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FUNCTIONAL STATE OF TRACK-AND-FIELD ATHLETES DURING OF THE ACCLIMATION TO THE MIDDLE ALTITUDE CONDITIONS, INCLUDING ATHLETES WITH COVID-19

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Key words: functional state, track-and-field athletes, middle altitude, acclimation, cardiorespiratory system, COVID-19.

Annotation. The aim of the work was to study the functional state of elite track-and-field athletes of national teams during the period of acclimation to middle altitude conditions, including athletes with a history of the COVID-19 infection. The results of the study showed signs of slight hypoxia in all athletes. In indicators of heart rate variability, central hemodynamics and spirometry, no significant deviations from the physiological norm were found on the 3rd and 10th days of training camps in the middle altitude. The existing physiological changes were due to the processes of long-term adaptation of athletes to specific sports loads.

Introduction. At the modern stage of the development of sports physiology, the issue of increasing the effectiveness of adaptation capabilities of athletes, important for achieving high sports results, is relevant. Performance of physical and psychoemotional loads on a maximum level makes increased demands to the activity of the athlete's organism and requires more significant adaptation rearrangement in the functioning of all organs and systems, making it able to increase a general level of performance [1-2].

The organism of elite athletes is a biological system, the result of adaptation of which is an increase of functional reserves of the organism. One of main tasks of the sports physiology is the study of ways of the athlete's organism and its internal organ systems to adapt to increased physical loads, which is especially relevant in middle altitude conditions. Urgent adaptation to these conditions is characterized by specific reactions, accompanied by stress of the cardiovascular and respiratory systems' activity [3].

The aim of this study is to examine the functional state of elite track-and-field athletes of national teams during the period of acclimation to middle altitude conditions, including athletes with a history of COVID-19 infection.

Methods and organization. Elite track-and-field athletes of Russian national teams (Candidate Master of Sports, Master of Sports, Master of Sports of

International Class, Honored Master of Sports), male and female, aged 18-35 years, participated in the study. During the study, the athletes participated in the preparatory period of the training process, and performed several intense training sessions each day.

The study was carried out in the Biomedical Technologies Center of the FSBI NCFSCC of the FMBA of Russia located in Kislovodsk, on the Maloe Sedlo mountain, at an altitude of 1240 m in conditions of training camps of athletes in the Federal State Unitary Enterprise "Yug Sport" [4].

The study took place during the pandemic, related to the spread of COVID-19 on the territory of Russia. Twenty seven athletes participated, sixteen of them had COVID-19 in autumn-winter of 2020, which was proven by the presence of IgG antibodies (immunoglobulins), 8 of them suffered from the disease in severe and moderate form, the remaining 8 people had no symptoms or a mild form of disease. A questionnaire and making an anamnesis were used to define the presence of previous COVID-19 disease in athletes.

Recording of the functional state of track-and-field athletes when adapting to middle altitude conditions included the study of the heart rate variability (HRV), central hemodynamics, oxygen indicators (saturation, oxygen consumption from the microcirculation system) and spirometry.

The study of HRV, central hemodynamics and body composition was carried out using the ESTECK System Complex (LD Technology, USA). Following indicators were analyzed: heart rate, HF – high frequency wave power, LF – low frequency wave power, SI – stress index, SDNN – mean root square deviation of cardiointervals, stiffness index, reflection index, augmentation index, peripheral resistance, cardiac output, volumetric blood flow index, BP – blood pressure, SpO_2 – blood oxygen saturation, VO_2 - oxygen consumption from the microcirculation system per minute.

Spirometry indicators of athletes were registered using the Carefusion MicroLab Mk8 portative spirometer made by MicroMedical company, "Williams Medical Corporate" (South Wales, UK). For analysis, following indicators were used: vital capacity (VC), forced vital capacity (FVC), Tiffeneau index – a ratio of the forced expiratory volume for 1 second and the forced vital capacity (FEV1/FVC).

Athletes were tested twice: on the 3rd and 10th days of training camps. The testing was conducted during daytime, before the athletes were given any training loads.

The statistical processing of the study data was performed using the Statistica 10.0 program. The Wilcoxon's T-test, as well as the Mann-Whitney U-test were used to evaluate differences between two independent groups.

Results and discussion. During the stay of track-and-field athletes in the middle altitude conditions of training camps, a decrease in the indicator of blood oxygen saturation was revealed. In all athletes, this indicator was lower than 97%, which indicated signs of slight hypoxia (Table 1). Indicators of oxygen consumption from the microcirculation system in all athletes were mainly normal and were not significantly different between men and women.

Furthermore, during the test, the current functional state, according to HRV (Table 3) and central hemodynamics (Table 4) indicators, was defined. As the result of the obtained data, it was revealed that values of all indicators were within the physiological norm. According to HRV indicators in athletes, during the first test, higher indicators of high frequency wave power (HF) and low frequency wave power (LF) were registered in men, which might indicate a participation of the parasympathetic division of the vegetative nervous system (VNS) in the heart rhythm regulation of the track-and-field athlete'organism. Thus, the HR indicator in female track-and-field athletes was significantly higher than in male athletes. SI indicators in all athletes were within the norm and did not have significant differences in men and women.

Table 1

Indicators of blood oxygen saturation and oxygen consumption from the microcirculation system in elite male and female track-and-field athletes during the acclimation to hypoxia in middle altitude conditions, M±m

№	Indicators	Men	Women	Norm
1	SpO_2, %	96,1±0,3	96±0,3	95-100
2	VO_2, ml/min/m²	294±14	297,5±13,2	200-300

Note: SpO2 – saturation (blood oxygen saturation); VO_2 – blood consumption from the microcirculation system per minute

The table below shows VC and FVC indicators in track-and-field athletes. Both indicators were significantly lower in men compared to women (Table 2).

Table 2

VC and FVC indicators in male and female track-and-field athletes during the acclimation to middle altitude hypoxia, M±m

№	Indicators	Men	Women	P<
1	VC, l	5,86±0,3	4,23±0,21	0,002
2	FVC, l	5,74±0,27	4,16±0,2	0,01

Note: VC – vital capacity; FVC – forced vital capacity

Most examined indicators of blood hemodynamics in all athletes did not exceed limits of the physiological norm (Table 3). The augmentation index – an indicator of vascular wall's elasticity, which is positively correlated to the aorta's stiffness, was evaluated in men and women. In men, this indicator was higher in comparison with women, as well as the systolic blood pressure (sBP) indicator.

Table 3

HRV indicators in elite track-and-field athletes during the acclimation to the middle altitude hypoxia, M±m

№	Indicators	Men	Women	Norm	P<
1	HR, beats/min	65,6±2,5	74,9±3,5		0,05
2	HF, ms²	37,6±1,9	35,3±1,8	22-34	–
3	LF, ms²	34,4±3,8	28,5±1,4	22-46	–
4	LF/HF	1,0±0,1	0,8±0,1	0,5-2	–
5	SI, c.u.	68,1±7,6	93,5±13,5	50-200	–
6	SDNN, ms	65,2±3,7	60,3±4,1	40-80	–

Note: HF – high frequency wave power; LF – low frequency wave power; SI – stress index; SDNN – root mean square deviation of cardiointervals

In all track-and-field athletes, stiffness index indicators, related to blood pressure in major arteries, and reflection index indicators, characterizing blood pressure in small and middle arteries, were below the norm, and did not have any significant differences between men and women. Moreover, in all athletes, mean BP indicators and sBP indicators reduced below the norm's threshold. The peripheral resistance in men was lower than in women, the cardiac output in the state of rest in men was higher than the cardiac output in women (Table 4).

Table 4

Indicators of central hemodynamics in elite track-and-field athletes during the acclimation to the middle altitude hypoxia, M±m

№	Indicators	Men	Women	Norm	P<
1	Stiffness index, m/s	6,8±0,2	6,2±0,3	7-9	–
2	Reflection index, %	28,7±1,7	26,7±0,7	30-45	–
3	Augmentation index, c.u.	1,1±0	1,0±0	0,8-1,28	0,002
4	Peripheral resistance, mPa*S/m³	1097,1±43,8	1236,1±42,4	900-1500	0,03
5	Cardiac output, l/min	6,7±0,2	5,6±0,2	6,8-8,3	0,001
6	Volumetric blood flow index, l/min/m	3,5±0,1	3,4±0,1	2,8-3,4	–
7	Average BP, mm of Mercury	91±2	86±2	100	–
8	sBP, mm of Mercury	125±3	114±3	120	0,01
9	dBP, mm of Mercury	74±2	71±2	80	–

Note: sBP – systolic blood pressure; dBP – diastolic blood pressure

Indicators of HRV and central hemodynamics in male track-and-field athletes in the second test (at the 10th day of training camps) did not change significantly (Table 5). The sBP indicator in women increased after the second test. HF indicators, showing the activity of the parasympathetic division of the vegetative nervous system, exceeded the norm both in the first and in the second test (Table 6).

Table 5

Dynamics of indicators of HRV and central hemodynamics of examined male track-and-field athletes at the third and the tenth day of training camps in middle altitude conditions, M±m

№	Indicators	3rd day	10th day	Norm
1	SpO_2, %	96,1±0,3	96,1±0,3	95-100
2	VO_2, ml/min/m²	294±14	285,8±16,3	200-300
3	ЧСС, beats/min	65,6±2,5	63,4±3,0	-
4	HF, ms²	37,6±1,9	40±2,4	22-34
5	LF, ms²	34,4±3,8	35,8±3,3	22-46
6	LF/HF	1,0±0,1	0,9±0,1	0,5-2
7	SI, c.u.	68,1±7,6	71,1±9,6	50-200
8	SDNN, ms	65,2±3,7	63,1±3,5	40-80
9	Stiffness index, m/s	6,8±0,2	6,8±0,3	7-9
10	Reflection index, %	28,7±1,7	27,9±0,7	30-45
14	Peripheral resistance, mPa*S/m³	1097,1±43,8	1078,3±48,1	900-1500
15	Cardiac output, l/min	6,7±0,2	6,8±0,2	6,8-8,3
16	Volumetric blood flow index, l/min/m	3,5±0,1	3,5±0,1	2,8-3,4
17	Average BP, mm of Mercury	91±2	90±3	100
18	sBP, mm of Mercury	125±3	125±4	120
19	dBP, mm of Mercury	74±2	72±2	80

Note: HF – high frequency wave power; LF – low frequency wave power; SI – stress index; SDNN – root mean square deviation of cardiointervals; sBP – systolic blood pressure; dBP – diastolic blood pressure

During the process of testing on the 3rd and the 10th day of training camps, no athletes, who had history of the COVID-19 infection, revealed any deviations from the physiological norm in indicators of HRV and central hemodynamics. According to the questionnaire results, all athletes, who had COVID-19, felt great during training camps.

Table 6

Dynamics of indicators of HRV and central hemodynamics of examined female track-and-field athletes at the 3rd and the 10th day of training camps in middle altitude conditions, M±m

№	Indicators	3rd day	10th day	Norm	P<
1	SpO2, %	96±0,3	96,2±0,4	95-100	-
2	VO2, ml/min/m²	297,5±13,2	317±1,5	200-300	-
3	HR, beats/min	74,9±3,5	73,6±3,5		-
4	HF, ms²	37,2±1,2	40±2,4	22-34	-
5	LF, ms²	28,5±1,4	33,8±1,3	22-46	0,007
6	LF/HF	0,8±0,1	0,9±0	0,5-2	-
7	SI, c.u.	93,5±13,5	89,8±9,2	50-200	-
8	SDNN, ms	60,3±4,1	59,6±2,1	40-80	-
9	Stiffness index, m/s	6,2±0,3	6,3±0,3	7-9	-
10	Reflection index, %	26,7±0,7	27±0,8	30-45	-

Table 6 (continued)

14	Peripheral resistance, mPa*S/m³	1236,1±42,4	1259,5±48,6	900-1500	-
15	Cardiac output, l/min	5,6±0,2	5,6±0,2	6,8-8,3	-
16	Volumetric blood flow index, l/min/m	3,4±0,1	3,4±0,1	2,8-3,4	-
17	Average BP, mm of Mercury	85±2	87±2	100	-
18	sBP, mm of Mercury	114±3	116±3	120	0,03
19	dBP, mm of Mercury	71±2	72±2	80	-

Note: HF – high frequency wave power; LF – low frequency wave power; SI – stress index; SDNN – root mean square deviation of cardiointervals; sBP – systolic blood pressure; dBP – diastolic blood pressure

Conclusion. As a result of the conducted study, the functional state of elite track-and-field athletes during the acclimation to middle altitude conditions, including those, who had a history of the COVID-19 infection, was defined. There were no significant deviations in indicators of HRV, central hemodynamics and spirometry from the physiological norm on the 3rd and the 10th day of training camps in middle altitude conditions. The present changes are related to processes of the long-term adaptation of track-and-field athlete to specific sports loads. Therefore, the middle altitude hypoxia is not a substantial factor, which is able to cause maladaptation in the work of functional systems of elite track-and-field athletes.

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