Original Article

Peculiarities of correcting load parameters in power training of mixed martial arts athletes

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Abstract.
Purpose: to identify the optimal load parameters in the process of power training of Mixed Martial Arts athletes with a wrestling style on the basis of studying adaptive and compensatory body reactions in conditions of intense muscular activity of different intensity and volume of work.*Material:* We examined 40 sportsmen aged (21 ± 0.8), who participated in Mixed Martial Arts fights during the last (2.0 ± 0.3) years and used predominantly a wrestling style of fighting. The athletes were divided into 2 groups: group A and B. The participants of group A used the low-intensity load and the large amount of work in the training process. Athletes of group B used loads of high intensity and small volume of work. Morphometric, biochemical, and statistical methods of research were used to study the features of adaptive and compensatory body reactions of these athletes in conditions of power training of different intensity. *Results:* The obtained results show that athletes of group A increased their circumference indices by 1.9% on average after 3 months of research. In group B, for the same period of time, the studied indices increased by 5.5% on average compared to the baseline data. It was noted that at the beginning of the study, the cortisol concentration in blood serum of group A athletes decreased after exercises by 23.9% in comparison with the basal ones. This fact indicates compensatory reactions to the stimulus and high energy costs. We observed completely opposite changes in group B sportsmen. They were expressed in the increase of the studied indicator by 46% in comparison with the data recorded before exercises. This fact testifies to the adequacy of the loads to the functional body capabilities of this group of athletes. The results of biochemical control of the changes in the hormone testosterone and the enzyme lactate dehydrogenase in the blood of both groups' athletes confirm the fact that it is the use of high-intensity loads that promotes the enhancement of the athletes' adaptive body capabilities for training activities in MMA. *Conclusions:* The analysis of the results obtained during the series of experimental studies indicates the necessity of correcting load parameters during power training. It should be based on the analysis of athletes' adaptive and compensatory body reactions to a stress stimulus. Otherwise there should be developed completely new training programs.
Key words: mixed martial arts, power loads, cortisol, testosterone, lactate dehydrogenase, adaptive and compensatory reactions.

Introduction.

One of the important aspects of training in Mixed Martial Arts (hereinafter – MMA), allowing for the shortest possible time to increase the level of athletes' performance, is the use of optimal training schemes, taking into account the individual characteristics of carrying out fights (James et al., 2016; Matthews et al., 2017, Chernozub et al., 2018).

In conditions of competitive activity, the level of physical, technical, psychological and tactical preparation allows defeating the enemy (Latyshev et al. 2017; Loturco et al., 2018). The level of physical training is determined not only by the indicators of maximum strength (1 PM) and power endurance, but also by the morphometric parameters of the athletes' bodies (Henselmans et al., 2014). For MMA athletes, who have a predominantly wrestling style of fighting, the availability of optimal parameters for fat, lean and active body weight contributes to economizing the work of the energy supply system in conditions of intense muscular activity (Slimani et al., 2017; Podrigalo et al., 2018). The growth of muscle mass, accompanied by increasing of the body circumference, contributes to the progress in adaptive body capabilities. The combination of optimal

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ANDRIY CHERNOZUB, SVETLANA DANYLCHENKO, YEVGENIY IMAS, MARINA KOCHINA, IEREMENKO NATALIA, GEORGIY KOROBEYNIKOV, LESIA KOROBEYNIKOVA, VLADIMIR POTOP, WOJCIECH J. CYNARSKI, ALEXANDR GORASHCHENCO

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morphometric and strength indicators of athletes' bodies, low body fat level together with the high level of fitness, contributes to the increase of effectiveness in this sport. Individualization of the system of athletes training is a necessary condition for improving the effectiveness of training activities in modern sports (Chernozub, 2013; James et al., 2017).

To solve the problem of integration of tactical, technical, general and special physical training, taking into account the individual capabilities of MMA fighters, there should be conducted complex studies by specialists in combats and sports physiology. The obtained results will allow revealing the features of adaptive and compensatory reactions of the organism to stressful situations, including physical loads of various intensity and direction (Latyshev et al., 2017; Loturco et al., 2018).

The modern process of optimizing the training activities requires the development of completely new training programs for power training in MMA. The construction of these programs, adjustment of their structure and the amount of training loads, improvement of the management mechanisms of the training system, must be done taking into account the individual level of athletes' training, the morphometric features of their organisms and the style of fighting (Chernozub, 2016; Sinnett et al., 2018; Slimani et al., 2017).

The search for criteria for assessing the impact of training and competitive loads on the functional state of the athlete's body is one of the most problematic in the sports world. The use of these criteria makes it possible to evaluate the effectiveness of the athletes' training process and to predict its effectiveness. At present, most researchers in martial arts and power sports (Chernozub, 2014; Schoenfeld et al., 2016) use mostly non-invasive diagnostic methods to study the response of the athlete's organism to a stress stimulus. Among these diagnostic methods are the following: anthropometry, bioimpedanceometry, testing the power capabilities, methods of recording heart rate and assessing heart rate variability, etc. However, the use of these methods allows only partially assess the extent to which loads affect the adaptation process of the athlete's organism to training and competitive loads.

Biochemical methods of blood analysis are used to primarily determine the nature of changes in the adaptive capabilities of the organism or to identify compensatory reactions in conditions of training activity. The most frequently used methods are those revealing the characteristics of the endocrine system and the energy supply system reactions to physical loads of different intensity (Philippou et al., 2017). Thus, for example, an increase in the concentration of glucocorticoid hormone cortisol in the serum of athletes indicates a normal response to a stress stimulus (Walker et al., 2017). On the other hand, a decrease in the concentration of this hormone indicates that the load exceeds the primary level of adaptive capacity of the body. In this case, energy deficiency increases and gluconeogenesis processes are activated, because the hormone cortisol takes an active part there (Shaner et al., 2014).

The study of the lactate dehydrogenase (LDH) enzyme concentration change in the blood of athletes is of a great interest to us. This enzyme catalyzes the reverse reduction of pyruvic acid to lactate during anaerobic glycolysis. Unfortunately, the dynamics of this indicator has been rarely studied in conditions of sport activity (Henselmans et al., 2014). The increase or decrease in the activity of this enzyme in the athlete's serum reflects the characteristics of the training load in conditions of aerobic or anaerobic energy supply regimes.

In power sports, the study of the testosterone concentration in blood serum of athletes of different fitness levels is also rather informative. It is shown that a decrease in the basal level of this hormone in the blood indicates the processes of long-term adaptation of the organism to anaerobic power loads in athletes engaged in fitness (Chernozub, 2013).

In the accessible scientific literature, we found no articles on the adequacy of training loads for the functional capabilities of the MMA athletes' bodies using biochemical indicators.

Having analyzed the research results of leading specialists in various types of martial arts (Julio et al. 2017; Matthews et al., 2017; Korobeynikov et al., 2017, 2018; Wiechmann et al., 2016) we noticed that they mostly use the same types, magnitude and nature of power exercises in the development of programs for power trainings of athletes. These programs do not take into account the style of conducting fights (shock or wrestling). Moreover, the issue of the effectiveness of using power loads of anaerobic or aerobic character in the training process of MMA athletes has not been adequately covered in modern literature,. The problem of optimizing the training schemes is especially relevant for athletes using a wrestling style of fighting. For these athletes, the development of explosive strength and power endurance are necessary conditions for achieving maximum effectiveness in the training process.

Thus, the development of optimal schemes for the training process is a relevant scientific problematic. In the process of schemes development we should take into account the peculiarities of conducting fights, individual adaptive and compensatory reactions of athletes' bodies, and assess them with the help of morphometric and biochemical indicators.

The purpose of the study was to identify the optimal load parameters in the process of power training of MMA fighters with a wrestling style of fighting on the basis of studying adaptive and compensatory body reactions in conditions of intense muscular activity of different intensity and volume of work.

ANDRIY CHERNOZUB, SVETLANA DANYLCHENKO, YEVGENIY IMAS, MARINA KOCHINA,
IEREMENKO NATALIA, GEORGIY KOROBEYNIKOV, LESIA KOROBEYNIKOVA, VLADIMIR
POTOP, WOJCIECH J. CYNARSKI, ALEXANDR GORASHCHENCO

Materials and methods

We examined 40 sportsmen aged (21 ± 0.8), who during the last $(2,0 \pm 0,3)$ years participated in MMA fights and used predominantly a wrestling style of fighting. Athletes were divided into 2 groups: the athletes of group A used in the process of training low-intensity power loads; the sportsmen of group B used loads of high intensity.

The experimental study was approved by the Ethics Committees for Biomedical Research in accordance with the ethical standards of the Helsinki Declaration. Written consent to the research was given by the athletes according to the recommendations of the Ethics Committees for Biomedical Research [WHO Regional 2000].

The equipped and certified medical laboratory was used to provide a medical examination and a comprehensive biochemical laboratory control (16 indicators) of the MMA fighters taking part in experimental power training.

Evaluation of the basal parameters of the athlete's body circumference and dynamics during the 3-month study period was carried out using the anthropometry method. Changes in the athletes' body composition were determined using the method of bioimpedanceometry. For this, a bioimpedance analyzer was used: the computerized hardware-software complex KM-AR-01 of the "Diamant-AST" configuration (body composition analyzer) (VYUSK, 941118.001 RE). The measurements were carried out at the beginning of the studies and during 3 months at intervals of 30 days. We determined the following indicators: body mass index (BMI), active cell mass (ACM), body fat mass (BFM), fat-free body mass (FFBM).

The testosterone and cortisol concentration in blood serum of the athletes was determined by the method of enzyme immunoassay in the conditions of a certified medical laboratory. The activity of lactate dehydrogenase (LDH) in blood serum was determined by the kinetic method on the equipment of "High Technology Inc." (USA). Blood sampling from the vein was made by a medical worker before and after the training session with the observance of all norms. Blood samples were numbered, underwent the necessary description and delivered to the clinical laboratory.

The power training programs developed for the participants of our study were almost identical in structure and quantity of exercises, and an algorithm for using them to train certain body muscle groups. The programs offered to the athletes of both groups differed significantly in terms of the amount of training loads.

In the course of 3 months of research, athletes of group A used a training program built on the basis of low-intensity power loads in the aerobic mode of energy supply. The duration of muscle tension in each set consisting of 10 repetitions was about 60 seconds.

For the athletes of group B, a training program was developed with the predominant use of high-intensity power loads in the anaerobic mode of energy supply. The duration of muscle tension in each set consisting of 3-4 repetitions was about 36 seconds.

The athletes of both groups had significantly different programs for the duration of rest intervals between sets, the magnitude of the movements, as well as the duration of the concentric and eccentric phases of motion while performing power exercises. Training exercises were carried out with a barbell, dumbbells and on simulators with observance of the given technics. The duration of one training session was no more than 40-50 minutes. There were 3 training sessions per week.

Statistical analysis

Statistical analysis of the obtained results was performed using the IBM * SPSS * Statistics 20 software package (StatSoftInc., USA). We used discrete statistics methods to calculate the mean, mean error, median (Me), 25%, and 75% quartiles. To assess the reliability of paired differences we used the non-parametric Wilcoxon test. To confirm the reliability of the differences between the studied parameters in dynamics of observation we used Friedman's Repeated Measure ANOVA.

Results

The results of changes in the morphometric parameters of the athletes' bodies in both groups during the 3 months of the study are presented in Tables 1-2.

Significant differences in the values of the studied parameters during the observation period were confirmed by Friedman's method of Repeated Measure ANOVA. Using the Wilcoxon test allowed confirming the presence of significant differences between the subsequent and previous measurements of the indicator.

The results analysis showed that group A athletes, who used loads of low intensity, increased anthropometric indicators significantly by an average of 1.9%. The athletes of group B using high-intensity loads in the process of power training significantly increased the body circumference on average by 5.5% in comparison with the basal values.

-- 483

ANDRIY CHERNOZUB, SVETLANA DANYLCHENKO, YEVGENIY IMAS, MARINA KOCHINA,
IEREMENKO NATALIA, GEORGIY KOROBEYNIKOV, LESIA KOROBEYNIKOVA, VLADIMIR
POTOP, WOJCIECH J. CYNARSKI, ALEXANDR GORASHCHENCO

Table 1. Body circumference of athletes of both groups during the research

| Body circumference, cm | Group | Terms of research, months | | | | χ^2, p df=3 |
		Basal data	1	2	3	
Chest	A	106.9±1.4	108.1±1.5*	108.8±1.4*	109.5±1.5*	χ^2=60,0 p<0,00000
	B	106.7±1.0	108.9±1.1*	110.5±1.0*	111.6±0.9*	χ^2=60.0 p<0.00000
Shoulder	A	37.5±1.0	38.3±1.0*	38.7±1.1*	39.2±1.1*	χ^2=59.5 p<0.00000
	B	37.3±0.8	38.6±0.8*	39.4±0.8*	40.3±0.9*	χ^2=60.0 p<0.00000
Hip	A	56.9±0.8	57.6±0.7*	58.1±0.7*	58.5±0.7*	χ^2=60.0 p<0.00000
	B	56.2±0.9	57.6±0.9*	58.6±0.8*	59.5±0.9*	χ^2=59.5 p<0.00000
Shin	A	37.5±0.7	38.1±0.6*	38.6±0.6*	39.1±0.9*	χ^2=60.0 p<0.00000
	B	36.8±0.6	37.6±0.6*	38.2±0.6*	38.9±0.6*	χ^2=60.0 p<0.00000

Note: * - differences in comparison with previous results are reliable by the Wilcoxon test (p <0.05); df is the number of degrees of freedom; p is the level of significance.

The results of studying the parameters of the body composition performed using the method of bioimpedanceometry are presented in Table 2.

Table 2 Average values of body composition parameters of both groups athletes during the research

| Body composition parameters | Group | Terms of research, months | | | | χ^2, p df=3 |
		Basal data	1	2	3	
BMI, c.u	A 2.8%	26.1±1.3	26.3±1.3	26.6±1.3	26.8±1.3* Z=3.9; p<0.00009	χ^2=60.0 p<0.00000
	B 5%	26.4±1.2	26.9±1.3	27.3±1.2	27.7±1.2* Z=3.9; p<0.00009	χ^2=60.0 p<0.00000
ACM, kg	A 2.5%	43.2±2.2	43.3±2.2	44.3±2.2	44.8±2.2* Z=3.9; p<0.00009	χ^2=53.1 p<0.00000
	B 7%	52.0±2.3	53.4±2.4	54.5±2.5	55.7±2.5 Z=3.9; p<0.00009	χ^2=58.7 p<0.00000
BFM, kg	A	15.3±2.6	15.2±2.3	15.3±2.5	15.4±2.4	χ^2=7.4 p<0.06095
	B	15.2±1.7	15.5±1.7	15.4±1.7	15.2±1.7	χ^2=48.7 p<0.00000
FFBM, kg	A 1.7%	69.1±3.3	70.0±3.3	70.8±3.4	71.3±3.3* Z=3.9; p<0.00009	χ^2=58.9 p<0.00000
	B 6.2%	68.7±3.4	70.0±3.4	71.5±3.3	73.0±3.4 Z=3.9; p<0.00009	χ^2=60.0 p<0.00000

Note: * - differences in the basal values of the parameters and values after 3 months of training are reliable by the Wilcoxon test; df is the number of degrees of freedom; p is the level of significance.

The analysis of the data presented in Table 2 showed that the use of low intensity power loads in group A led to a significant increase in the BMI by 2.8% compared to the baseline level. In group B, high-intensity loads were performed predominantly in conditions of anaerobic energy supply which led to a significant increase in BMI by 5% in 3 months of training. Even more noticeable differences between the groups were found in the values of FFBM index. In group A, the indicator significantly increased by 1.7% during the observance period, and in group B it increased by 6%. In addition, we noted a significant increase in ACM by 2.5% in athletes of group A and 7% in athletes of group B.

Thus, the analysis of the anthropometry and bioimpedanceometry results showed that the predominant use of anaerobic loads in the process of power training not only promoted the increase in the muscular mass of MMA athletes, but also positively affected the change in the body composition. Power loads of low intensity affected the dynamics of athletes' body circumference and body composition less than high intensity loads. High intensity loads contributed to more pronounced adaptive body changes, manifested by a reliable growth of

484 --

ANDRIY CHERNOZUB, SVETLANA DANYLCHENKO, YEVGENIY IMAS, MARINA KOCHINA, IEREMENKO NATALIA, GEORGIY KOROBEYNIKOV, LESIA KOROBEYNIKOVA, VLADIMIR POTOP, WOJCIECH J. CYNARSKI, ALEXANDR GORASHCHENCO

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morphometric indicators and positive changes in body composition. This fact confirms the expediency of their using in the process of power training of MMA athletes with a wrestling type of fighting.

To study the peculiarities of the developed training sessions influence on the functional state of the athletes' organisms, we used biochemical blood indices (concentration of cortisol, testosterone and LDH activity). The dynamics of these indicators is associated with adaptive and compensatory reactions of an athlete's organism to power loads of different intensity and volume (Chernozub, 2014; Schoenfeld et al., 2016). This allows them being used as markers of changes in athletes' functional state in the training process. The results of studying the biochemical indicators of athletes' blood are presented in Table 3. Since there was a wide range of indicators, we used the median (Me) and quartiles (25%, 75%) to describe them.

The analysis of the research results revealed that cortisol concentration in the blood serum reduced after exercises by 23.9% in athletes of group A. We observed completely opposite changes in the athletes of group B. There was an increase of the studied indicator by 46% in comparison with the data fixed before exercises. The results of blood biochemical control of both groups athletes after 3 months of using power loads of different intensity demonstrated an increase in the level of this hormone by 24% in the sportsmen of group A. At this stage of the study, the cortisol concentration in the serum increased by 43% in group B athletes in response to power load, which was identical to the changes detected at the beginning of the study. The basal level of cortisol in blood increased by 4.5% in group A and by 42.9% in group B after 3 months of training, compared with the results noted at the beginning of the study.

Table 3. Biochemical blood indices of both groups' athletes during the research (Me, 25%, 75%)

Indices	Group	At the beginning of the study		After 3 months of training	
		Before exercises	After exercises	Before exercises	After exercises
Cortisol, nmol/l	A	372.9 (299.7;431.8)	283.5* (255.9;315.0) Z=3.2; p<0.001	389.6 (345.1;468.0)	483.9* (407.6;548.3) Z=2.5; p<0.01
	B	313.4 (277.6;365.6)	458.8* (387.7;593.2) Z=3.8; p<0.0002	447.9 (389.58;541.3)	641.3* (598.4;689.0) Z=3.9; p<0.00009
Testosterone, nmol/l	A	16.6 (14.7;21.8)	20.9* (16.2;23.6) Z=3.1; p<0.002	17.8 (13.3;33.3)	20.0* (17.5;32.3) Z=3.1; p<0.002
	B	22.9 (17.9;27.4)	25.5* (17.91;30.1) Z=2.9; p<0.004	24.1 (19.4;26.8)	30.0* (28.9;32.7) Z=3.8; p<0.0001
LDH, c.u.	A	371.5 (321.0;409.0)	492.0* (472.0;527.0) Z=3.9; p<0.00009	428.0 (367.0;485.0)	440.0 (400.8;488.5)
	B	368.0 (342.0;393.8)	465.0* (367.8;499.8) Z=3.2; p<0.001	365.0 (342.0;388.5)	366.5 (332.5;385.0)

Note: * Differences in before and after exercise values are significant by the Wilcoxon test (p <0.05)

We researched the nature of the change in testosterone in the athletes' blood while using different power training programs. This hormone showed a significant increase at all stages of control. Thus, at the beginning of the study, the cortisol concentration in blood serum increased by 26% among the participants of group A and by 11.4% in group B. It happened in response to physical exercises. After 3 months of training, cortisol concentration also increased after exercises in participants of both groups. After 3 months of training, the basal levels of testosterone in blood increased by 7.2% in group A and by 5.2% in group B compared with the baseline data.

Analysis of the LDH enzyme activity results in blood of the athletes during the power training of different intensity indicated that at the beginning of the study this indicator increased by 32% in group A and by 26% in group B in response to the stress stimulus. The results, fixed after 3 months of using the given power loads, demonstrated a slight increase in LDH in blood serum by 2.8% in group A and only 0.4% in group B. In group A, the basal LDH values in the athletes' blood serum showed an increase in parameters by 15.2%. In group B, the basal level of the studied indicator showed a tendency to decrease by 0.8% compared with the data revealed at the beginning of the study.

Discussion

The development of the athletes' muscular mass by increasing the body's circumference is one of the key components necessary in the process of MMA competitive activity. However, the effectiveness of such

--- 485

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changes in the body will be appropriate only in conditions of body fat decrease and a simultaneous active body weight and fat-free mass increase. Similar changes in the morphometric body indices indicate an increase in the adaptive body capabilities of athletes in the process of special training (Wiechmann et al., 2016; Chernozub et al., 2018).

The necessity to achieve optimal parameters of morphometric indices in MMA athletes, using the wrestling style of fighting, is due to the peculiarities of this kind of sport (Matthews et al., 2017). Thus, in training process construction we need to take into account not only the level of technical and tactical training, but also the ability to predict the effectiveness of their implementation, depending on fat and muscle mass parameters of the athletes (James et al., 2016). Despite the technical implementation of throws, retention and other elements at a high level, the conditions of competitive activity require these athletes to mobilize the work of all body systems (James et al., 2017).

The obtained results allowed us to determine the most effective combination of power load volume during training, which contributes to reducing body fat, but at the same time increases the muscular mass of athletes and power capabilities in the shortest possible time. The proposed high-intensity loads provide an increase in morphofunctional parameters due to an increase in intramuscular and intermuscular coordination, as well as muscle hypertrophy of predominantly fast-twitch fibers (Vogt et al., 2014). The obtained data coincide with studies in bodybuilding and power fitness (Chernozub, 2013, 2016), which demonstrate a rapid increase in body size in men due to the growth of muscle mass in conditions of high intensity and low power load, regardless of the level of fitness. At the same time, in conditions of low-intensity loads and a large amount of work, the bodybuilders' body fat mass decreased by 15-25%, although no significant increase in morphometric parameters was detected.

Competitive activity in MMA requires from athletes a lot of energy supply due to using a huge arsenal of blows, throws and other technical elements (Loturco et al., 2018). The increase in the adaptive capacity of the organism during the preparation period will maximize the technical potential of athletes in the process of anaerobic and aerobic energy supply (Slimani et al., 2017). However, the results of studies by MMA specialists showed (Matthews et al., 2017) that 70-73% of athletes had physical fatigue much earlier than the fight ended. Such changes are caused by the manifestation of compensatory reactions of the organism in conditions of increased energy consumption. This circumstance indicates that the operating modes used in preparation process do not correspond to the loads during fights. With the help of biochemical methods of blood analysis it is possible to identify the features of adaptive and compensatory body reactions in conditions of different intensity loads and to assess their adequacy to the capabilities of athletes (Philippou et al., 2017).

The obtained data on biochemical control of steroid hormones testosterone and cortisol, as well as enzyme lactate dehydrogenase in the blood of MMA athletes partially coincide with the results of studies of adaptation changes in the body of weightlifters (Shaner et al., 2014), bodybuilders (Chernozub, 2013) in conditions of heavy loads of different intensity.

In the process of power training, loads of large volume and low intensity contribute to a decrease in the concentration of cortisol in the blood serum of MMA athletes by an average of 25-30% in comparison with the state of rest. Similar changes in the given conditions of muscular activity occur in athletes specializing in bodybuilding and power fitness, regardless of their level of fitness (Chernozub 2016). This fact indicates the activation of the gluconeogenesis process, the active role in which takes the hormone cortisol, provoked by high energy costs as a consequence of intense muscular activity of an aerobic nature (Shaner et al., 2014). Long-term usage of such load parameters will contribute to the development of the state of overtraining in athletes and possibly the manifestation of disadaptation processes.

One of the factors that reflect the process of adapting the athletes' organism to training loads is the change in the basal level of testosterone in blood serum (Chernozub, 2013; Philippou et al., 2017). High intensity loads performed during 3-4 months in the anaerobic mode of operation contribute to a 13-17% decrease in this indicator in the blood of athletes engaged in power fitness and bodybuilding. The results of our studies demonstrate a completely different tendency to change this level of testosterone. Thus, for MMA athletes who use predominantly wrestling style of fighting, the basal level of the studied steroid hormone practically does not change after power loads. Perhaps this is due to the characteristics of MMA training activities, which contributes to the development of high adaptive body capabilities of the athletes. It can also be assumed that the decrease in the baseline level of testosterone among MMA athletes will be manifested after a longer (more than 3 months) period of time, in comparison with the results of bodybuilders.

The change in the LDH enzyme activity in blood in conditions of training and competitive activity mainly reflects the lactate level increase. However, an increase in this indicator in the athlete's blood by 3-4 times may indicate structural breakdowns in muscle tissue caused by too high intensity or volume of physical load [Honor 2017]. Our results fully coincide with the data of similar studies in power fitness (Chernozub, 2014), as well as with studies of adaptation changes in the body of military special force employees (Chernozub, 2016). Long-term use of high-intensity loads in the process of power training significantly increases the adaptive

486 ---

ANDRIY CHERNOZUB, SVETLANA DANYLCHENKO, YEVGENIY IMAS, MARINA KOCHINA,
IEREMENKO NATALIA, GEORGIY KOROBEYNIKOV, LESIA KOROBEYNIKOVA, VLADIMIR
POTOP, WOJCIECH J. CYNARSKI, ALEXANDR GORASHCHENCO
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reserves of the organism, as evidenced by a decrease in the activity of the studied enzyme in response to a stress stimulus.

Conclusions

Thus, the obtained results testify to the necessity of the load parameters correction during power training based on the analysis of the athletes' adaptive and compensatory body reactions to a stress stimulus, or to the development of completely new power training programs. Power loads of high intensity and small volume of work contribute to a more effective impact on the changes in the morphometric body parameters of the participants of research. They also accelerate the process of organism adaptation to training activity. It is generally accepted that conducting fights by MMA athletes with a wrestling style in primarily aerobic mode contribute to the increase in their level of fitness. The obtained results of biochemical blood indicated quite the opposite results. Long-term (more than 2-3 months) application of heavy loads of high volume and low intensity in the preparation process, activates compensatory body reactions to the stress stimulus, which can lead to the development of athletes' overtraining and disadaptation in future.

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-- 487

ANDRIY CHERNOZUB, SVETLANA DANYLCHENKO, YEVGENIY IMAS, MARINA KOCHINA, IEREMENKO NATALIA, GEORGIY KOROBEYNIKOV, LESIA KOROBEYNIKOVA, VLADIMIR POTOP, WOJCIECH J. CYNARSKI, ALEXANDR GORASHCHENCO

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488 --

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