate variability, tension index

I. INTRODUCTION

The achievement of the maximum results in modern sport is guaranteed through systematic, targeted, significant muscular loads in the conditions of training and competitive activities, which require maximum permissible mobilization of the functional reserves of the body [1, 2]. As the level of sports training increases, the athlete still needs higher strength of the stimulus (considerable muscular loads), contributing to the achievement of a higher level of his/her professional activity. The increase of the volume and intensity of training loads promotes structural and functional improvement of trophic functions of the nervous system, the formation of a sufficient energy store, the increase of the capillarization of the skeletal and cardiac muscles. These changes in the body are aimed at developing the potential abilities of the body, increasing its functional reserve, adjusting to loads, accelerating recovery [3, 4]. The quicker the recovery is the more opportunities the body has to cope with further work and, consequently, the higher its functional abilities and performance capacity are [5]. So, the problem of the recovery of the body and its performance after load is of great importance for sports science and forms an integral part of the training process, no less important than direct training impacts on the athlete.

Therefore, the aim of our research is to define the dynamics of the recovery processes of the physiological systems in highly-skilled wrestlers and non-trained volunteers in the post-stress period.

II. MATERIALS AND METHODS

Vegetative support of blood circulation, respiration and metabolism plays an important role during the training activity and in post-stress period. The efficiency and speed of the activation of regulatory systems should define the training regime with respect to the length of the warming-up, training and recovery period.

HRV analysis is a modern, non-invasive method, which allows getting the data about the state of the vegetative nervous system [6]. HRV analysis gives an opportunity to estimate the functional status [7], to define the adaptation potential, reserve abilities [1, 5, 7-9], the degree of tension in the regulatory systems of the body in the post-stress period, to characterize the state of different elements of vegetative regulation and to estimate functional reserves of the regulatory mechanism.

Young people aged 18-22 years participated in the study on a voluntary basis after giving a written informed consent. All the examined underwent screening and belong to the main medical group according to the health status. Depending on the level of physical fitness all the examined were divided into two groups. The first group (n=10) included highly skilled athletes (masters of sport, candidates for master of sport) developing speed-strength qualities, whose muscular activity was realized mainly in anaerobic regime (Greco-Roman wrestling, wrestling, sambo, judo) and the level of training loads comprised no less than 8-10 hours a week. The comparison group (n=10) included practically healthy

volunteers attending PE classes for no more than four hours a week.

The electrocardiogram (ECG) and HRV analysis data were obtained with the help of the Varicard 2.51 hardware and software system. The cardiac rhythm was registered for 5 minutes in the II lead while sitting. The study was carried out in four stages: in the conditions of muscular rest (BL), just after muscular load (ML), 10 minutes after ML, 15 minutes after ML.

The vegetative tonus of the participants was estimated at rest. As a dosed muscular load, the participants performed exercises on the cycle ergometer for 60 minutes at the level of 70-75 % from maximum oxygen consumption, with power 130 W. The cadence comprised 60-70 r/min.

In accordance with the information presented in the modern literature, the individual vegetative status was estimated in terms of the values of the spectral analysis (HF, LF, VLF, TP), tension index and mean root square derivation (SDNN).

The statistical processing was performed by using the method of Student-Fisher.

III. RESULTS AND DISCUSSION

Table 1 shows the results of HRV analysis at relative muscular rest and in the post-stress period.

In the initial condition, the main difference between the vegetative regulation of highly-skilled wrestlers and non-trained volunteers was in the relative predominance of parasympathetic influences in athletes (significant increase of HF at the significant decrease of the index of tension of regulatory systems). The wrestlers also had much higher total power of HRV spectrum (5069.0±502.2 mc^2 compared to 1902.7±238.1 mc^2 in non-trained volunteers, $p<0.001$). It is important to note that while having such distinct differences the average pulse rate in the initial condition was not statistically different (72.5±1.7 BPM in the comparison group and 67.0±1.8 BPM in the group of wrestlers).

Just after the dosed cycle ergometer load the intensification of differences in the corresponding values between the groups was registered. An important value is mean root square derivation (SDNN) – a sensitive value, informing of the state of the regulatory mechanisms. The baseline level of SDNN was within the reference values both in the group of wrestlers and in the comparison group. Just after the muscular load in the group of wrestlers the value decreased by 2 times, which proved the increase of the sympathetic regulation and a significant tension of the regulatory systems. The increase of the sympathetic activity is traditionally registered in athletes from various sports [10]. In the post-stress recovery period, SDNN increased, i.e. the sympathetic nervous system intensified. In the group of non-trained volunteers, SDNN after muscular load decreased compared to the baseline value but to a lesser degree than in the group of wrestlers. In the post-stress period this value recovered slower, which points to the duration of the influence of sympathetic regulation.

The index of tension underwent significant changes – a value, characterizing the tension of adaptation compensatory mechanisms of the body. This mechanism reacts to the increase of the tonus of the sympathetic nervous system. Just after muscular load in the group of wrestlers a significant increase of the tension index was observed (up to 849.7±86.1; $p<0.001$), in the post-stress recovery period this value decreased but it did not reach its baseline value. In the comparison group,

Table 1

HRV values
in the post-stress recovery period
(M±m)(n=20)

Parameter	Group	BL	ML	PSP 10 min	PSP 15 min
HR, BPM	Comparison group (n=10)	72.5±1.7	76.6±3.6	78.4±4.0	82.,7±3.8*
	Wrestlers (n=10)	67.0±1.8	70.6±8.3	73.3±4.4	74.0±3.6
SDNN, mc	Comparison group (n=10)	52.3±9.7	32.4±5.3*	32.6±6.6*	33.7±6.8*
	Wrestlers (n=10)	58.5±4.9	28.5±7.4*	35.5±4.5*	48.7±6.9
Tension index, standard unit	Comparison group (n=10)	154.7±21.1	229.5±34.4*	312.2±35.3**	194.0±21.4
	Wrestlers (n=10)	62.2±6.7	849.7±86.1***	245.7±25.6***	168.5±29.1**
HF, %	Comparison group (n=10)	23.1±1.9	33.4±3.2*	20.9±3.1	11.2±1.1*
	Wrestlers (n=10)	30.1±4.1	29.4±6.9	33.9±4.3	23.4±3.3
LF, %	Comparison group (n=10)	52.3±2.2	58.4±4.3	65.7±4.9*	68.9±6.0*
	Wrestlers (n=10)	48.7±4.7	57.,4±6.4	52.6±8.2	54.9±7.2
VLF, %	Comparison group (n=10)	24.6±3.1	8.2±1.1**	13.4±1.6*	19.8±2.1
	Wrestlers (n=10)	17.4±2.3	13.2±1.3	17.1±2.6	21.6±3.7
TP, mc^2	Comparison group (n=10)	1902.7±238.1	1063.8±171.0*	1305.4±193.0	1683.7±182.5
	Wrestlers (n=10)	5069.0±502.2	740.7±116.0*	960.8±98.6*	2971.7±259.9

Note:
BL – baseline level; ML – immediately after muscular load; PSP – post-stress period;
* - differences are significant in relation to baseline values $p<0.05$; ** - $p<0.01$; *** - $p<0.001$.

the increase of the tension index was also registered after the muscular load, but the peak of the tonus of the sympathetic nervous system was stated in the post-stress period 10 minutes. 15 minutes after the muscular load the tension index

corresponded to the baseline level. A significant tension of adaptation compensatory mechanisms in wrestlers just after the cycle ergometer load is likely connected with the non-specificity of this kind of load for athletes, developing speed-strength qualities.

So, just after the muscular load the vegetative balance of wrestlers shifted to the predominance of the sympathetic element of regulation [11]. A more expressed increase of the tension index and the decrease of SDNN compared to the initial level pointed to it. Moreover, the total power (TP) of the spectrum of wrestlers decreased significantly. Here, a huge difference in the decrease of the total power of spectrum in the group of non-trained volunteers and in highly skilled wrestlers stands out (just after the muscular load this value decreased by 45 % and by 85 % respectively).

It should be noted that in this case it is about the reserves of the system of the management of the physiological functions but not about its energetic and metabolic resources. R. M. Baevskiy separates three types of management of functional reserves – self-regulation, activation and mobilization. The influence of any loads (muscular, emotional) on the body requires the activation of the regulatory systems and the interference of the central elements of the regulatory mechanism into management processes. So, a significant decrease of power of very low-frequency vibrations of HRV just after the muscular load (in the group of non-trained volunteers the power of low-frequency vibrations decreased by 67.7 %, and in the group of wrestlers by 24.2 %) may be considered as the transition from the activation of the functional reserves to their mobilization by including higher and higher levels of the management of physiological functions into the adaptation to the load. This interpretation corresponds to the ideas of the double-contoured model of the regulation of heart rate where the decrease of the activation of the lower (autonomous) contour is seen as the value of the inclusion of the higher (central) contour into the process of management.

The analysis of the change of HRV frequency characteristics in the post-stress recovery period revealed the increase of the power of high-frequency component of the spectrum (HF) in the comparison group by 44.6 % just after muscular load. In the post-stress recovery period, this value decreased significantly and in 15 minutes after muscular load comprised 48.5 % of the baseline level, which proves the intensification of the sympathetic regulation, a significant tension of the regulatory systems. In the group of wrestlers, HF decreased to a lesser degree (in PSP 15 minutes there was a decrease by 22.3 % compared to the background level), which may be connected with a higher level of training.

The analysis of the mean group values of heart rate in the examined groups revealed its instability against the cycle ergometer load and in the post-stress period. The change of HRV parameters points to the significant activation of the sympathetic nervous system and the intensification of the centralization of heart rate management after the dosed cycle ergometer load. The vegetative balance in the post-stress period shifted to the intensification of the activity of the sympathetic system, a significant decrease of parasympathetic regulation of heart rate is stated (to a greater degree in the group of wrestlers, to a lesser degree in the group of non-trained volunteers), the total HRV decreased at the normal activity of the vasculomotor subcortical center. The increase of the activity of the sympathetic subcortical center suggests the functional reserve of the vascular element of regulation. There is a tendency for the decrease in the activity of the humoral channel of heart regulation just after the muscular load and in the post-stress period in the comparison group. The group of wrestlers in PSP 10 minutes showed the gradual recovery of the activity of the humoral channel of regulation. The degree of tension of the regulatory systems just after the muscular load intensifies both in wrestlers and in the group of non-trained volunteers, but the degree of wrestlers' tension decreases more quickly in the recovery period. In the post-stress period, wrestlers recover more quickly than non-trained volunteers, the activation of the vegetative nervous system goes on faster. Obviously, the shift of these values depends on the perfection of the mechanisms of viscerosomatic interaction.

IV. CONCLUSION

The achievement of the required level of the functioning of the body or its certain systems goes on as a result of the mechanisms of regulation and management. The mobilization of the functional reserves is ensured through the change of the level of activity of the regulatory systems, in particular it is connected with the intensification of the tonus of the sympathetic system. The results of the study contribute to the data about the adaptation abilities of athletes in the post-stress recovery period. The identified peculiarities of the mobilization of the functional reserves are of theoretical and practical significance.

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