

Developing a training strategy for teenage athletes in mixed martial arts for high-level competitions

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Abstract:

Background: With the increasing demands faced by teenage athletes in mixed martial arts (MMA) competitions, there is a pressing need for scientists to develop innovative training. This study aims to formulate a strategy for training teenage athletes to excel in high-level MMA competitions, leveraging the physiological characteristics of neuromuscular system adaptation to stress-inducing stimuli. Additionally, the practical efficacy of this strategy is to be assessed. **Materials and methods:** The research encompassed 24 male athletes, representing various age and weight categories of the Ukrainian national youth team in MMA: U14 (G02–G05), U16 (F01–F04) and U18 (E03–E06). At first, the results of athletes' performance at the 2022 MMA World Championships were analyzed. The training procedures for these competitions were analyzed. In the second stage, the strategy for sportsmen's preparation for the World MMA Championship 2023 was developed. It employed physiological features of the neuromuscular system adaptation to stressful stimuli. An innovative system of training management was implemented. The mechanisms for improving the functional support of technical actions in fights were developed. In the third stage of the study, a comparative analysis of the athletes' performance at the World MMA Championships in 2022 and 2023 was carried out. **Results:** The 2nd place at the 2022 MMA World Championship was won by the study participants due to the successful implementation of suffocation and painful techniques. 20% of the victories in fights depended on the referees' decision. The strategy for training athletes for similar MMA competitions in 2023 was based on maximizing the adaptive potential of the neuromuscular system. The strategy implementation allowed for winning first place at the World MMA Championship 2023. The dynamics primarily increased owing to the growth of the maximum strength and adaptive body reserves, as well as a change in the priority of using technical actions. The number of victories by knockout and technical knockout doubled compared to similar competitions of the previous year. The number of victories obtained by referees' decisions decreased by 3.5 times, which reduced the possibility of errors during judging. **Conclusions:** Developing a strategy for training teenage MMA athletes requires a detailed study of the physiological processes of the neuromuscular system adaptation to different load modes. The efficiency of performed technical actions and their priority depends on the functional capabilities to carry out these tasks. An important factor of the training system is the validity of using power load regimes depending on the expediency of increasing adaptive reserves of priority muscle groups.

Keywords: training strategy, adaptive reserves, MMA, competition, neuromuscular system, teenage athletes.

Introduction

The growing popularization of MMA training among adolescents indicates the need for a more in-depth study of the training system, taking into account age-related physiological characteristics (Bešlija et al., 2021; Bueno et al., 2022). This circumstance is justified by using a large arsenal of technical actions (punches, throws, painful and suffocating techniques) that athletes should use during fights (Naiara et al., 2019; Antonietto et al., 2023). At the same time, such a variety of combined technical actions during a fight requires a sportsman to have the ability of their technical realization and at the same time the appropriate level of functional capabilities. This correlation between the size of an external stressful stimulus and the level of adaptive reserves of an organism is especially important in pre-competitive mesocycles and during competitions (Barley et al., 2021; Manolachi et al., 2023).

The problem of finding effective ways to improve the training system in MMA has been focused on by many specialists in recent years (Chernozub et al., 2022; Kabaday et al., 2022). Most studies are devoted to the

problem of optimizing training loads and improving the technical skills of athletes (Ciacconi et al., 2023; Faro et al., 2023). Several researchers (Chernozub et al., 2018; Lane & Briffa, 2020; Smajla et al., 2022) studied the issues related to the specifics of training athletes in the striking or wrestling style of fighting. First of all, these studies solved the problems concerning the correspondence of power load training regimes to the level of an athlete's body resistance to a similar physical stimulus. Researchers in sports physiology pay attention to studying the issues related to adaptation-compensatory reactions in response to training loads and competitive activity (Ouergui et al., 2022; Stepanyan et al., 2023; Wang et al., 2023).

The analysis of the MMA research results presented in the scientific literature shows that the vast majority of them were conducted with athletes over 18-20 years old (Faro et al., 2023; Folhes et al., 2023; Manolachi et al., 2023). There have been no in-depth studies on the physiological processes of adaptation of adolescent athletes during MMA training and their combination with different load modes. There is also no research concerning the regularities of developing different types of force in this sport depending on the physiological features of the neuromuscular system of teenagers. Such studies should include the physiological priority of certain muscle group activation while performing technical actions in MMA. There are no research results that would have a scientific justification for the expediency of changing the priority of technical actions (strikes, throws, techniques). The study of this problem will allow for revealing the optimal mechanism of correcting the structure of tactical combinations during fights depending on the athlete's characteristics. It mainly concerns the increase of efficiency of attacking, counterattacking, and defensive actions due to the adequacy of training loads to adaptation body reserves of a sportsman in competitive activity.

The study aim. To develop a strategy for training adolescent athletes for high-level MMA competitions engaging physiological characteristics of the neuromuscular system adaptation to stressful stimuli. The practical implementation of this strategy and its effectiveness must be also determined.

Material & methods

Participants

The research involved representatives of the Ukrainian youth national MMA team, who participated in the World MMA Championships in 2022 and 2023. 24 athletes (aged 13-16) of different age and weight categories: U14 (G02-G05); U16 (F01-F04); U18 (E03-E06) took part in the study. The training process and preparation of these athletes for both World Championships took place in the sports club "Saigon" in Chernivtsi (Ukraine).

Following the ethical standards of the Declaration of Helsinki, the algorithm and methods of the study were approved by the Ethical Committee for Biomedical Research of Lesya Ukrainka Volyn National University. According to the recommendations of biomedical research ethics committees (WHO Regional, 2000) the study participants and their parents provided written consent.

Analysis of the competition results

The 2022 MMA World Championship was held in Nashville, Tennessee, USA. The 2023 MMA World Championship was held in Alexandroupolis, Greece. A comparative analysis of the Ukrainian national youth team's performance at these competitions was carried out based on studying the protocols and video recordings of the fights.

183 protocols of competitions where the study participants took part were analyzed. One of the priority tasks of the study was to determine how the athlete won or lost each fight. Control over competitive activity was based on the analysis of the results of the total number (%) of victories in fights by a certain variant: by referee's decision, knockout, clear advantage (technical knockout), suffocation, and painful technique. When analyzing the protocols of fights with a victory, the following data were determined: punches or throws that led to a knockout; a series of punches that led to a technical knockout; painful and suffocating techniques that were effective, the style of fighting (striking or wrestling).

The video recordings of the study participants' fights during the competitions at the MMA World Championships 2022-2023 were also carefully analyzed. It was aimed at determining the priority of using individual kicks, throws, and painful or suffocating techniques, as well as their combinations. Not only the technique of performing actions during fights was determined, but also the ability to implement them depending on combinations of actions and athletes' physical fitness. Based on the video analysis the expediency of using certain technical actions depending on individual abilities of teenage athletes was determined.

Analysis of pre-competitive training in MMA

The analysis of pre-competitive training in MMA was carried out to observe using the physiological priority of activation of certain muscle groups while performing technical actions. There was a system analysis of applying kinematic characteristics when performing technical actions in MMA: kicks, throws, suffocating and painful techniques, and submissions. The study involved the frequency of developing maximum and static strength, strength endurance, loading modes, and features of individual adaptation of the neuromuscular system of athletes. The protocols of pre-competitive mesocycles concerning the priority of using technical actions were studied. The correction mechanisms of the structure of tactical combinations during fights were analyzed depending on the individual features of teenage sportsmen.

Experimental design

In the first stage of the study, the results of the Ukrainian national youth team's performance at the 2022 MMA World Championship were analyzed. A detailed analysis of preparing the members of the national team for these competitions was carried out. In the second stage, a strategy was developed to prepare teenage MMA athletes for the 2023 World Championship. The strategy took into account the athletes' physiological characteristics of the neuromuscular system adaptation to stressful stimuli. The developed strategy allowed for the implementation of an innovative management system for training athletes of this age in MMA. The mechanism of increasing functional maintenance of technical actions in fights was developed. It depends on individual features of developing strength and active involvement of the main muscle groups. At this stage, there was a practical application of the developed strategy in the training of teenage MMA sportsmen. In the third stage of the research, a comparative analysis of the Ukrainian national youth team's performance at the World MMA Championships in 2022 and 2023 was carried out.

Statistical analysis

The statistical analysis of the research results was performed using the IBM *SPSS*Statistics 26 program package (StatSoftInc., USA). Nonparametric methods of mathematical statistics were used. Median, interquartile range (IQR) were determined. The G-Power 3.1.96 program was used to calculate statistical power (determining the smallest sample size for the study). The non-parametric Wilcoxon T-test was used to compare the results of the Ukrainian national youth team's performance at two MMA World Championships.

Results

Figure 1 presents the management system of training MMA teenage athletes, taking into account the physiological characteristics of the neuromuscular system adaptation to a stressful stimulus. The proposed algorithm of actions was developed based on a preliminary detailed study of the peculiarities of the Ukrainian national youth team's preparation for the 2022 MMA World Championship. The structure of the training process, load parameters, features of physical and technical training, and their combination with age-related physiological processes of adaptation were evaluated. The research showed that the system of training teenage athletes differs from adults only in terms of load volume and intensity. However, despite a similar approach to the training system for teenage athletes, the youth team managed to win second place at the MMA World Championship in 2022.

One of the main parts of the developed system of management is a detailed analysis of the results of previous competitions (Fig. 1). We studied the options for ending the won fights by knockout, technical knockout, painful or suffocating hold. The list of individual technical actions (kicks, throws, painful and suffocating techniques) or their combinations that allowed athletes to win was also determined.

There is a wide range of technical actions used in MMA, which is why one of the main tasks is to determine the most priority complex for each athlete. The solution to this task requires determining the ratio of activity and involvement of muscle groups used by the athlete during effective technical actions. The obtained results allow for defining muscle groups that need additional development of maximum, static force, or power endurance. It is especially important in the case of using a combination of several different kicks or their combination with throws and transition to struggle.

The proposed mechanism of selective increasing the strength capabilities of agonist and synergist muscle groups for effective technical actions and variants of their combinations (fig. 1). The performance of suffocating and painful techniques requires the development of power endurance and static force of agonist and synergist muscle groups that fulfill these technical actions. Athletes of the striking style of fighting need mainly accelerated development of the maximum explosive force of the agonist muscles by increasing the number of active muscle motor units. The realization of a technical knockout requires the simultaneous development of power endurance and explosive power of agonist muscle groups that take part in counterattacking and attacking combinations.

Selective increase of strength capabilities of some muscle groups leads to the change in priority of using a complex of technical actions during fights. The predicted changes will occur during attacking, counterattacking, and defensive actions. These changes occur as a result of the following factors: change in the level of adaptation body reserves; an increase of the level of resistance to a stressful stimulus in conditions of a fight; development of variable combinations of kicks, throws, suffocating and painful techniques depending on changes in functional capabilities.

Figure 2 shows the mechanism of increasing the functional maintenance of technical actions in MMA depending on individual features of strength development in teenage sportsmen. Determination of the work duration before the decrease of muscle group power providing the technical action performance will allow for the establishment of the energy supply type. Establishing the priority of anaerobic-alactate or anaerobic-lactate type of energy supply of kicks and throws or a series of their combinations helps to define the training mode of power loads.

A detailed analysis of the activity of each muscle group involvement allows for predicting the training correction. Load indicators depend on the level of development of agonist, synergist, or stabilizer muscle groups that ensure the effectiveness of the technique or kicks. Combining the results of determining the type of energy supply and the priority of involving muscle groups that ensure the performance of technical actions will accelerate

the improvement of strength training. This process will be mainly directed at increasing the number of active motor units of agonist and synergist muscle groups and growing adaptation body reserves of sportsmen.

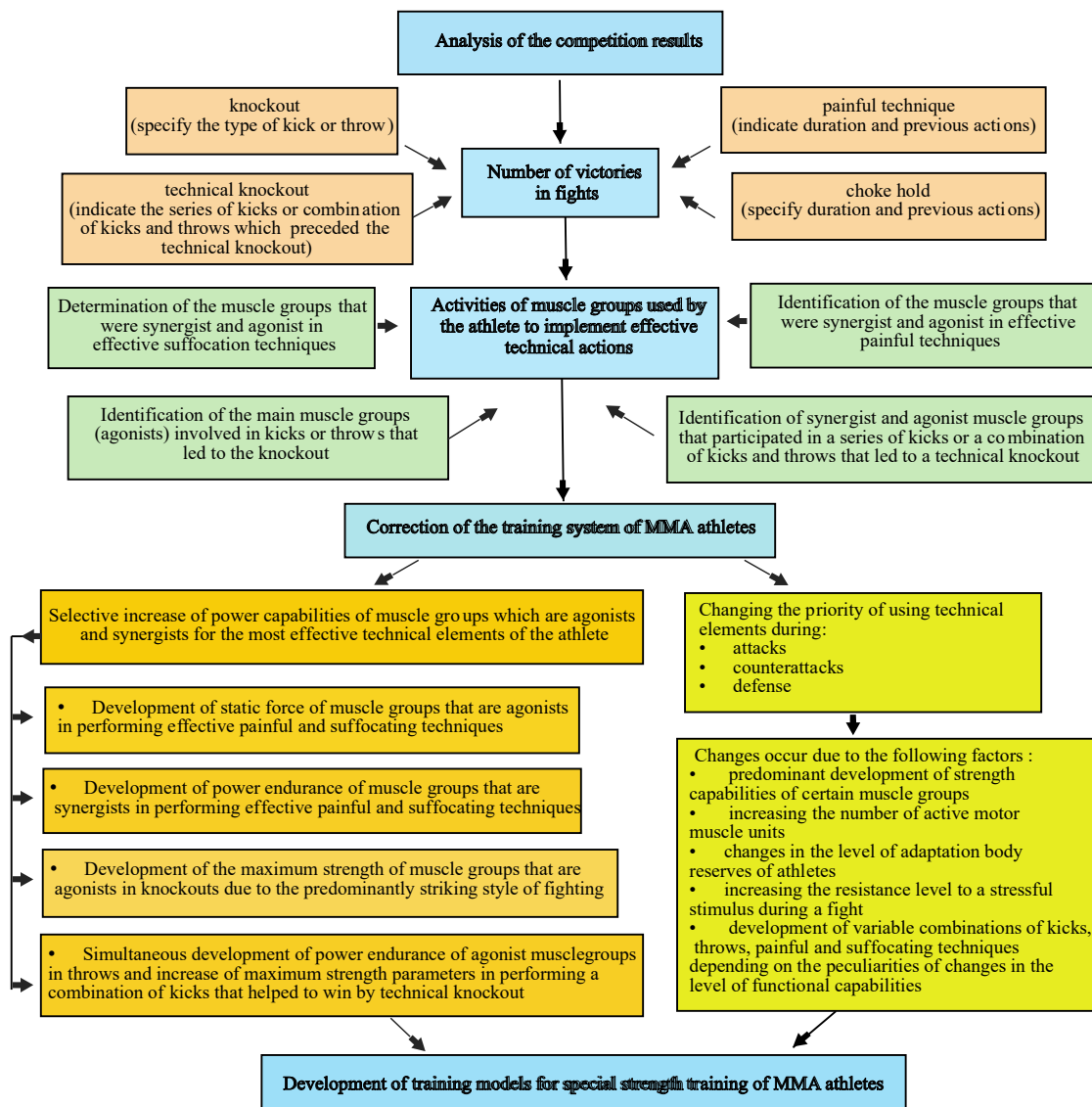


Fig. 1. The system of management of MMA teenage athletes training implementing physiological features of their neuromuscular system adaptation to a stressful stimulus

The variant of improving power training of teenage MMA athletes implies the selective development of strength in a certain group of muscles. First of all, it concerns the development of maximal and static force, and power endurance of sportsmen, depending on features of technical actions. A combination of different intensity power load modes and correlation of variants of training exercises for certain muscle groups was developed.

The development of power load modes and exercises for certain muscle groups was carried out using generally accepted methods in power fitness [2]. For example, using high-intensity loads in basic exercises for agonist muscle groups helps to increase the number of active motor muscle units. At the same time, similar loads on synergist muscle groups will lead to an increase in intermuscular coordination and an increase in creatine phosphate reserves. These adaptation body changes will lead to the growth of maximum and explosive force which increases the effectiveness of kicks and throws.

Thus, the mechanism of increasing functional support of technical actions changes the system of management of MMA teenage training. These changes occur in the system of training correction taking into account individual physiological features of the neuromuscular system adaptation to a stressful stimulus.

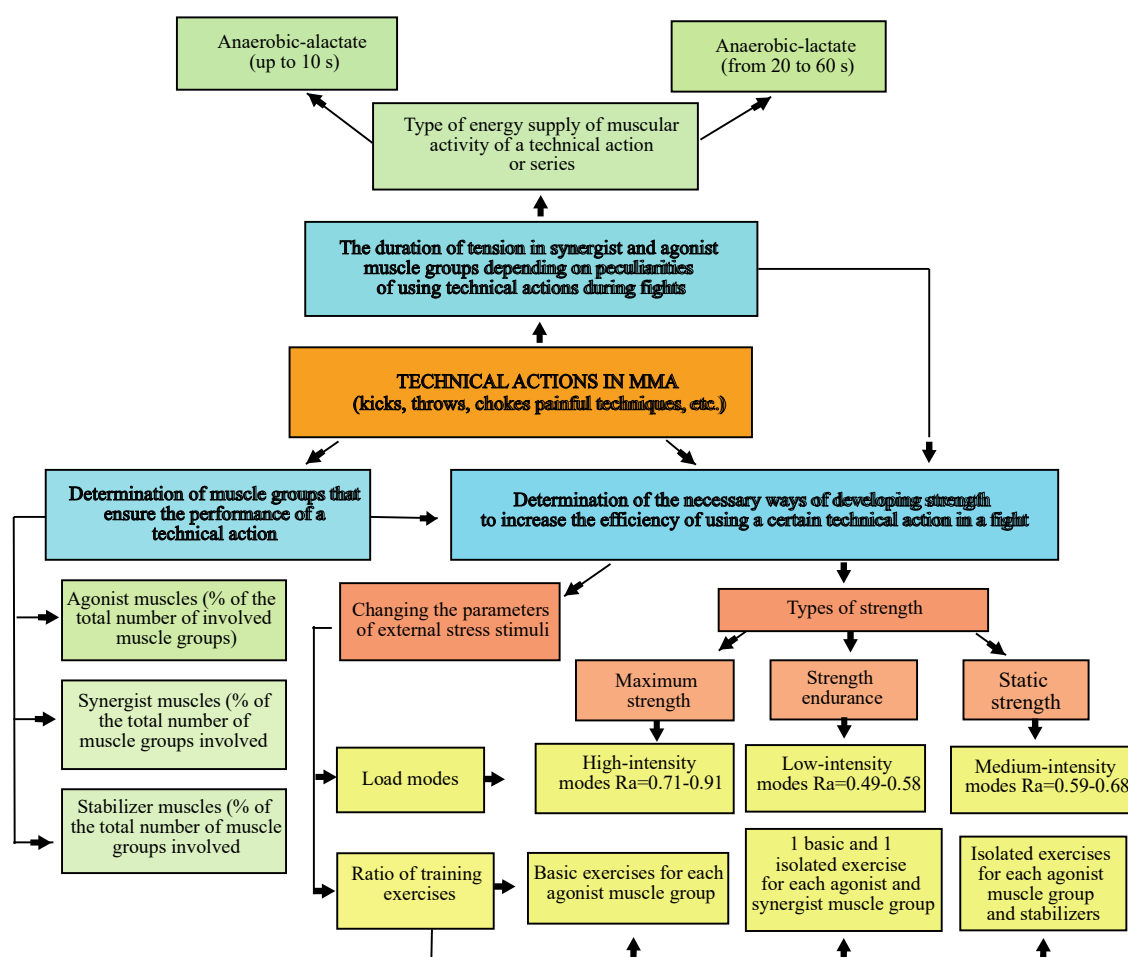


Fig. 2. The mechanism of increasing functional maintenance of technical actions in MMA depending on individual features of the strength capabilities development and priority of muscle group involvement

A comparative analysis of the results of the Ukrainian national youth team's performance at the World Championships in 2022-2023 is presented in Figure 3. The control was based on the analysis of the total number (%) of victories in the fights recorded in competition protocols. The following variants of winning fights were selected: by the referee's decision, knockout, clear advantage (technical knockout), suffocation, and painful technique.

The analysis of the results of the Ukrainian MMA teenage athletes' performance at the World Championship in 2022 shows that the greatest number of victories in fights was obtained by suffocation (35.0%) and painful (25.0%) techniques. This fact indicates that perhaps the vast majority of athletes of the youth national team use the wrestling style of fighting. It is also possible to justify the advantage of getting victory in fights by this variant due to the development of power endurance and static force in sportsmen. The smallest number of victories in these competitions (5.0%) was obtained by knockouts. This may be justified by the age characteristics of the participants, or by the low level of maximum strength development or insufficient energy supply. At the same time, a fairly high percentage (20.0%) of the victories were won by referee decisions, which is not always a clear criterion for determining the winner of a fight. Depending on the circumstances and personal approach to the athlete's actions during the fight, the victory may be given to an athlete notwithstanding a clear advantage over his opponent.

The results of the study participants' performance at the 2023 World Championship demonstrate a completely different ratio of certain options for winning fights compared to previous competitions. These changes can be attributed to the strategy for training teenage athletes used in the process of preparation for the World Championship. This strategy applied the physiological characteristics of the neuromuscular system adaptation to a stressful stimulus which helped in achieving better results. The offered system of management of teenage athletes' training and the mechanism of increasing functional maintenance of technical actions in MMA was used during 3 mesocycles.

The results of the Ukrainian teenage MMA athletes' performance at the 2023 World Championship showed that the largest number of victories (31.0%) in fights was obtained by technical knockout (by a clear

advantage over the opponent). The video analysis of these fights showed that in most cases the referee suspended the fight in the absence of the fighter's ability to defend himself from repeated kicks of the opponent. This indicates the power of attacking or counterattacking kicks and throws and the ability to use them during repeated series. These changes occur only if athletes increase their maximum strength and power endurance and have high adaptive body reserves.

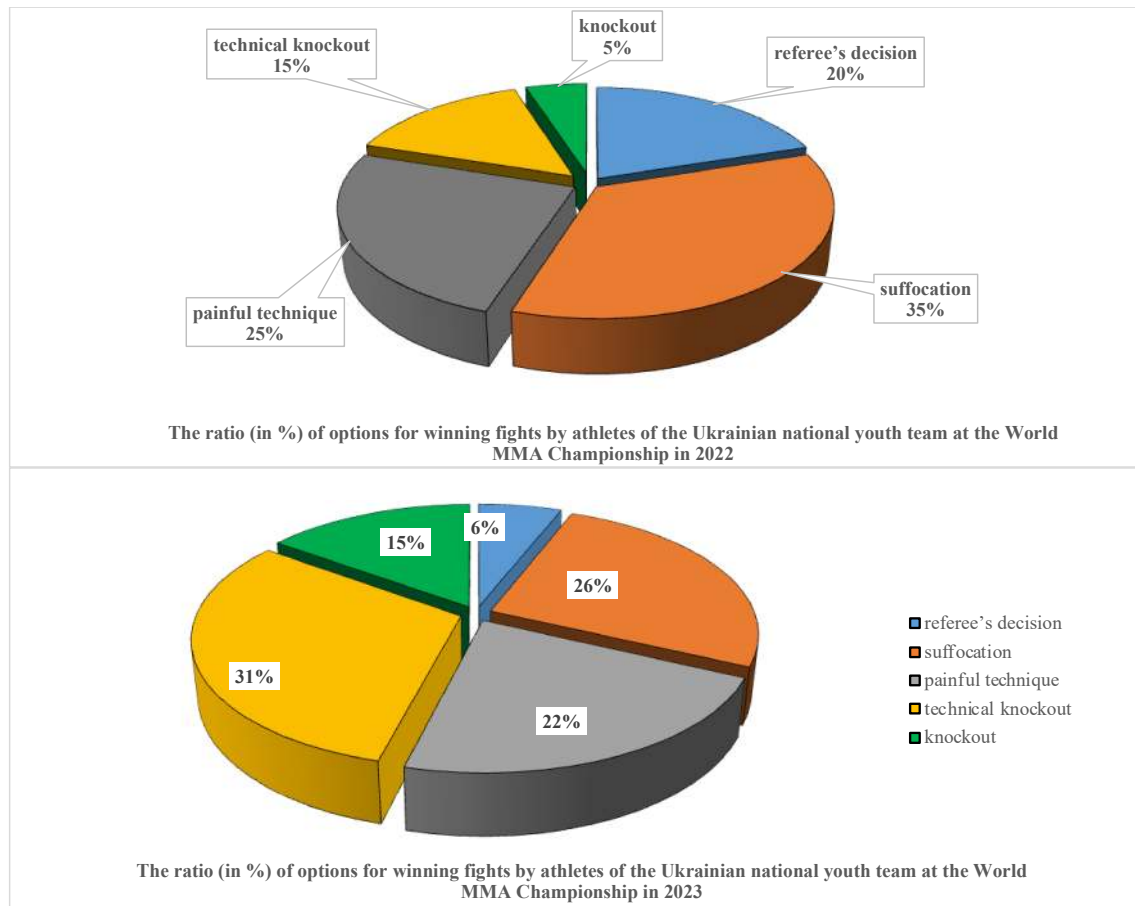


Fig. 3. Comparative analysis of the results of the Ukrainian national youth team performance at the World MMA Championships 2022-2023

One of the peculiarities of the 2023 World Championship is that athletes increased the number of knockout victories by 3 times compared to the previous competition results. It is well-known that kicks to the head are prohibited at such competitions. Thus, the performance of knockouts is possible only by applying kicks to the body. This fact indicates an increase in the technical skill of performing kicks to trigger points of the body (liver, spleen, abdominal plexus of nerve ganglia). Using high-intensity power loads during training by athletes with a striking style of fighting led to an increase in their performance. The development of the maximum and explosive force of sportsmen took place due to the increase in the number of active motor muscle units and reserves of creatine phosphate.

Comparing the results of competitions presented in Figure 3 showed that the quantitative indicator of victories in fights by the referee's decision decreased by 3.3 times. It became possible due to increasing the number of victories by knockout and technical knockout, which reduced the percentage of referees' ability to make controversial decisions.

The number of victories obtained by athletes of the Ukrainian national youth team at the World Championships in 2022-2023 by painful techniques does not differ statistically. This fact indicates that the effectiveness of the implementation of painful techniques primarily depends on the level of the athlete's technical skill. However, the number of victories by chokehold decreased by 9.0% ($p < 0.05$) after practicing the strategy for training MMA teenage athletes developed by the authors of the study. These dynamics are grounded by the change of priority of using some techniques and kicks in attacking and counterattacking actions. The change in priority can be also connected with the increase of adaptation body reserves to perform kicks and throws with the necessary power. These adaptive changes in the level of functional maintenance of technical actions are caused by the increased ability of the neuromuscular and energy systems to counteract an external stressful stimulus.

Discussion

This research focuses on studying the influence of different strategies for training MMA teenage athletes on their performance in competitive activity. This mainly concerns the practical implementation of the suggested strategy at the 2023 World Championship during 3 mesocycles of training. One of the directions of this study was aimed at the development of the management system of training in MMA taking into account physiological features of the neuromuscular system adaptation of teenage athletes. There are several studies on improving the training in pre-competitive mesocycles in MMA (Miarka et al., 2018; James et al., 2020; Stellpflug et al., 2022). The authors of this research suggested a mechanism for improving the functional maintenance of technical actions. The use of a high-intensity load regime accelerated the growth of maximum strength by increasing the number of active motor muscle units in athletes (Pavelka et al., 2020; Chernozub et al., 2022).

The modern MMA training system involves using a large arsenal of technical actions (punches and kicks, throws, chokes and painful techniques, etc.) In this regard, scientists (Beránek et al., 2023; Gottschall & Hastings, 2023) pay close attention to the study of issues related to tactical and technical training and its impact on the outcome of the fight. Several works are devoted to the study of improving general physical fitness speed and strength using methods generally accepted in martial arts (Plush et al., 2021; Loturco et al., 2023; Manolachi et al., 2023). However, scientists practically do not pay attention to the functional support of performing technical actions and the search for new solutions to this problem. The way out is to obtain appropriate body adaptive reserves for the expenditure of effective realization of technical actions in MMA by using the necessary number of muscle groups. This strategy also provides an optimal variant of the ratio of agonist and synergist muscle groups for the effective implementation of a technical action or their combination during a fight.

Some leading MMA scholars have only partially paid attention to the reasons for changing the priority of using certain combinations of technical actions in fights. In most cases, the priority of using certain kicks throws, and various techniques was justified by the athlete's conducting fights in a striking or wrestling style (Chernozub et al., 2018; Branco et al., 2022; Stellpflug et al., 2022). The suggested system for managing the training of teenage MMA athletes taking into account the physiological characteristics of the neuromuscular system adaptation to a stressful stimulus, fully solves this issue. The results of the ratio of winning variants obtained during the 2023 MMA World Championship confirmed the effectiveness of the proposed training strategy.

The study results showed that using the mechanism for improving the functional maintenance of technical actions in MMA changed the priority of technical actions. Thus, the number of victories by knockout increased by 3 times, and by technical knockout by 2 times, compared to the results recorded at the 2022 MMA World Championship. It happened due to an increase in the maximum strength of the agonist and synergist muscle groups, which ensure the performance of kicks, punches, and throws. The adaptive changes in these muscle groups occurred due to expanding the number of active motor muscle units and the level of intermuscular coordination (Bartel et al., 2022; Polechoński et al., 2022).

Applying the developed training strategy to the training of teenage athletes for the 2023 MMA World Championship significantly influenced the ratio of victory options. Thus, the increase in the functional maintenance of technical actions in MMA contributed to a 3.3-fold decrease in the number of victories in fights by referees' decisions. It is possible to assume that these changes were caused by enlarging the power of attacks and counterattacks in various combinations and changes in the priority of their use. An important factor of the training system is the validity of using power load modes depending on the physiological features of the neuromuscular system adaptation to a stressful stimulus.

Conclusions

A comparative analysis of the strategy for training athletes for the 2022-2023 World Championships and evaluation of the results of athletes' performance allows for drawing the following conclusions. The development of the strategy for training the Ukrainian national youth MMA team requires an in-depth study of the physiological processes of the neuromuscular system adaptation to different load modes. The effectiveness of performing technical actions in fights and the change in priority of their usage depend on the body's functional capabilities to carry out these tasks. An important factor of the training system is the validity of using power load modes depending on the expediency of increasing the adaptation reserves of priority muscle groups. A significant increase in the number of victories in fights by knockout and technical knockout is a consequence of the growth of the power of attacking and counterattacking combinations of technical actions. These changes are generated by the maximum strength development due to increasing the number of active motor muscle units in the agonist and synergist muscle groups.

Conflicts of interest - There is no conflict of interest.

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