ADAPTATION RESERVES OF ATHLETES FROM DIFFERENT COMBAT SPORTS DURING FUNCTIONAL TRAINING FOR MIXED MARTIAL ARTS COMPETITIONS

АДАПТАЦІЙНІ РЕЗЕРВИ СПОРТСМЕНІВ З РІЗНИХ ВИДІВ ЄДИНОБОРСТВ У ПРОЦЕСІ ФУНКЦІОНАЛЬНОЇ ПІДГОТОВКИ ДО ЗМАГАНЬ MIXED MARTIAL ARTS

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Abstracts

Purpose – to study the characteristics of changes in adaptation reserves based on the initial resistance level of athletes from various combat sports during functional training for competitions, using classical Mixed Martial Arts (MMA) training models.

Material and Methods. Eighty elite athletes from different combat sports participated in this study, completing an eight-week functional training program structured according to a training model developed for MMA competitions. Participants were divided into four groups of 20: kickboxers, Muay Thai boxers, Greco-Roman wrestlers, and judokas. The athletes' adaptive and compensatory physiological responses were assessed under Test Loads 1 and 2 at both the beginning and the end of the study. Test Load 1 focused on creating exercise conditions that lowered the physiological resistance of athletes from all four groups. Test Load 2 was designed to deplete energy reserves within 20 seconds by performing powerful, signature elements from the studied combat sports. Blood biomarkers, including creatine phosphokinase (CPK), lactate dehydrogenase (LDH), cortisol, and creatinine, were used to evaluate adaptation reserves, compensatory responses, and potential adaptation failure.

Results. At the beginning of the study, the initial baseline levels of CPK and LDH in the blood exceeded the upper limits of reference values only in kickboxers and judokas. Significant decreases in cortisol levels, accompanied by increases in CPK and LDH concentrations, were observed in these groups following Test Load 1. Decreased cortisol and CPK levels, accompanied by an increase in LDH above the normal range, were observed only in the judokas in response to Test Load 2. In the kickboxer and Muay Thai groups, LDH activity in the blood did not change in response to Test Load 2, indicating the activation of short-term adaptive mechanisms.

In Greco-Roman wrestlers, in response to this load, the insufficient creatine phosphate reserves were compensated for by increased muscle glycogen accumulation. Baseline blood creatinine levels increased only in Greco-Roman wrestlers and judokas after eight weeks of functional preparation using the classical MMA training model. In kickboxers and Muay Thai boxers, CPK and LDH activity in the blood increased simultaneously in response to test loads 1 and 2.

Conclusions. Adaptation fails when elite athletes' baseline blood CPK and LDH levels exceed reference values in response to unconventional MMA-specific loads. These changes are accompanied by a reduction in blood cortisol levels, occurring alongside the depletion of creatine phosphate and muscle glycogen reserves, irrespective of the athletes' combat sport discipline. The observed physiological responses to stress stimuli indicate both a low level of adaptation reserves and the development of functional overstrain in elite kickboxers and judokas. The application of the classical MMA training model during functional preparation for competition effectively promotes long-term adaptation, particularly in Greco-Roman wrestlers and judokas. For kickboxers and Muay Thai boxers, such training loads represent insufficient stress stimuli to accumulate creatine phosphate reserves in the muscles.

Key words: mixed martial arts, adaptation reserves, blood biomarkers, test loads, elite athletes.

Мета – вивчити особливості зміни адаптаційних резервів залежно від вихідного рівня резистентності спортсменів різних видів єдиноборств у процесі функціональної підготовки до змагань, використовуючи класичні в Mixed Martial Arts моделі тренувань.

Матеріал і методи. У дослідженні взяли участь 80 елітних спортсменів з різних видів єдиноборств, які протягом 8 тижнів функціональної підготовки до змагань з ММА використовували задану модель тренувань. Учасників розділено на 4 групи по 20 осіб: кікбоксери, таїландські боксери, борці греко-римського стилю, дзюдоїсти. Оцінювали адаптаційно-компенсаторні реакції організму учасників в умовах тестових навантажень (ТН) № 1 та № 2 на початку та наприкінці дослідження. Основною характеристикою ТН № 1 є створення умов, до яких у спортсменів усіх 4 груп буде низький рівень резистентності. ТН № 2 було направлено на виснаження за 20 с енергетичних резервів за рахунок виконання потужних, коронних елементів для кожного з досліджуваних видів єдиноборств. Для оцінки адаптаційних резервів учасників груп та можливих компенсаторних реакцій, а також зриву адаптації використовували біомаркери крові: креантинфосфокіназа, лактатдегідрогеназа, кортизол, креатинін.

Результати. Встановлено, що на початку досліджень вихідний базальний рівень ферментів КФК та ЛДГ у крові перевищує верхні межі референтних значень лише у групах кікбоксерів та дзюдоїстів. Саме у спортсменів цих груп виявили суттєве зниження кортизолу на тлі підвищення КФК та ЛДГ у крові після ТН № 1. У відповідь на ТН № 2 лише в групі дзюдоїстів спостерігаємо зниження параметрів кортизолу, КФК з одночасним підвищенням ЛДГ за верхні межі норми. У групах кікбоксерів та таїландських боксерів у відповідь на ТН № 2 фіксували відсутність зміни активності ЛДГ у крові, що свідчить про реалізацію механізмів короткочасної адаптації. У борців греко-римського стилю у відповідь на такий подразник недостатній рівень резервів креатинфосфату компенсувався накопиченнями м’язового глікогену. Використання протягом 8 тижнів у процесі функціональної підготовки «класичної» в ММА моделі тренувань призвело до базального рівня креатиніну в крові лише у борців греко-римського стилю та дзюдоїстів. Встановлено, що у відповідь на ТН № 1 та № 2 лише у кікбоксерів та таїландських боксерів одночасно підвищувалась активність КФК та ЛДГ у крові.

Висновки. Встановлено, що у разі перевищення референтних значень базального рівня КФК та ЛДГ у крові елітних спортсменів у відповідь на нестандартні для ММА навантаження відбувається зрив адаптації. Відповідні зміни пов’язані зі зниження кортизолу в крові на тлі виснаження резервів кретинфосфату та м’язового глікогену у спортсменів не залежно від виду єдиноборств. Виявлені реакції систем організму на стресовий подразник вказують на низький рівень адаптаційних резервів, а також розвиток функціонального перенапруження одночасно у елітних кікбоксерів та дзюдоїстів. Використання «класичної» для ММА моделі тренувань у період функціональної підготовки до змагань ефективно впливає на процеси довготривалої адаптації переважно борців греко-римського стилю та дзюдо. Для підвищення адаптаційних резервів кікбоксерів та таїландських боксерів подібні навантаження є надто малим стресовим подразником, який би вплинув на накопичення запасів креатинфосфату в м’язах.

Ключові слова: змішані єдиноборства, адаптаційні резерви, біомаркери крові, тестові навантаження, елітні спортсмени.

Introduction. The rapid evolution of professional Mixed Martial Arts competitions in recent years has steadily increased the demands on athletes’ functional capacities and technical skills [11; 13; 18]. Despite the growing popularity of this combat sport, more than 85% of the participants in major tournaments are elite athletes specializing in Muay Thai, hand-to-hand combat, jiu-jitsu, and various styles of wrestling [21; 22]. Their advanced preparation and diverse technical repertoires draw considerable spectator interest to these bouts, making them highly dynamic and visually compelling. However, in most cases, by the end of the first round, the speed and power of attacks decline due to the early depletion of the body’s energy reserves [4; 6; 19].

The issue is that the general training practices of athletes from most other combat sports do not always correspond to the specific demands of MMA competition preparation. Several researchers [10; 12; 16] believe that one of the main ways to address this issue is to optimize training load regimes during the functional preparation of athletes from other combat sports. The practical implementation of this approach is complicated by the absence of a clearly defined mechanism for adjusting training loads during the pre-competition mesocycle, considering athletes' adaptive reserves and their capacity to tolerate external stressors [8; 18].

To study the adaptive and compensatory responses of athletes' physiological systems to training and competitive loads in MMA, researchers have used a broad spectrum of informative blood biomarkers [11; 16; 20]. Most studies have focused on evaluating the basal activity of key enzymes and hormone concentrations in athletes' blood serum, particularly before the competition [14; 15]. Other researchers [5; 6; 18] have examined changes in blood biomarkers in response to training loads that approximate the intensity and volume of competitive performance

However, despite numerous fundamental studies [17; 19; 20], few have specifically investigated the adaptive reserves of athletes from different combat sports during preparation for MMA competitions. Addressing this issue would enable the development of an effective mechanism for adjusting training loads in the pre-competition mesocycle for these athletes, taking into account their adaptation reserves.

Purpose of the study is to examine the characteristics of changes in adaptation reserves based on the initial resistance level of athletes from various combat sports during functional training for competitions, using classical Mixed Martial Arts (MMA) training models.

Materials and methods. A series of experimental investigations was conducted in 2025, eight weeks of specialized functional preparation before the qualifying competitions for the Ukrainian MMA Championship. The research was carried out at MMA training clubs in Kyiv, Mykolaiv, and Chernivtsi. Additional studies were performed at the branches of the Research Center of Modern Kinesiology "KINEZUS" in these cities.

The study involved 80 athletes aged 17 ± 1.2 years (68 Masters of Sport and 12 Candidates for Master of Sport). The average duration of training experience in their combat sport among the male participants was 7.9 ± 1.2 years. The participants were divided into 4 groups of 20 people: kickboxers, Muay Thai boxers, Greco-Roman wrestlers, and judokas.

The Bioethics Committee of Lesya Ukrainka Volyn National University, Ukraine, approved the study design. After receiving detailed information about the potential risks and benefits of the study, all athletes signed a written informed consent in compliance with the Declaration of Helsinki ethical principles.

Laboratory Blood Tests

Changes in selected blood biomarkers, measured before and after two test loads, were used to evaluate the adaptive and compensatory responses of the athletes' physiological systems to a stressor. The activity of lactate dehydrogenase (LDH) and creatine phosphokinase (CPK) in the blood of study participants was determined using the kinetic method. The concentrations of cortisol and creatinine in blood serum were measured by enzyme-linked immunosorbent assay (ELISA). Taking into account the range of reagents used in laboratory conditions, the reference values for the analyzed blood biomarkers were as follows: CPK (39–308 U/L), LDH (135–225 U/L), cortisol (171–536 nmol/L), and creatinine (62–106 μmol/L).

Venous blood samples were collected by a nurse under the supervision of a physician, in accordance with standards for international biomedical research. The blood samples were labeled, thoroughly documented, accompanied by the required paperwork, and transported to a clinical laboratory. In total, 480 samples were collected and analyzed over two stages of the study. Deviations of the measured values from reference norms and the patterns of their changes were evaluated.

Test Loads

Two test loads were designed with different structures, content, intensity, volume, and energy supply, enabling the assessment of participants' adaptive reserves throughout the study.

The primary characteristic of Test Load 1 was the creation of exercise conditions that brought the physiological resistance of athletes from all four groups to a low level. This TL consisted of two exercises: (1) hanging on a horizontal bar with arms flexed and legs held straight at a 90° angle (parallel to the floor); (2) push-ups performed with full flexion and partial (90%) extension, with a 2-second concentric phase and a 5-second eccentric phase. A critical requirement of this TL was to elicit maximal fatigue in the recruited muscle groups (agonists, synergists, and stabilizers) during each exercise, necessitating substantial energy expenditure. Exercises were alternated once a noticeable decline in technical execution was observed. It was caused by the depletion of energy reserves, particularly muscle glycogen. The exercises were performed alternately for a total duration of 3 minutes.

Test Load 2 aimed to deplete energy reserves within 20 seconds by performing powerful, signature elements from the studied combat sports. Over 20 seconds, using the creatine phosphokinase energy system, athletes from different combat sports performed their signature MMA strike or throw combinations. Kickboxers executed a three-strike combination: cross, hook, and roundhouse kick. Muay Thai boxers performed a sequence consisting of a low kick, a jumping knee strike, and an elbow strike. Judokas executed two throws, Ippon Seoi Nage and Tsuri Goshi, at maximum speed and power within the given time. Greco-Roman wrestlers continuously performed the Suplex exercise for 20 seconds, with four athletes of the same weight category taking turns in succession.

Organization of the study

The research was conducted in several stages throughout 2025.

At the initial stage, the baseline level of adaptation reserves was assessed in elite athletes specializing in kickboxing, Muay Thai, Greco-Roman wrestling, and judo who had chosen to prepare for MMA competitions. To achieve this objective, two test loads (TL1 and TL2) were designed, differing markedly in their structure, content, intensity parameters, volume, and underlying energy supply mechanisms.

The athletes' baseline physiological resilience was evaluated by examining their adaptive and compensatory responses to the applied test loads. Blood biomarkers, including CPK, LDH, cortisol, and creatinine, were used as objective indicators of these responses.

At the second stage, a detailed analysis was conducted to identify the most effective contemporary functional training models employed in MMA to enhance athletes' adaptive reserves during the pre-competition mesocycle [4; 6]. Taking into account the specific characteristics of the examined athletes (type of combat sport and level of resistance), participants were assigned a training model with a load regime of $R_a = 0.68$ [13; 18].

This load regime, combined with a series of free-weight exercises performed under anaerobic glycolysis energy supply, acted as a powerful stress stimulus. It was hypothesized that these training loads would enhance the accumulation of creatine phosphate and glycogen in most of the engaged muscle groups. This, in turn, was expected to improve the athletes' physiological resilience during the competition preparation period.

At the third stage, a comparative analysis was performed to examine changes in the basal levels of the studied blood biomarkers in the athletes after eight weeks of adhering to the developed functional training model. The purpose of these investigations was to evaluate the effectiveness of specified training on the athletes' long-term adaptation during the pre-competition mesocycle.

The changes in CPK, LDH, cortisol, and creatinine levels in the participants' blood, in response to acute test loads 1 and 2, were assessed following the eight-week training period. The collected laboratory data were systematically processed and analyzed to identify the athletes' adaptive and compensatory responses to the applied stress stimuli.

Statistical Analysis

Statistical analysis of the study results was performed using IBM SPSS Statistics 26 (StatSoft Inc., USA). The G*Power 3.1.96 program (Germany) was used to determine the minimum required sample size for the study (statistical power calculation). Non-parametric statistical methods were applied to calculate the median (Me) and interquartile range (IQR). The Kruskal-Wallis test was used to compare baseline parameters between groups of athletes. The Wilcoxon signed-rank test was employed to compare two dependent samples. A two-factor Friedman rank analysis of variance was used to compare differences in the dynamics of more than two variables. W-Kendall (Kendall's coefficient of concordance) was applied to determine the level of effect.

Results of the study

Figure 1 graphically presents the changes in CPK levels in the blood of athletes from the examined groups in response to acute test loads 1 and 2. Monitoring of the adaptive and compensatory responses to the applied stimuli was conducted both at the beginning of the study and after eight weeks of using the developed functional training model.

Baseline laboratory control data indicated that the CPK level in the blood of the examined kickboxers exceeded the upper limit of the normal range by 14.2%. Among the participants of the other three groups, the baseline CPK values corresponded to reference norms.

In response to TL1, there was a significant ($p < 0.05$) increase in CPK activity in the blood of kickboxers (+5.7%) and judokas (+10.7%), with values exceeding the upper limit of the normal range. Results after TL2 showed a decrease in CPK levels only in the judoka group (–4.4%, $p < 0.05$). A significant increase in CPK in response to TL2 was observed in the Muay Thai group (+53.6%). Meanwhile, in the Greco-Roman wrestlers, CPK activity did not change in response to either TL1 or TL2.

The data collected after eight weeks of implementing the proposed functional training model demonstrated significant changes in the pattern of CPK responses to the test loads. The baseline CPK level decreased in the kickboxers (–41.4%), Greco-Roman wrestlers (–13.7%), and judokas (–51.8%). Among the Muay Thai athletes, the basal level of this biomarker rose 2.4-fold, approaching the normal upper threshold.

Applying TL1 resulted in a 21.8% rise in CPK levels among kickboxers, while in Muay Thai athletes (+10.9%), the values went beyond the reference range. The data collected after TL2 indicated elevated CPK levels in each of the four groups.

Figure 2 presents the baseline levels and changes in LDH activity in the blood of study participants in response to acute Test Loads 1 and 2. Monitoring of the changes in this blood biomarker in response to the applied loads was conducted both at the beginning of the study and after eight weeks of functional training.

Analysis of the results obtained at the beginning of the study indicates that the baseline LDH activity in the blood of kickboxers (+6.2%) and judokas (+9.8%) exceeded the upper limit of the normal range. In response to Test Load 1, a significant increase in LDH levels was observed across all groups, particularly in Muay Thai boxers (+25.6%). In response to Test Load 2, an increase in this biomarker was recorded only in Greco-Roman wrestlers (+8.5%) and judokas (+4.4%). After eight weeks of using the developed functional training model, the baseline LDH level decreased in all groups except the Muay Thai boxers, who increased it by +16.8%.

In response to Test Load 1, LDH activity increased in all groups, particularly in Muay Thai boxers (+21.9%) and judokas (+26.1%). After Test Load 2, the most pronounced increases in this biomarker were observed in Greco-Roman wrestlers (+17.9%) and judokas (+18.1%). However, in the Muay Thai group, LDH levels did not change in response to this stimulus under the same conditions.

Figure 3 presents the changes in cortisol concentration in the blood of athletes from the examined groups in response to acute Test Loads 1 and 2. The manifestations of short-term adaptation mechanisms and compensatory responses to stress stimuli were monitored both at the beginning of the study and after eight weeks of using the developed functional training model.

The results obtained at the beginning of the study indicate that cortisol concentration increased only in the Greco-Roman wrestlers (+22.9%) in response to TL1. In the other three groups, a significant ($p < 0.05$) decrease in this biomarker was observed in response to the stress stimulus, particularly in judokas (–14.7%).

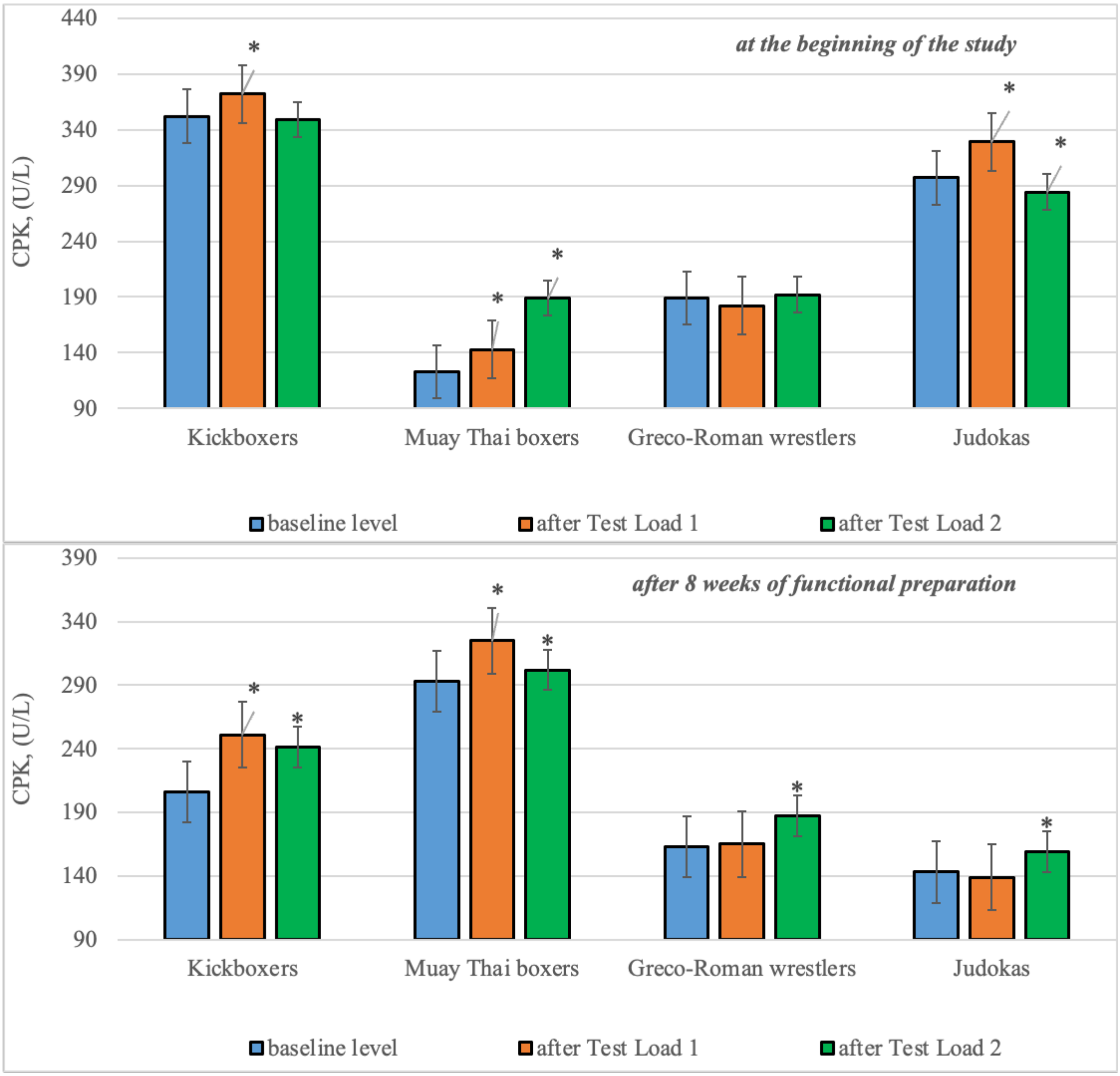

Fig. 1. Changes in creatine phosphokinase activity in the blood of athletes from the examined groups in response to test loads 1 and 2 at the beginning of the study and after 8 weeks of functional training, n = 80

Note: p < .05 – compared with pre-load values, at the state of rest.

Following TL2, a decline in cortisol levels was detected only among the judokas (–19.9%). In the other participants, cortisol levels increased in response to this stress stimulus, especially in Greco-Roman wrestlers (+34.4%). However, all measured values of this biomarker remained within the reference range. After eight weeks of specialized functional training, baseline cortisol levels decreased in Muay Thai boxers (–31.1%) and judokas (–17.4%), and increased in Greco-Roman wrestlers (+13.0%) and kickboxers (+13.5%).

In response to TL1, a 5.2% decrease in blood cortisol concentration ($p < 0.05$) was observed only in kickboxers, while the Muay Thai athletes exhibited the highest increase (+17.7%).

During TL2, cortisol concentrations increased in all groups compared to the state of rest. However, in the Greco-Roman wrestlers and judokas, cortisol levels were almost four times higher than in athletes representing striking combat styles.

Figure 4 presents the changes in creatinine concentration in the blood of the examined groups during Test Loads 1 and 2. Changes in blood creatinine were evaluated at rest and after the loads, both at the beginning of the study and after eight weeks of functional training using the developed training model.

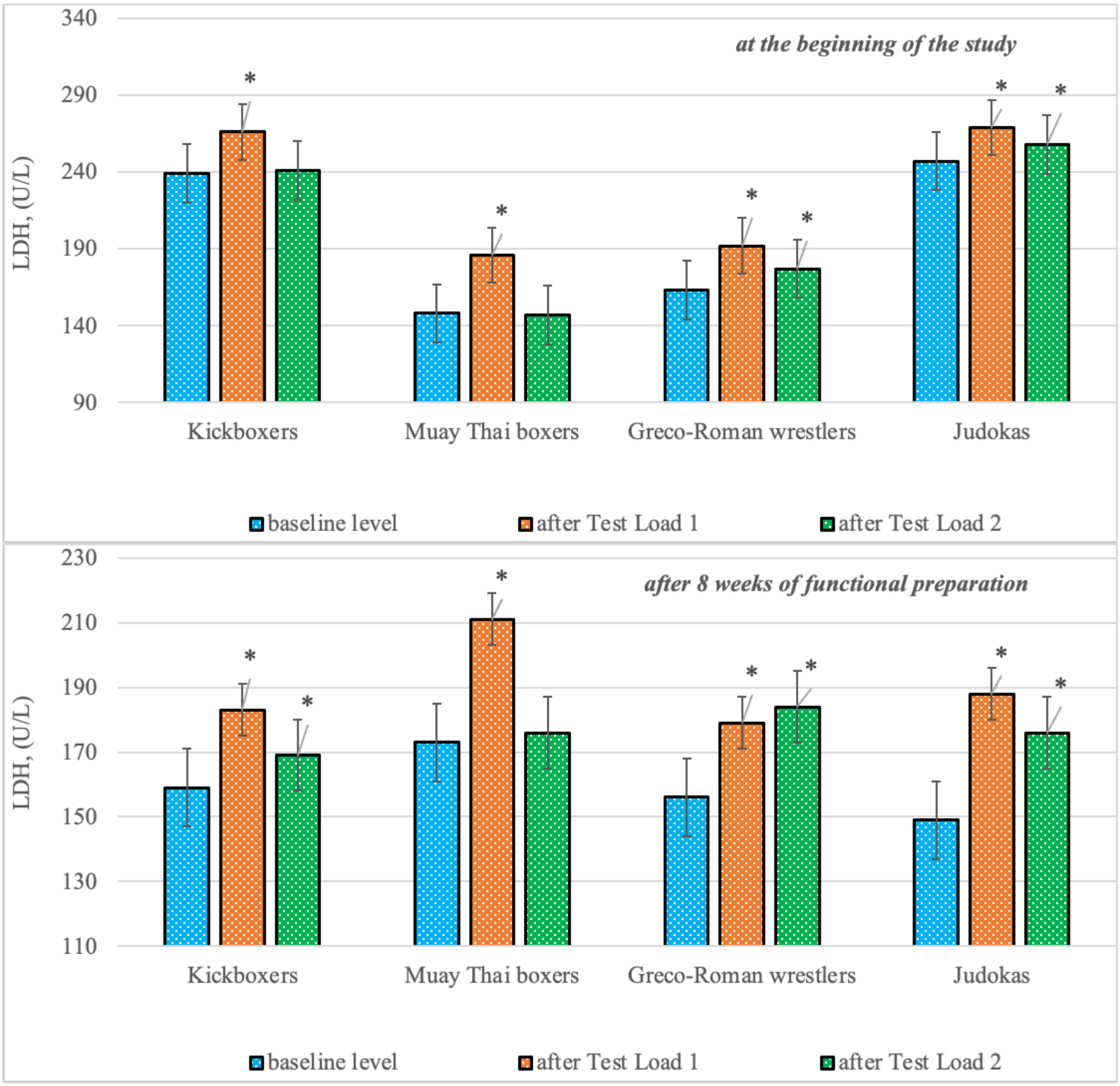

Fig. 2. Changes in lactate dehydrogenase activity in the blood of athletes from the examined groups in response to Test Loads 1 and 2 at the beginning of the study and after 8 weeks of functional training, n = 80

Note: p < .05 – compared with pre-load values, at the state of rest.

The basal creatinine levels in the serum of the participants at the beginning of the study were within the reference range. In response to Test Load 1, all four groups exhibited an average increase of 8.8% in serum creatinine concentration ($p < 0.05$). A similar pattern of changes was observed after Test Load 2, but the increase was slightly more pronounced, by 2–3%, across all examined athlete groups.

After completing the eight-week functional training program, elevated basal creatinine levels were recorded only in the Greco-Roman wrestlers (+11.5%) and judokas (+11.0%). In response to TL1, nearly identical increases in blood creatinine were observed across all groups, averaging +7.6% ($p < 0.05$). The results following TL2 showed a similar pattern and magnitude of changes in this biomarker across all examined groups, with an average increase of +6.7%.

Discussion. This study presents an approach for assessing the baseline level of adaptive reserves through blood biomarkers in elite martial arts athletes preparing for MMA competitions. It addresses one of the most debated issues among MMA coaches and researchers: the search for an effective functional training model for this category of athletes [4; 11; 13]. The challenge becomes especially pressing when adjust-

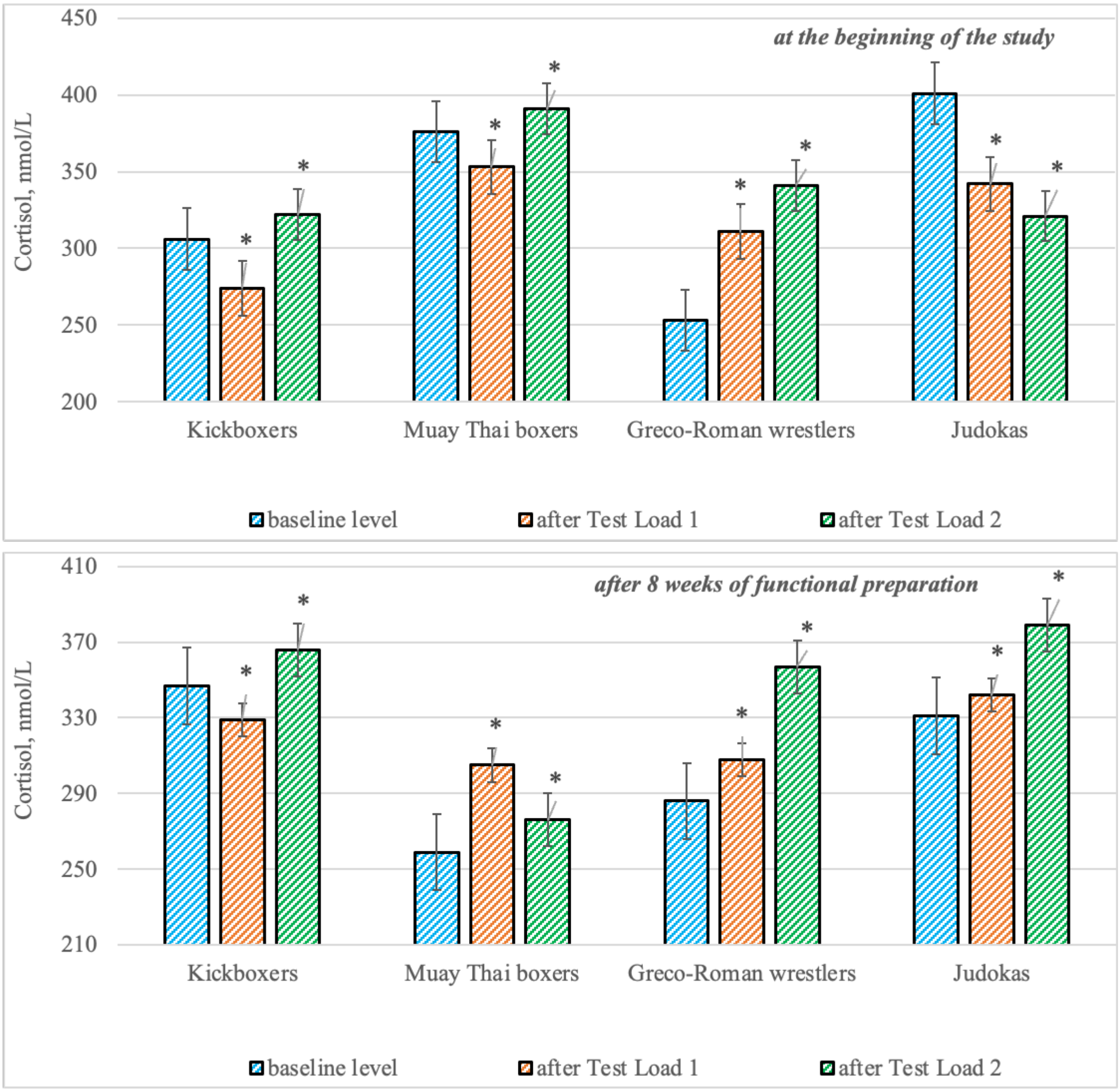

Fig. 3. Changes in cortisol concentration in the blood of athletes from the examined groups in response to Test Loads 1 and 2 at the beginning of the study and after 8 weeks of functional training, n = 80

Note: $p < .05$ – compared with pre-load values, at the state of rest

ing training loads to achieve maximal adaptation reserve development during the pre-competition mesocycle [18; 21]. Implementing this approach is complicated by the participants' (elite kickboxers, Muay Thai athletes, Greco-Roman wrestlers, and judokas) high resistance to loads that deviate by 75–80% from classical MMA training standards.

One of the key issues during preparation for competitions is studying the features of adaptive and compensatory responses in athletes from other combat sports under conditions using the most common MMA training models [6; 12; 19]. Changes in basal levels of blood biomarkers (CPK, LDH, cortisol, and creatinine) were examined in athletes over an eight-week training period using a classical functional MMA training model. A comparative analysis of biomarker responses to acute test loads enabled the assessment of participants' short-term adaptive capacity and the activation of compensatory processes induced by energy deficits. The research evaluated whether the developed test loads could effectively assess adaptive reserves in athletes from different sports, using blood biomarkers during their functional preparation for MMA.

At the beginning of the study, the baseline levels of CPK and LDH in the blood exceeded

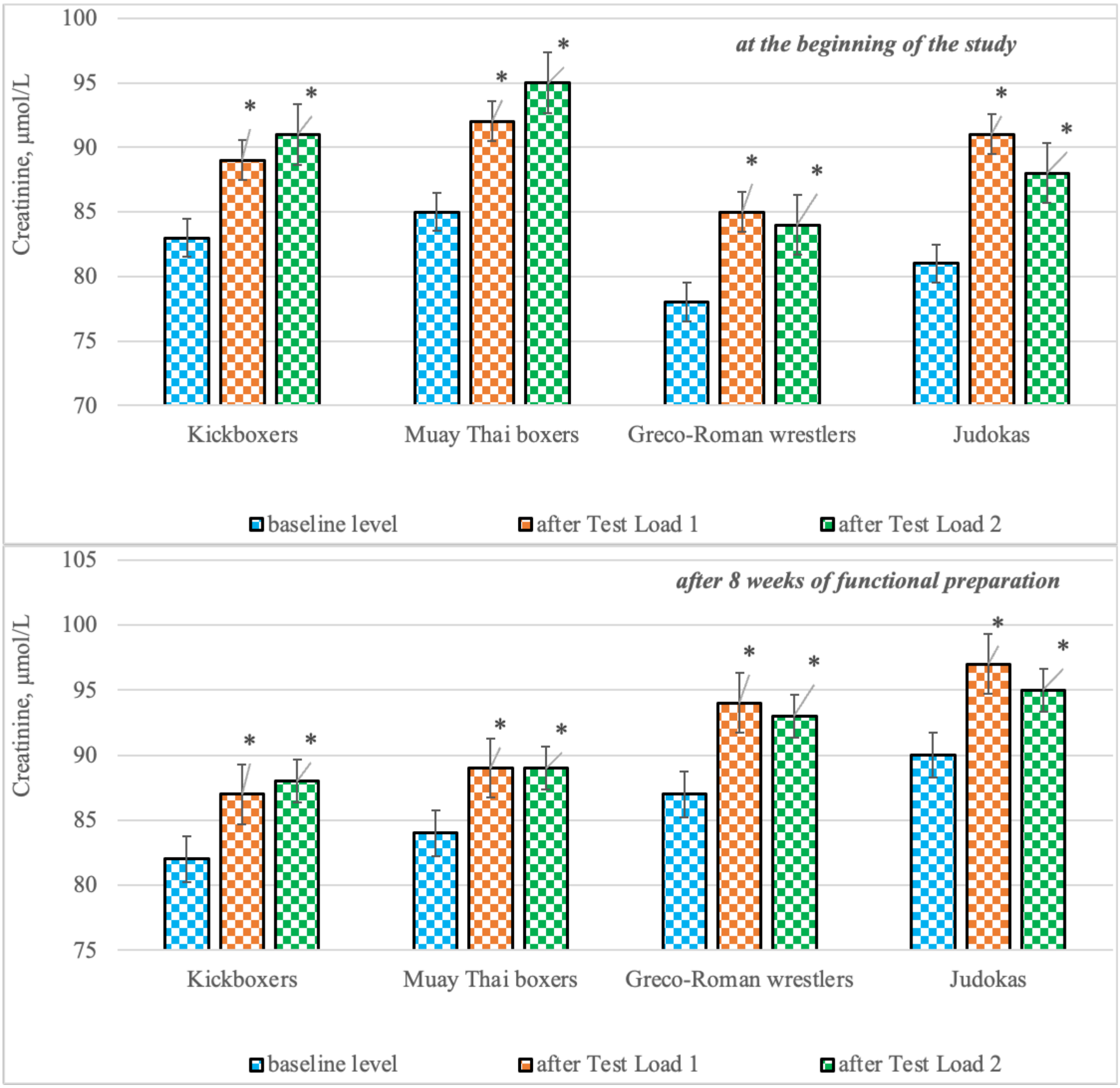

Fig. 4. Changes in creatinine concentration in the blood of athletes from the examined groups in response to Test Loads 1 and 2 at the beginning of the study and after 8 weeks of functional training, n = 80

Note: $p < .05$ – compared with pre-load values, at the state of rest

the upper reference limits only in kickboxers and judokas. These results indicate pronounced manifestations of functional overstrain [8; 16] due to training or competitive loads, leading to damage in the most active muscle groups. At the same time, the parameters of other blood biomarkers (cortisol, creatinine) remained within normal ranges among athletes in all four groups.

Evaluation of adaptive and compensatory responses to TL1 revealed a significant decrease in cortisol accompanied by increases in CPK and LDH, specifically in kickboxers and judokas. The observed changes in blood biomarkers under combined anaerobic and aerobic glycolytic conditions indicate the engagement of compensatory mechanisms due to adaptation failure [5; 13; 14].

In response to TL2, only the judokas exhibited a decrease in cortisol and CPK levels, accompanied by an increase in LDH above the upper reference limits. It should be noted that this load was performed for 20 seconds and relied on energy supply from the creatine-phosphokinase system.

Such changes in the studied blood biomarkers indicate depletion of creatine phosphate and muscle glycogen reserves in the recruited muscle groups, which led to the forced activation of gluconeogenesis processes [3; 6]. The absence of LDH activity changes in kickboxers and Muay Thai athletes following TL2 reflects the operation of short-term adaptation mechanisms [12; 18]. Greco-Roman wrestlers compensated for low creatine phosphate levels through increased muscle glycogen, indicating adaptation to anaerobic glycolysis-based loads [7; 9; 16].

After eight weeks of implementing the most common MMA functional training model during the pre-competition mesocycles, the results revealed a distinctly different pattern of adaptive changes.

The significant rise in baseline creatinine levels observed in Greco-Roman wrestlers and judokas reflects an increase in muscle mass resulting from long-term adaptive processes [5; 8]. At the same time, representatives of the other three groups showed stabilization of baseline blood biomarker levels within the reference range compared with initial measurements. The obtained results suggest that the loads used in the proposed functional training model were not excessively stressful for most participants [13; 18].

In certain cases, training with a similar load regime promoted the recovery and re-adaptation of physiological reserves in participants who had previously shown signs of functional overstrain [3; 4]. However, in elite athletes, their level of resistance does not improve if 60–70% of training sessions do not include a stress stimulus that exceeds the body's current adaptive capacity [11; 15].

In response to the three-minute TL1, simultaneous increases in blood CPK and LDH activity were observed only in kickboxers and Muay Thai athletes. This occurred although energy during this test load was supplied primarily from muscle glycogen under conditions of anaerobic and partially aerobic glycolysis [10; 17; 22].

Following TL2, which relied on the creatine-phosphokinase energy mechanism, all measured blood biomarkers in the athletes increased, yet stayed within normal reference values. Unlike the initial findings, the applied stimulus triggered elevations in both LDH and CPK in kickboxers and Muay Thai athletes, reflecting an adaptive response. The additional recruitment of muscle glycogen under creatine-phosphokinase energy conditions during intense muscle activity indicates reduced resistance due to depletion of creatine phosphate reserves [1; 2; 20].

The observed patterns of energy reserve changes in the examined wrestlers and judokas, resulting from the applied functional training model, indicate pronounced adaptation responses [6; 19].

Conclusions. Using blood biomarkers is an effective mechanism for assessing the correspondence between the adaptation reserves of athletes from different combat sports and the classical MMA training loads during the phase of functional preparation for competition. The study results indicated that unconventional MMA-specific loads caused adaptation failure in elite athletes whenever basal CPK and LDH levels surpassed the reference range. The observed alterations correspond to reduced blood cortisol levels in the context of creatine phosphate and muscle glycogen depletion, irrespective of combat sport discipline.

The observed physiological responses to stress stimuli indicate low adaptation reserves and the development of functional overstrain, particularly in elite kickboxers and judokas. Under conditions of creatine-phosphokinase energy supply during high-intensity activity, only judokas exhibited compensatory reactions, whereas kickboxers relied on short-term adaptation mechanisms.

The classical MMA functional training model applied during the pre-competition phase was most effective in promoting long-term adaptation in Greco-Roman wrestlers and judokas. However, such loads provide an insufficient stress stimulus to accumulate creatine phosphate reserves in the muscles of kickboxers and Muay Thai athletes.

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