SYSTEMATIZATION OF THE RECOVERY OF ADAPTIVE BODY RESERVES IN QUALIFIED MMA ATHLETES DURING THE SHORT-TERM PERIOD BETWEEN CONSECUTIVE COMPETITIONS

СИСТЕМАТИЗАЦІЯ ПРОЦЕСІВ ВІДНОВЛЕННЯ АДАПТАЦІЙНИХ РЕЗЕРВІВ ОРГАНІЗМУ КВАЛІФІКОВАНИХ СПОРТСМЕНІВ ММА В КОРОТКОСТРОКОВИЙ ПЕРІОД МІЖ СЕРІЄЮ ЗМАГАНЬ

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Abstracts

The aim is to study the systematization features of restoring adaptive body reserves of qualified MMA athletes in the short-term period between competitions.

Material and methods. The Ukrainian junior MMA team participated in the study. The team consisted of 16 men aged 17 ± 0.87 years. 8 team representatives used mainly the striking fighting style and the other 8 athletes had a wrestling style. The experience of MMA training was 5 ± 0.58 years. The study used control testing methods, heart rate variability assessment, and biochemical blood analysis, including creatine phosphokinase and lactate dehydrogenase measurements. Registration of RR interval signals and biochemical studies were carried out in a state of rest before and after performing test loads during three stages.

Results. During short-term periods of training and recovery between a series of competitions, the qualified MMA athletes showed different types of adaptive and compensatory reactions to test loads. Before the first competitions, there was an increase in the influence of autonomous regulation of the heart rhythm and a balance of vagal-sympathetic tone mechanisms in response to test loads. The creatine phosphokinase activity grew in the blood of the striking-style athletes, but wrestling-style athletes increased only the LDH level. After the first competitions, there was a shift in the vegetative balance from the side of parasympathetic and sympathetic regulation in response to test loads in athletes of both styles. Strengthening the central circuit of sinus rhythm regulation in response to loads that previously decreased the sympathetic tone may indicate compensatory reactions and lower adaptive reserves. The simultaneous rise in both enzymes in the blood of certain wrestling-style athletes under high-intensity test loads, utilizing the creatine phosphokinase energy supply mechanism, suggests compensatory reactions. Adjustments in the load regime and energy supply mechanism affect restoring adaptive reserves during the short-term preparation period between competitions. These changes in athletes' bodies reflect the balance of vagal-sympathetic tone mechanisms and fluctuations in CPK and LDH enzyme levels in the blood in response to a stressful stimulus.

Conclusions. The practical significance of implementing the proposed system for monitoring adaptive reserves and adjusting training loads in MMA athletes preparing for competitions with short recovery periods has been confirmed. The developed algorithm for structuring training models in pre-competition mesocycles effectively facilitates the recovery of athletes with depleted adaptive reserves. The findings of the study confirm the effectiveness of using HRV indicators and biochemical blood analysis to evaluate the adaptive reserves of qualified athletes.

Key words: mixed martial arts, vegetative balance, test loads, qualified athletes, fighting styles.

Мета – вивчити особливості систематизації процесів відновлення адаптаційних резервів організму кваліфікованих спортсменів ММА в короткостроковий період між серією змагань.

Матеріал і методи. У дослідженні брала участь збірна команда України з ММА серед юніорів. Команда складалась із 16 чоловіків віком 17 ± 0,87 року. 8 представників команди переважно використовували ударний стиль ведення поєдинків, а інші 8 спортсменів – борцівський стиль. Стаж занять ММА становив 5 ± 0,58 року. В дослідженні використовували методи контрольного тестування, варіабельність серцевого ритму, біохімічний аналіз крові (креатинфосфокіназа, лактатдегідрогеназа). Реєстрації сигналів інтервалів RR та біохімічні дослідження проводились у стані спокою до та після виконання тестових навантажень протягом трьох етапів.

Результати. Встановлено, що у кваліфікованих спортсменів ММА під час короткострокових періодів підготовки та відновлення між серією змагань спостерігаємо різний характер адаптаційно-компенсаторних реакцій на тестові навантаження. Так, перед початком перших змагань у відповідь на тестові навантаження спостерігаємо підвищення впливу автономної регуляції ритму серця та збалансованість механізмів вагусно-симпатичного тонусу. При цьому у спортсменів ударного стилю виявлено підвищення лише активності креатинфосфокінази у крові, а серед спортсменів борцівського стилю зростає рівень показника ЛДГ. Після перших змагань у відповідь на тестові навантаження спостерігаємо серед спортсменів обох стилів випадки зміщення вегетативного балансу в бік як парасимпатичної, так і симпатичної регуляції. Посилення центрального контуру регуляції синусового ритму у відповідь на навантаження, які попередньо викликали зниження симпатичного тонусу, може свідчити про компенсаторні реакції та зменшення адаптаційних резервів. Одночасне підвищення обох ферментів у крові в деяких спортсменів ударного стилю на тестові навантаження високої інтенсивності з креатинфосфокіназним механізмом енергозабезпечення свідчить про компенсаторні реакції. Встановлено, що зміни режиму навантажень і механізму енергозабезпечення ефективно впливають на відновлення адаптаційних резервів у короткостроковий період підготовки між серіями змагань. Відповідний характер змін в організмі спортсменів пов'язаний із збалансованістю механізмів вагусно-симпатичного тонусу й відповідною зміною ферментів КФК та ЛДГ в крові в умовах стресового подразника.

Висновки. Встановлено практичну цінність використання запропонованої системи контролю адаптаційних резервів організму спортсменів ММА та корекції навантажень у процесі підготовки до серії змагань із короткостроковими періодами відновлення. Запропонований алгоритм побудови моделей занять у передзмагальних мезоциклах ефективно впливає на процеси відновлення спортсменів із виснаженими адаптаційними резервами. Виявлені під час дослідження дані демонструють ефективність реалізації показників ВСР та біохімічного аналізу крові в процесі оцінки адаптаційних резервів кваліфікованих спортсменів.

Ключові слова: змішані єдиноборства, вегетативний баланс, тестові навантаження, кваліфіковані спортсмени, стилі ведення поєдинків.

Introduction. The search for effective mechanisms for managing the training system of qualified mixed martial arts (MMA) athletes has been one of the pressing issues in recent years [2; 7; 9]. The majority of studies focus on optimizing MMA training methods to enhance tactical and technical skills while improving athletes' physical performance levels [1; 5]. The studies mainly consider the stage of specialized basic training, which allows scientists to assess the impact of loads of various types on the processes of athletes' adaptation to stressful stimuli [3; 13]. Recently, there has been increased focus on studying the adaptive and compensatory reactions of athletes from various fighting styles during specialized strength training [4; 14]. The problem of finding effective informative physiological and biochemical markers for assessing body resistance under conditions of acute training loads is also being studied in depth [7; 9]. Despite the increasing interest among researchers [10; 11] in improving the MMA training system, several challenges remain unsolved.

One of the relevant yet underexplored issues in MMA is the absence of a system for monitoring the adaptive reserves of athletes' bodies during preparation for a series of competitions with short recovery periods [2; 12]. There is also no scientific justification for the mechanisms for correcting training models for qualified athletes in similar conditions. Simultaneously, there is an issue regarding the impracticality of using a specific ratio of physiological and biochemical indicators to evaluate the execution of short-term adaptation to a stimulus or compensatory reaction [3; 14]. This issue is significant in pre-competition mesocycles of training qualified athletes separately in striking and wrestling styles

of fighting. However, the implementation of these issues while conducting in-depth scientific research remains unresolved.

The study aims to explore the systematization features of restoring adaptive body reserves of qualified MMA athletes in the short-term period between competitions.

Material and methods. A series of experimental studies were conducted in 2024 in preparation for the Ukrainian and European MMA championships for juniors. The studies were conducted at the Saigon sports club in Chernivtsi (Ukraine) during the pre-competition mesocycles of training and after the athletes' performance at the Ukrainian championship. The Ukrainian junior MMA team participated in the study. The team consisted of 16 men aged 17 ± 0.87 years. 8 team representatives used mainly the striking fighting style, and the other 8 athletes used the wrestling style. The length of MMA training was 5 ± 0.58 years. The ethics committee of Lesya Ukrainka Volyn National University approved the study design. After explaining the risks and benefits of the study, participants signed an informed consent form prepared following the ethical standards of the Declaration of Helsinki.

Test loads. Test trials were proposed to create conditions similar to the loads on the athletes' bodies during attacks or counterattacks during MMA fights. Athletes specializing in striking fighting style executed sidekicks on a mannequin with maximum force and speed for 20 seconds. Representatives of the wrestling style executed a deflection throw at maximum speed for 40 seconds, taking turns with three partners from their weight category. The main task of the proposed test loads was to involve the maximum number of muscle groups of agonists, synergists, and stabilizers in the work. The simultaneous activation of these muscle groups while performing a series of kicks or throws under anaerobic energy supply conditions will decrease adaptive body reserves [4; 11]. Using physiological and biochemical control methods in the comparative analysis will allow for assessing the level of functional capabilities of athletes in given conditions. It is possible to determine the manifestation of short-term adaptation or activation of compensatory mechanisms under conditions of similar stressful stimuli [3; 14].

Heart rate variability (HRV). A Polar V800 heart rate monitor (Finland) was used to measure RR intervals. Heart rate and raw RR intervals were recorded using a sensor mounted on a chest strap (H10, Finland). The RR interval data were transferred to a computer using the Polar Flow web service. Kubios HRV Standard 3.5.0 software was used to calculate HRV parameters. Fast Fourier transform was selected for spectral analysis in the frequency domain. While analyzing the spectral HRV power characteristics, the following ranges were distinguished: low-frequency (LF, %), very-low-frequency (VLF, %), and high-frequency (HF, %). The LF/HF ratio was determined as an indicator of the vegetative balance. RR interval signals were recorded in the study participants sitting at rest before and after the test load. To standardize HRV studies with short recordings, the optimal recording duration was 5 minutes.

Biochemical parameters. The activity of lactate dehydrogenase (LDH) and creatine phosphokinase (CPK) in the blood serum of the study participants were measured using the kinetic method on equipment from High Technology Inc. (USA) with a PRESTIGE 24i LQ LDH reagent kit (Poland). Blood samples were collected in a designated department of the sports club "Saigon" by medical laboratory staff according to international medical and biological research standards. Biochemical studies were carried out at rest before and after performing test loads. The obtained samples were stored in special refrigerated boxes, and after completion of the sampling, they were quickly sent to the medical laboratory. The total number of biochemical samples during the research was 192 units.

Research organization. The research was conducted in several stages during 2024.

In the first stage, control test loads were conducted at the end of the pre-competition mesocycle (7–8 days before the competition) preparing for the Ukrainian Junior MMA Championship in 2024. The study participants were divided into two groups (A and B). Group A included 8 athletes of the striking fighting style, and group B included

8 athletes of the wrestling style. The main goal of this stage was to assess the initial functional capabilities of athletes depending on their fighting style. For athletes of the striking and wrestling styles of fighting, test loads reflected the main characteristics of the attacking and counterattacking actions of these styles. The adaptive and compensatory reactions of the participants in the examined groups to the test loads were evaluated using HRV and biochemical blood analysis methods.

In the second stage, control testing of the study participants was carried out 3–5 days after their participation in the Ukrainian MMA Championship 2024 among juniors. As a control stress stimulus, we used the test loads developed for athletes of the striking and wrestling styles of fighting. One of the tasks of this stage was to assess the reduction of the adaptive reserves in the participants after competitive activity. Based on the obtained HRV results and biochemical blood parameters at rest and in response to a physical stimulus, the participants of both groups were divided into subgroups. Each subgroup consisted of four qualified athletes. Subgroups A^1 (striking style) and B^1 (wrestling style) included athletes who manifested short-term adaptation in response to the control test loads after performing at these competitions. Subgroups A^2 (striking style) and B^2 (wrestling style) included athletes who demonstrated compensatory reactions in response to test loads at this stage of control.

After the performance at the Ukrainian MMA Championship, the functional capabilities of study participants were evaluated. It became necessary to adjust the training process because only 30 days remained before the next competition (the European Championship). Athletes in subgroups A^1 and B^1, due to the lack of compensatory responses to the prescribed loads, continued to follow the standard training model for pre-competition mesocycles. Experimental models of training classes were developed for participants of subgroups A^2 and B^2, taking into account their level of adaptive reserves and fighting style. Athletes of subgroup A^2 were offered a training model using the load regime $R_a = 0.71$ [4; 11] and the creatine phosphokinase mechanism of ATP resynthesis. Athletes of subgroup B^2 were offered a training model using the load regime $R_a = 0.65$ [5; 15] in the anaerobic glycolysis of ATP resynthesis. Athletes of both subgroups used special isolated exercises to increase the adaptive reserves of individual agonist muscle groups in performing the main technical elements.

In the third stage, the characteristics of the participants' adaptive and compensatory reactions to the stimulus were assessed. It was after 30 days of following the training models developed for each subgroup in the pre-competition mesocycle. The changes in the spectral analysis of heart rhythm were identified in members of the examined subgroups under the conditions of using each proposed training model. CPK and LDH activity in the blood serum were also assessed in the study participants under test loads. A comparative analysis of the collected data was conducted, and the results were processed.

Statistical analysis. The statistical analysis of the study results was performed using the IBM *SPSS*Statistics 27 software package (StatSoft-Inc., USA). The G-Power 3.1.96 program allows for determining the smallest sample size for the study (calculation of statistical power). Non-parametric methods of statistical analysis were used. The median (Me) and interquartile range (IQR) were calculated. The Kruskal-Wallis test was used to compare the baseline parameters between groups A and B at the beginning of the study. The Wilcoxon t-test was used to compare two dependent samples with each other.

Research results. The ability to demonstrate a high level of functional capabilities in several competitions in a short period is one of the important problems of the training system of qualified athletes in MMA [5; 9]. One of the challenges in optimizing loads during pre-competition mesocycles is the ability to simultaneously activate the mechanisms of readaptation and enhance functional capabilities effectively. This especially applies to the issues of selectively increasing the body's energy reserves, which will affect the level of resistance to competitive loads in athletes with different fighting styles [7; 11].

Figure 1 presents a diagram of the system for monitoring the adaptive reserves of MMA

athletes' bodies and adjusting the training loads during preparation for a series of competitions with short recovery periods. This diagram illustrates a mechanism for implementing this issue, considering the relevant control stage and the defined objective. Scientifically grounded test loads were proposed for athletes specializing in striking and wrestling styles, considering the physiological processes of adaptation. Implementing these test tasks allows for the maximum decrease in the adaptive body reserves in conditions of creatine phosphokinase and anaerobic glycolysis energy supply regimes. To evaluate the body's adaptive and compensatory reactions under these conditions, we suggest using HRV and biochemical control indicators. The indicators from spectral analysis of heart rhythm, with CPK and LDH activity in blood serum, will provide an assessment of short-term adaptation under anaerobic load conditions.

A non-standard mechanism for correcting MMA training in the pre-competition mesocycle based on the results of physiological and biochemical control methods is presented. This especially applies to the correction of fighting tactics based on the results of HRV and control over changes in the activity of enzymes that reflect the mechanisms of anaerobic energy supply. At the same time, a mechanism for categorizing athletes into groups after the competition is presented, based on the analysis of the results from assessing the level of exhaustion of their adaptive reserves. A new algorithm for building training models in pre-competition mesocycles for competitions with short-term recovery periods for athletes with depleted adaptive reserves is proposed. The key aspect of these models is the search for effective ways to effectively implement ergogenic aids and load regimes simultaneously during the monthly pre-competition mesocycle. When developing such training models, it is necessary to consider the adaptive reserves of energy supply, the style of fighting, and the individual level of resistance to loads during the competition.

Table 1 presents the results of spectral analysis of the heart rate of qualified MMA athletes of striking and wrestling fighting styles during the study. At each of the three stages of the study, the controlled indicators were recorded at rest and after test loads. Test loads were developed separately for athletes of striking and wrestling fighting styles.

The heart rate spectral analysis of the study participants obtained at the end of the pre-competition mesocycle of training demonstrated the following. Before test loads, the vegetative balance of athletes of striking (group A) and wrestling (group B) fighting styles shifted towards sympathetic regulation. Such tension in the heart rate regulation systems of the study participants is the result of using high-volume and intensity loads during the pre-competition mesocycle.

The HRV results decreased after test loads in sympathetic tone together with lowering LF in groups A (–10.9%) and B (–8.9%). At the same time, the influence of autonomic regulation increased against the background of HF growing in groups A (+10.4%) and B (+7.1%). The vegetative balance shifted towards parasympathetic regulation among representatives of groups A and B, although they used completely different test loads. This fact indicates the effective implementation of short-term adaptation in both groups to similar conditions of muscle activity. The most pronounced balance of vagus-sympathetic tone mechanisms in response to a stressful stimulus was found in athletes of the striking style of fighting (group A).

Here is the analysis of the studied HRV indicators after competitions (the Ukrainian MMA Championship). The spectral analysis of the heart rhythm indicators before the load simultaneously shifted the vegetative balance towards sympathetic and parasympathetic regulation in each group. Based on the analysis of these results, the athletes of groups A and B were divided into subgroups (A^1, A^2, B^1, B^2). Participants of all subgroups had different results in response to the test loads in the spectral analysis of the heart rhythm indicators. There was a strengthening of the central circuit of sinus rhythm regulation after the test load in subgroups A^2 (VLF +12.5%) and B2 (VLF +12.7%).

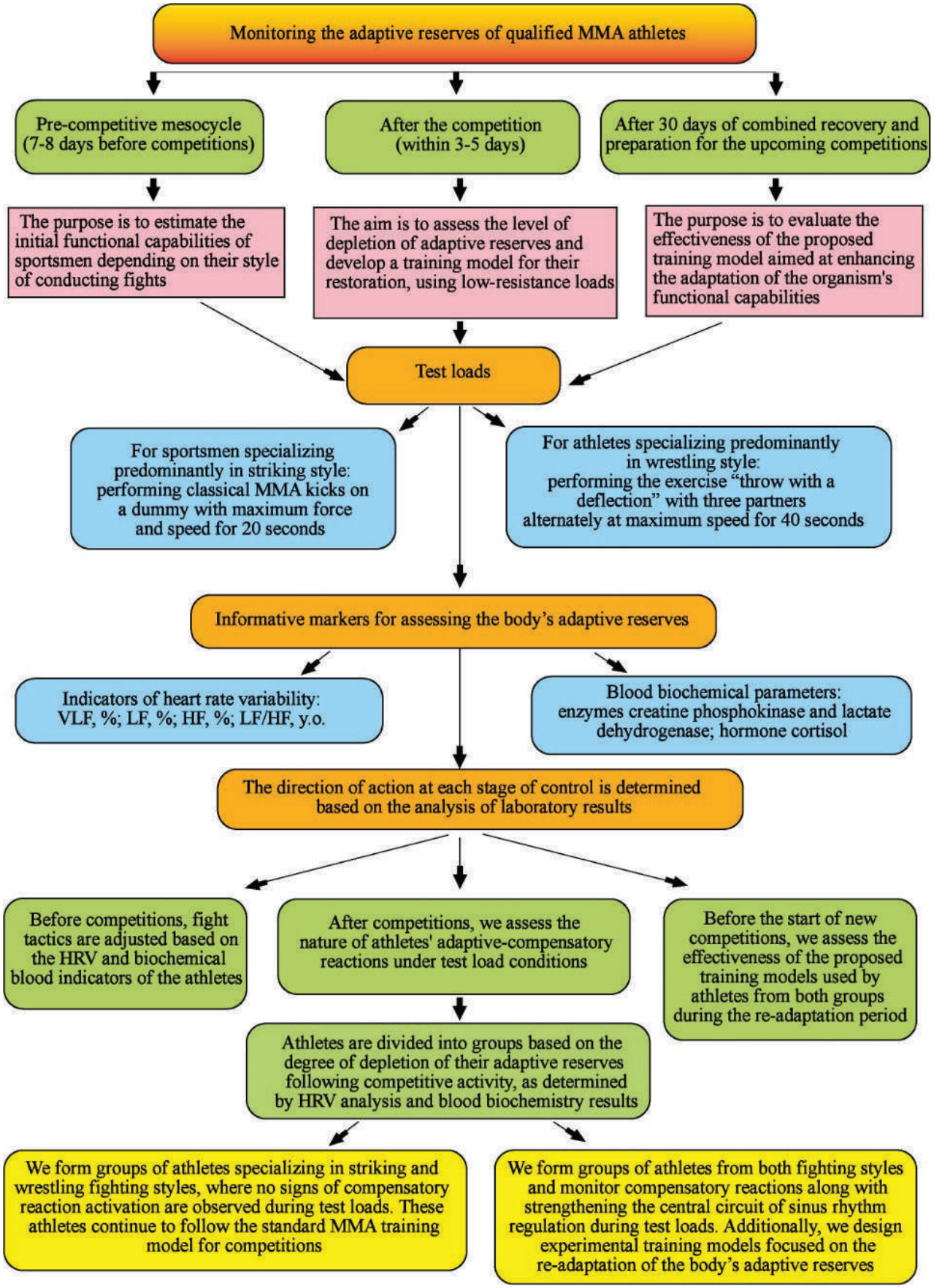

Fig. 1. The system for monitoring the adaptive reserves of MMA athletes' bodies and adjusting training loads during preparation for a series of competitions with short recovery periods

Table 1

Indicators of spectral analysis of heart rhythm of qualified MMA athletes of striking and wrestling fighting styles during the study (Me, IQR), n = 16

Study participants	Test loads	Indicators of spectral analysis of heart rhythm			
		VLF, %	LF, %	HF, %	LF/HF
Stage 1 of the research: at the end of the pre-competitive mesocycle training (7–8 days before the start of the competition at the Ukrainian Championship)					
Group A	initial values	6.84 (1.23)	56.34 (3.23)	36.82 (2.64)	1.53 (0.12)
	after loads	7.37 (1.82)	45.37 (2.22)	47.26 (2.91)	0.96 (0.11)
Group B	initial values	5.88 (1.05)	64.15 (2.87)	29.97 (3.04)	2.14 (0.35)
	after loads	7.81 (1.36)	55.17 (2.72)	37.03 (2.71)	1.49 (0.11)
Stage 2 of the research: after the end of competitions of the Ukrainian Championship (within 3–5 days)					
Subgroup A^1	initial values	7.49 (1.73)	58.37 (2.65)	34.14 (2.73)	1.71 (0.13)
	after loads	10.50 (1.15)	38.06 (3.11)	51.44 (3.08)	0.74 (0.11)
Subgroup A^2	initial values	14.73 (1.13)	59.35 (2.69)	25.92 (1.83)	2.29 (0.21)
	after loads	27.28 (2.41)	58.29 (3.31)	14.43 (1.61)	4.01 (0.33)
Subgroup B^1	initial values	7.37 (1.82)	58.84 (2.81)	33.82 (2.31)	1.74 (0.12)
	after loads	7.73 (0.95)	44.46 (2.45)	47.81 (3.03)	0.93 (0.09)
Subgroup B^2	initial values	16.77 (1.88)	64.61 (2.55)	18.62 (1.79)	3.47 (0.39)
	after loads	29.45 (4.93)	60.19 (4.13)	10.36 (1.18)	5.81 (0.51)
Stage 3 of the research: after 30 days of simultaneous recovery and preparation for competitions at the European Championship					
Subgroup A^1	initial values	14.86 (1.25)	60.17 (2.47)	24.97 (2.01)	2.41 (0.14)
	after loads	29.78 (2.11)	55.86 (2.93)	14.36 (1.33)	3.89 (0.21)
Subgroup A^2	initial values	5.98 (0.39)	44.79 (2.38)	49.23 (1.88)	0.91 (0.23)
	after loads	11.45 (1.09)	34.22 (2.47)	54.33 (3.08)	0.63 (0.42)
Subgroup B^1	initial values	11.54 (1.23)	64.68 (.35)	23.78 (2.36)	2.72 (0.22)
	after loads	36.65 (2.95)	52.98 (3.11)	11.37 (1.54)	4.66 (0.31)
Subgroup B^2	initial values	8.93 (1.68)	52.15 (2.37)	38.92 (2.18)	1.34 (0.11)
	after loads	10.03 (1.44)	43.11 (2.93)	46.86 (3.27)	0.92 (0.13)

Note: * $p < 0.05$ – compared to before-exercise results at rest.

At the same time, there was a significant decrease in the influence of autonomic regulation against the background of HF reduction in groups A^2 (–11.5%) and B^2 (–8.2%). Subgroups A^1 (–56.7%) and B^1 (–46.5%) increased their parasympathetic activity due to a reduction in the autonomic balance index in response to a stressful stimulus. Athletes in subgroups A^1 and B^1 showed an increase in HF values and a decrease in LF, suggesting an enhanced vagal influence on the sinus node. It is essential to recognize that athletes specializing in striking (A1, A2) and wrestling (B1, B2) disciplines experienced test loads that varied considerably in terms of volume and energy supply mechanisms.

Before the pre-competition mesocycle of preparation for the European MMA Championship, experimental training models were developed for athletes of subgroups A^2 and B^2. When designing experimental models, we took into account adaptive and compensatory body responses to stressful stimuli encountered during preparation for and participation in the previous competition. According to the spectral analysis of heart rate results, athletes in subgroups A^1 and B^1 could continue following the standard training model for this stage of MMA preparation.

Using developed individual models for 30 days by participants of 4 subgroups when preparing for the European Championship brought completely different changes in the studied indicators. The comparative analysis of the spectral characteristics of HRV of the examined athletes at rest (before loads) between the two last stages of control showed the following results. Athletes in subgroups A^1 and B^1

exhibited a shift in vegetative balance toward sympathetic dominance at rest compared to previous results. However, subgroups A^2 and B^2 increased the controlled HRV indicators at rest in the influence of autonomic regulation and decreased the sympathetic tone.

After 30 days of preparation for the European Championship, test load responses revealed an increase in the central regulation of sinus rhythm in subgroups A^1 and B^1. The influence of autonomic regulation (HF) in groups A^1 (–10.6%) and B^1 (–12.4%) decreased. HF values in subgroups A^2 (+5.1%) and B^2 (+7.9%) increased in response to test loads. There was a decrease in the sympathetic tone indicator LF in subgroups A^2 (–10.5%) and B^2 (–9.1%). These changes support an increase in vagal influence on the sinus node in athletes of subgroups A^2 and B^2 as a response to a stressful stimulus.

Figure 2 presents the changes in the creatine phosphokinase activity in the blood serum of the examined athletes during all three stages of the study.

The first-stage results show that the initial CPK level in the blood of participants in both groups corresponded to the reference values. No significant difference was observed in the parameters of this biochemical blood indicator between groups A and B representatives. In response to test loads, group A athletes increased their CPK activity in the blood by 23.7% ($p < 0.05$). These results suggest that the energy for the test loads was supplied mainly by the creatine phosphate reserves. Group B representatives had no significant changes in the controlled biochemical blood indicator in response to a stressful stimulus.

In the second stage of the study (after participating in the Ukrainian MMA Championship), the athletes were divided into subgroups based on the HRV results. The biochemical control results showed that the initial level of creatine phosphokinase in the blood of athletes of subgroups A^2, B^1, and B^2 significantly decreased. Athletes of subgroup A^2 increased this biochemical indicator in response to the test load compared to the state of rest. A significant increase in CPK in

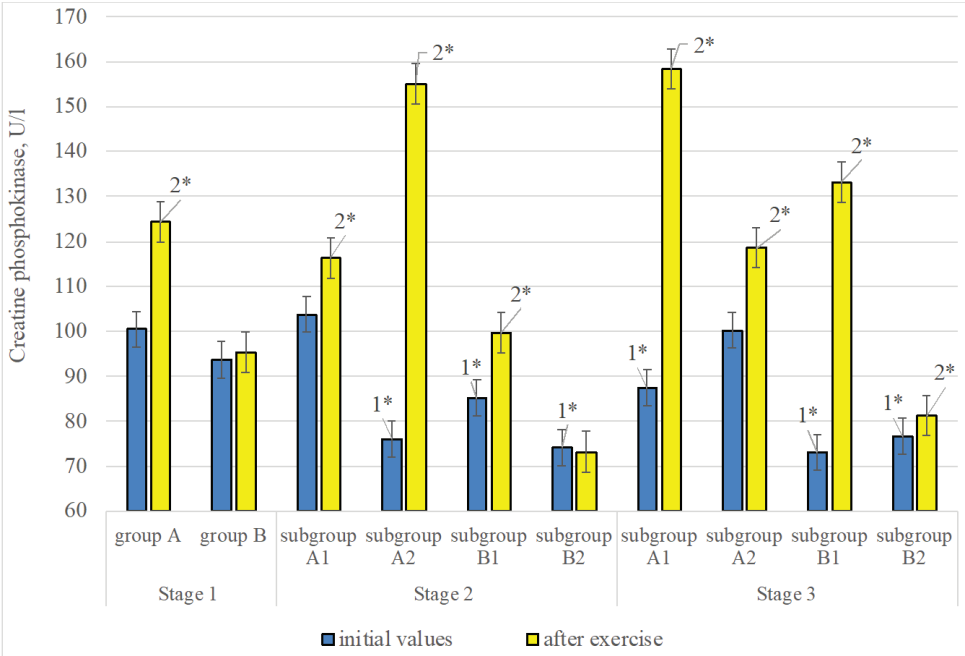

Fig. 2. Results of changes in creatine phosphokinase activity in the blood serum of the examined athletes during all stages of the study, n = 16

Note: Stage 1 – at the end of the pre-competition mesocycle of training; Stage 2 – after competitions; Stage 3 – after 30 days of simultaneous recovery and preparation for the next competition; 1* – $p < 0.05$ compared to initial values; 2* – $p < .05$ compared to pre-load indicators.

the blood serum was observed among athletes of subgroups A^1 (+12.1%) and B1 (+17.1%) in response to a given stimulus.

In the third stage of the study (after 30 days of preparation for the European Championship), CPK level increased in the blood of all study participants in response to the test load. The most significant increase in this biochemical indicator was observed in athletes from subgroups A1 (+81.1%) and B1 (+82.2%). This finding suggests significant energy expenditure in response to stressful stimuli in representatives from these subgroups, compared to other participants. At this stage of the study, representatives of subgroups A^1 and B^1 used a standard model of training sessions for pre-competition mesocycles. It should be noted that representatives of subgroups A^1 (striking style athletes) and B^1 (wrestling style athletes) used completely different test loads.

Figure 3 presents the changes in the lactate dehydrogenase activity in the blood serum of the examined athletes during all three stages of the study.

In the first stage of the study (at the end of the pre-competition mesocycle of preparation for the Ukrainian MMA Championship), the initial LDH activity in the participants' blood corresponds to the reference values. Wrestling-style athletes (group B) increased LDH activity in the blood by 66.9% ($p<0.05$) in response to the test load.

In the second stage of the study, there was a moderate increase in LDH in the blood serum of representatives of subgroups A^2 (+41.8%) and B^1 (+33.7%) in response to the test load. The LDH level in the blood of subgroup B2 not only showed the highest increase (+94.9%) but also surpassed the upper limits of the norm. The activity of this enzyme was not changed in response to a stressful stimulus in the representatives of subgroup A^1.

In the third stage of the study, LDH activity changed in the blood serum of the examined athletes compared to the previous results. In athletes of subgroup B^1, the LDH level in the blood increased greatly (+94.9%) and exceeded the upper limits of the norm. These are

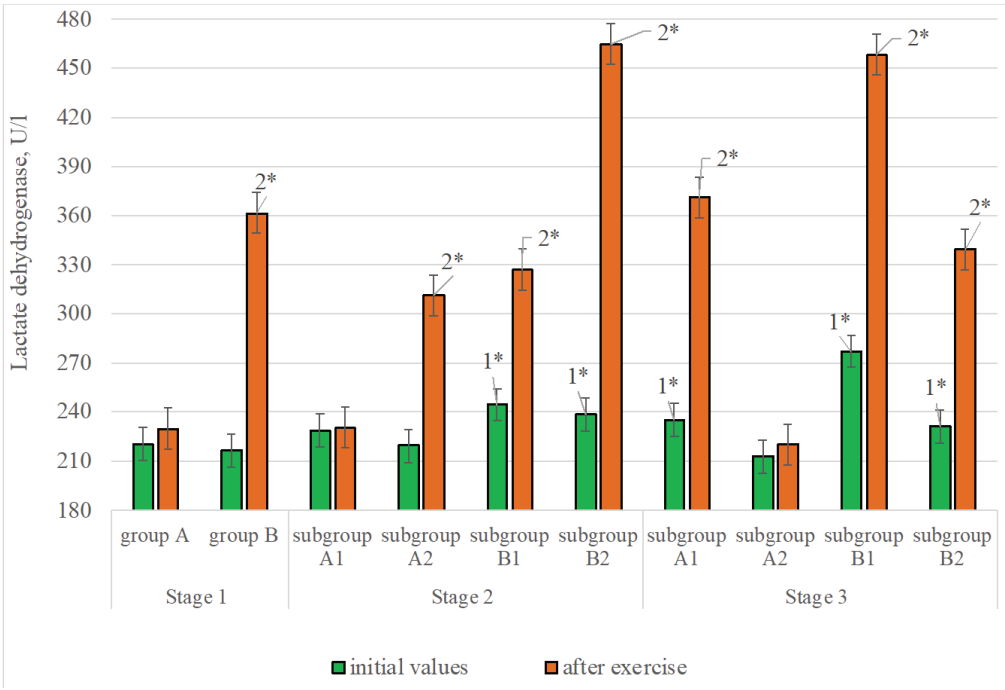

Fig. 3. Results of changes in the lactate dehydrogenase activity in the blood serum of the examined athletes during the study, n = 20

Note: Stage 1 – at the end of the pre-competition mesocycle of training; Stage 2 – after the end of the competition; Stage 3 – after 30 days of simultaneous recovery and preparation for the next competition; 1* – $p < 0.05$ compared to initial values; 2* – $p < 0.05$ compared to pre-load indicators.

manifestations of compensatory capabilities. An increase in this biochemical indicator, but within the normal range and with lower dynamics, was observed in athletes from subgroups A^1 (+57.9%) and B^2 (+46.6%). However, this biochemical indicator of the blood did not significantly change in the athletes of subgroup A^2 in response to the test load. These results suggest that muscle glycogen reserves were not the primary energy source for group A^2 athletes during the test task.

Discussion. The results presented in this study highlight a mechanism for addressing a critical issue in MMA – namely, the lack of effective methods for restoring adaptation reserves during the short-term recovery period between consecutive competitions [2; 7; 8]. We examined the characteristics of short-term adaptation to test loads under different energy supply modes in skilled athletes specializing in striking and wrestling fighting styles. The study explores the effectiveness of using spectral characteristics of HRV and biochemical blood parameters (enzymes and hormones) as informative markers for assessing the adaptation body reserves of MMA athletes. A monitoring system for assessing the adaptation reserves of MMA athletes was developed to adjust training loads during preparation for a series of competitions with short-term recovery periods. The results showed that even qualified athletes with a high level of resistance to loads decreased adaptation reserves in conditions of short-term recovery periods between a series of competitions [11; 13]. The study demonstrated that adaptive reserves declined in athletes of both striking and wrestling fighting styles due to prolonged stress, and triggered the simultaneous activation of multiple energy supply mechanisms [5; 9]. The study's findings will help address the challenge of identifying an effective mechanism for adjusting training loads in pre-competition mesocycles during short-term recovery periods between consecutive competitions. The obtained data will enhance the monitoring system for detecting declines in adaptive reserves among skilled MMA athletes using HRV analysis and biochemical blood assessments.

In mixed martial arts, insufficient attention is paid to the problem of controlling the level of adaptive reserves and adjusting loads, especially in short periods between a series of important competitions [2; 6]. Several researchers [5; 10] point only to the need to reduce the volume and intensity parameters during this period using ergogenic aids. Limited attention is given to the impact of drastic changes in load regimes and the activation of energy supply mechanisms for muscle activity, to which athletes may have a low level of resistance [1; 4]. A skeptical attitude persists regarding the need to modify the standard structure of pre-competition mesocycles in MMA, despite assessments of adaptive and compensatory responses to test loads [13; 15]. We believe this attitude stems from a lack of studies that evaluate the reasons behind the decline in load resistance during short-term recovery periods between consecutive competitions.

The study found that qualified MMA athletes exhibit varying adaptive and compensatory responses to test loads during short-term training and recovery periods between consecutive competitions. Thus, before the first competitions, test load responses increased autonomic regulation of heart rhythm and balanced interaction between vagal and sympathetic tone mechanisms. CPK activity in the blood serum of athletes with a striking fighting style increased. Among wrestling-style athletes, the level of LDH indicator rose. These changes in the body indicate the successful activation of short-term adaptation to a stressful stimulus, driven by a high level of adaptive reserves and load resistance [6; 9].

After the first competition, there was a shift in the vegetative balance from the side of parasympathetic and sympathetic regulation in response to test loads among athletes of both styles. Strengthening the central circuit of sinus rhythm regulation in response to loads that previously caused a decrease in sympathetic tone may indicate compensatory reactions and a decrease in adaptive reserves [4; 12]. The simultaneous increase in both enzymes in the blood of some athletes of the impact style to high-intensity test loads with a CPK energy supply mechanism indicates compensatory reactions [5; 9]. Similar changes in the CPK and LDH activity

in the blood in response to medium-intensity loads in the anaerobic glycolysis mode were observed in athletes of the wrestling style. This fact indicates a decrease in the body's resistance level to such a stressful stimulus due to possible manifestations of adaptation failure against the background of overload [5; 7].

The results revealed after a short-term training (30 days) between consecutive competitions demonstrate the feasibility of using the proposed system to control athletes' adaptive reserves and correct loads. It has been established that even in athletes with a high level of resistance to loads due to adaptive reserves, it is necessary to completely change the training model in the conditions of a short-term period between a series of competitions. Long-term use of the "standard" training program slows down adaptive shifts in the body to a stressful stimulus even in qualified athletes of the striking and wrestling style [4; 6]. Accordingly, most athletes in the absence of an organism's reaction to a stimulus increase the volume or intensity of training loads, which inevitably leads to a breakdown of adaptation [8; 12]. It has been established that changes in the load regime and the energy supply mechanism affect the restoration of adaptive reserves in the short-term training between consecutive competitions. The corresponding nature of changes in the body of athletes is associated with the balance of vagal-sympathetic tone mechanisms and the corresponding change in CPK and LDH enzymes in the blood under conditions of a stressful stimulus [7; 14].

Conclusions. The results demonstrate the feasibility of using the developed system for monitoring the adaptive reserves of the body of MMA athletes and correcting loads while preparing for a series of competitions with short-term recovery periods. The suggested algorithm for developing class models in pre-competition mesocycles significantly influences the recovery processes of athletes with exhausted adaptive reserves. The study findings highlight the effectiveness of using HRV indicators and biochemical blood analysis in evaluating the adaptive reserves of qualified athletes. The reinforcement of the central circuit of sinus rhythm regulation in response to previous loads, which reduced the sympathetic tone, may suggest compensatory reactions and a decline in adaptive reserves. In athletes of both striking and wrestling fighting styles, a decline in adaptive reserves caused by prolonged stress caused the simultaneous activation of multiple energy supply mechanisms. The obtained results will contribute to identifying an effective mechanism for adjusting loads in pre-competition mesocycles during short-term recovery periods between a series of competitions.

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