

Assessing the efficacy of an experimental strength and conditioning program for professional mixed martial arts athletes

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Abstract:

High demands on the physical training are set before athletes-fighters engaged in professional MMA. Therefore, the development of new programs for the integrated development of strength and conditioning training in mixed martial arts is an urgent direction in the training process. **Research aim:** to experimentally substantiate and develop a training program aimed at developing strength and conditioning readiness for fights among professional MMA athletes. **Materials and methods.** 24 professional mixed martial arts fighters aged 26.1 ± 2.5 and with 8.4 ± 1.3 years of experience in this sport participated in the research. The athletes completed two different strength and conditioning training programs for 18 weeks. Group 1 (CG) studied according to the standard physical training methodology, group 2 (EG) studied according to the experimental program developed by us. In the program, the strength and conditioning training of professional mixed martial arts athletes is divided into two blocks – the off-season (preparatory period) and the training camp (competitive period). In the first block, the training program consisting of three consecutive mesocycles included exercises to develop aerobic ability, as well as maximum aerobic power and speed-strength qualities. The second block of the program incorporated specific plyometric, strength, and conditioning exercises, focusing on diverse barbell exercises bodyweight workouts. Rigorous assessments were conducted to evaluate athletes' strength, conditioning, physical performance, and technical and tactical preparedness. **Results.** Revealed a significant improvement in the experimental group's athletes compared to those in the control group across various indicators, including strength, conditioning abilities, physical performance, and technical and tactical qualities. **Conclusions.** The experimental program uses in professional mixed martial arts fighters revealed an increase in the values of strength endurance by 18% and maximum strength by 12%. A positive relationship between the characteristics of fighters' strength and conditioning training and technical and tactical indicators has been established. The fighters' activity increased by 19.9%, the technical and tactical actions effectiveness by 27.1%, the defensive actions reliability by 13.6%.

Key Words: mixed martial arts, strength qualities, physical performance, technical and tactical training, physical education

Introduction

Currently, there is a desire among young people to engage in various types of martial arts at the amateur or professional levels (Ioannides et al., 2020; Koshcheyev & Dolbysheva, 2021). Specialists in the field of sports are faced with the task of constantly improving the means and methods used in martial arts training sessions (Osipov et al., 2020; Guillermo et al., 2020; Fathir et al., 2021). Unlike amateur, professional mixed martial arts (MMA) fights consist of a large number of different rigid interactions of fighters in shock and wrestling techniques (Alzhanov et al., 2021). Technical and tactical actions in MMA have a great variety, which leads to a rapid transition from one mechanism of working muscles energy supply to another. The fights format is from 3 to 5 rounds of 5 minutes each with a rest interval of 1 minute. Therefore, highly qualified professional MMA athletes have to perform a large number of attacking and defensive technical actions. It is due to significant physical exertion in terms of volume and intensity and high energy consumption in an athlete (Davidenko et al., 2021).

Research works by many authors show that in martial arts, important factors affecting the quality of functional readiness are the high level of anaerobic and aerobic abilities development of the body (Tota &

Wiecha, 2022). In bouts in various types of mixed martial arts, blood lactate levels exceed the anaerobic threshold at the end of the bouts. This state of the athlete's internal environment exerts a significant load on the cardiorespiratory system of the body (Coco et al., 2022). On the other hand, the high level of aerobic fitness of fighters allows maintaining the strength of muscle contraction for a long time without significant loss of physical work power. It is due to the fact that during one round, the resynthesis of ATP reserves occurs mainly due to aerobic glycolysis. Therefore, professional fighters need to develop many physical qualities and abilities to achieve success in MMA – static, dynamic, «explosive» muscle strength and strength endurance, aerobic and anaerobic abilities and maximum aerobic power (Bolotin et al., 2021; Davidenko et al., 2022). In addition, the indicators of maximum strength are important, especially the strength indicators of the upper and lower extremities muscles (Lariosa et al., 2017).

Many authors consider high-intensity training «crossfit» as an option of the most suitable method for strength and conditioning training in various types of mixed martial arts (Osipov et al., 2017; Klimek, 2018). Crossfit training often takes place against the background of incomplete recovery of the body and exercises are consistently replaced one after another by the method of circular and interval training, which has a positive effect on strength endurance indicators. Scientists and experiences specialists have found out that such training impact is associated with a significant expansion of the cardiorespiratory system's reserve capabilities. (Kong et al., 2016). It causes an increase in the VO_{2max} index of the body (Muhammad Syamsul Taufiq et al., 2021), which indicates an increase in the athlete's overall and special performance (Sapto Vibovo et al., 2021). The appearance of high-intensity interval training (HIIT) in sports practice, proposed by I. Tabata, made it possible to use its protocol in martial arts training sessions (Mischenko et al., 2021). The peculiarity of this workout is the increasing physical activity. Such a load allows increasing the aerobic and anaerobic abilities of the student's body, which develops general endurance, referring to the basic elements for improving special endurance (Syamsudin et al., 2021). There is an increase in physical performance and the stability of the athlete's body to the volume and intensity of physical activity.

Unlike other types of martial arts, where the episodes of active opposition of rivals are 10-30 seconds, professional MMA fights take place non-stop throughout the round (Davidenko & Bolotin, 2022). Therefore, in this sport, a large role is assigned to conditioning training and, accordingly, high demands are placed on the athlete's body. An analysis of the scientific literature has shown that there is currently insufficient research on complex strength and conditioning training in mixed martial arts. The issues of the relationship between the functional characteristics of the body and the indicators of the athlete's technical and tactical readiness are not fully covered. This area of knowledge is the interest of our research. We believe that studying these issues will improve the effectiveness of the training process in mixed martial arts, which will have a positive impact on the athletes' performance.

Research aim. To experimentally substantiate and develop a training program aimed at developing strength and conditioning readiness for fights among professional MMA athletes.

Material & methods

24 professional mixed martial arts MMA athletes took part in the research project. All athletes were members of the national team of the professional club «Sambo-Peter» (St. Petersburg, Russia). The average age of the athletes was 26.1 ± 2.5 , body length 174.2 ± 6.2 cm, body weight 79.5 ± 5.8 kg, experience in martial arts was 8.4 ± 1.3 years. Each of the fighters had at least one professional mixed martial arts match at the time of the start of the research project. All the subjects were engaged in 18-22 hours (9-10 workouts) per week.

The research was conducted in three stages. At the first stage, pedagogical supervision of the training process of professional MMA fighters was carried out, diagnostics of the initial level of strength, conditioning and technical and tactical readiness of fighters, taking into account the length of training and the level of sports qualifications. Technical and tactical training was determined during control fights and sparring sessions.

The second stage of testing the effectiveness of the experimental program of strength and conditioning training of MMA athletes provided for a pedagogical experiment. It included 18 weeks and lasted from September 2021 to February 2022. Technical and tactical training sessions were held in a general group. The pedagogical experiment involved only strength and conditioning classes, which took 3-6 hours (2-4 workouts) per week. By a randomized method, all athletes were divided into two groups of 12 people. Group 1 (control, CG) was engaged in standard physical training methods developed in accordance with the Russian federal standard of the sport «mixed martial arts» (Federal standard of sports training for the sport of mixed martial arts (MMA), 2017). Group 2 (experimental, EG) was engaged in an experimental program of strength and conditioning training developed by us.

Athletes in the EG in the preparatory period in the off-season trained 4 times a week, of which 2 trainings had an aerobic orientation and 2 trainings were aimed at developing speed and strength qualities. During the competitive period in the training camp, during the direct preparation for professional fights, training sessions were held 3 times a week with a rest interval of 1 day in between. All strength and aerobic exercises were selected taking into account methodological recommendations for the organization of training of professional athletes in various types of martial arts (Lariosa et al., 2017; Alzhanov et al., 2021). To do this,

athletes in the EG used various barbell exercises, plyometric exercises for the development of «explosive» strength, repeated sprints with incomplete recovery, weight lifting (carrying loads) and other loads.

The first block of the experimental program of strength and conditioning training in the preparatory period of the off-season consisted of three consecutive mesocycles of strength orientation, as well as supportive aerobic and maximum aerobic power training, Table 1.

Table 1. The program of strength and conditioning training of mixed martial arts fighters in the off-season

Days	Physical exercises	Number of approaches	Repetitions	Rest, s	Tempo*, s	Weight, % of the repeated maximum
1-6 week – aerobic abilities development						
1	Equal aerobic ability (running, cycling, rowing, etc.)	1	30-45 min	-	120-140bpm	
2	Maximal aerobic power (running, cycling, rowing, etc.)	4	4 min	120	140-150 bpm	
A mesocycle aimed primarily at an eccentric (yielding) force development						
1 st week						
1	Squats, Barbell bench press, Horizontal barbell pull	5	5	100	5.0.0	80-85
2	Deadlift, Bench press, Upright row	5	10	50	3.0.0	70-75
2 nd week						
1	Deadlift, Bench press, Upright row	5	5	100	5.0.0	85
2	Squats, Bench press, Lateral bar	4	8-10	50	5.0.0	75
A mesocycle aimed primarily at the isometric (static) force development						
3 rd week						
1	Squats, Barbell bench press, Horizontal barbell pull	4-6	5-6	100	0.2.0	80-85
2	Deadlift, Bench press, Upright row	3	10	50	3.0.0	75
4 th week						
1	Squats, Barbell bench press, Horizontal barbell pull	5-6	3-4	100	0.2.0	85-90
2	Squats, Bench press, Lateral bar	4	8	50	3.0.0	70-75
A mesocycle aimed primarily at the «explosive» power development						
5 th week						
1	Squats, Barbell bench press, Horizontal barbell pull	5-7	2-3	100	0.0.0	85-90
2	Deadlift, Bench press, Upright row	4	10	50	0.0.0	70-75
6 th week						
1	Deadlift, Bench press, Upright row	6-7	3	100	1.0.1	85-90
2	Squats, Bench press, Lateral bar	3	12	50	0.0.0	70-75

Note. *6.0.0 - the rate of eccentric, isometric and concentric phases of the exercise execution

Source: drawn up by the authors

The exercises were performed sequentially with a pre-set rest interval or until the heart rate normalized, taking into account the value set in the training program. During the competitive training period, the defining physical qualities for professional MMA fighters were strength endurance and speed-strength abilities. The second block of the experimental program of strength and conditioning training of athletes also consisted of three mesocycles, Table 2.

Table 2. The program of strength and conditioning training of mixed martial arts fighters on a training camp basis

№	Physical exercises	Number of approaches	Repetitions	Tempo*, s	Heart rate range, bpm
A mesocycle aimed at developing high-speed and maximum strength (muscle hypertrophy)					
1-2 week (3 times a week)					
1	High jumps on one leg (long, sideways)	2	10	0.1.0	
2a	«Goblet squats»	4	8	6.0.0	140-150
2b	Squats with a tourniquet under the knee bend	4	10	2.0.0	
3a	Bench Press with the close grasp	3	12	6.0.0	140-150
3b	Bench Press	3	10	6.0.0	140-150
4a	Horizontal barbell pull	3	12	3.0.0	140-150
4b	Spreading arms to the sides with a tourniquet	3	15	0.1.1	

5	«Farmer's Walk»	4	90 s		140-150
6	«Plank hold»	3	45 s		130-140
3-4 week (3 times a week)					
1	High jumps on one leg (long, sideways)	1	10		
2a	«Goblet squats»	3	5	0.0.0	120
2b	Squats with a tourniquet under the knee bend	3	10	0.0.0	
3a	Dumbbell bench press	3	8	0.0.0	120
3b	Spreading arms to the sides with a tourniquet	4	10	0.1.1	
4a	Pull-ups	3	5	0.0.0	120
4b	Spreading arms with dumbbells to the sides (forward, backward in a bend)	3	10	0.1.0	
5	«Farmer's Walk»	4	45 c		
A mesocycle aimed at developing strength endurance					
5-6 week (3 times a week)					
1	Triple long jump on one leg	4	1		
2	Jumping on a pedestal	6	1		
3	Jumping from side to side with a hands wave	5	10		
4a	Front squats	4	6	0.0.0	130-140
4b	Knee extension with a rubber tourniquet	4	10	0.0.0	
5a	Chest press on the floor	3	6	0.0.0	130-140
5b	Spreading arms to the sides with a tourniquet	3	10	0.1.1	
6	Barbell bentover rowing	9	8	0.0.0	130
7	Running with dumbbells	4	90 s		130-140
7-8 week (3 times a week)					
1	Jumping on a pedestal with one foot	4	2		
2	Jumping from the pedestal + triple long jump	4	3		
3	Throwing a med ball into the wall from a combat stance	2	10		
4a	Incline dumbbell bench press	3	5	0.0.0	140-150
4b	Front stretching the tourniquet	3	10		
5	Hex-bar deadlift	3	8	0.0.0	140
6	Weight pulling	1	180 m		150
7	«Plank hold»	3	45 s		120
A mesocycle aimed at developing «explosive» strength and maintaining strength endurance					
9-10 week (3 times a week)					
1	Jumping from side to side with a hands wave	6	2		
2a	«Zercher Squats»	2	1		140
2b	Jumping over the barrier	2	4		140
2c	Vertical jumping with a tourniquet	2	3		140
3a	Chest press on the floor	2	2		150
3b	Throwing a med ball into the wall from a combat stance	2	3		140
3c	Push-ups with full separation of the arms on a tourniquet	2	3		140
4	Pushing a sledge	3	10 m		130
11 and 12 week (3 times a week) – circular interval training 3 series, rest 60 s					
1	Pushing a sledge	3	60 s		150
2	Weight pulling		60 s		140
3	Kicking a boxing bag		60 s		140
4	Med ball throwing to the floor		60 s		150
5	Jumping over the barrier		60 s		140
6	Weight throwing -over		60 s		130

Note. *6.0.0 - the rate of the eccentric, isometric and concentric phases of the exercise execution.

Source: drawn up by the authors

Throughout the second block of the strength and conditioning training program, classes began with various plyometric exercises, the main task of which was the development of «explosive» strength and activation of the central nervous system. The strength exercises of the program in the training camp were performed with incomplete recovery until the pulse was maintained at the set values in sets of 2-3 exercises, one of which was the main one, and the rest were corrective.

The first mesocycle of the second block was aimed at the development of high-speed and maximum strength, which led to long-term adaptive changes in the body due to a significant increase in myofibrils in intermediate and glycolytic muscle fibers.

The second mesocycle was aimed at developing strength endurance, and strength training was supportive. The exercises included in the third mesocycle were aimed at developing «explosive» strength and maintaining strength endurance at the required level.

We conducted high-stakes testing of athletes. For this purpose, physical performance was determined using the PWC₁₇₀ bicycle ergometric test, kgm/min and calculating the relative value of the test for each athlete, kgm/min/kg. A high-stakes assessment of strength endurance was carried out using pull-up tests, the number of times; squats with a barbell weighing 70 kg (squat weight a 70 kg), the number of times. The assessment of maximum strength was carried out according to the squat with a barbell of maximum weight (squat one per max), kg; bench press with a single-repeat maximum (bench press one per max), kg; deadlift with maximum weight (deadlift one per max), kg. A high-stakes assessment in points of technical and tactical indicators was carried out during control fights and sparring using indicators: activity; striking technique (striking efficiency), fighting technique; overall effectiveness; technique of defensive actions. The activity of technical and tactical actions (TTA) is the average number of completed and evaluated TTA in one minute of the fight, the effectiveness and reliability of TTA is the ratio of estimated TTA to the total number of TTA, expressed as a percentage.

At the third stage of the research, the analysis, generalization and statistical processing of the data obtained during the pedagogical experiment were carried out. A significant difference in the values of the indicators was found using the Student's t-test. The values of the difference in indicators at $p < 0.05$ were considered statistically significant.

Results

The effectiveness of the experimental program impact over the level of the athletes' physical fitness was assessed based on the results of high-stakes testing compared with the performance of athletes in the control group. It was found that the values of the indicators in the PWC₁₇₀ test and in all tests of strength and conditioning fitness were significantly higher in EG athletes compared with CG ones, $p < 0.05$. The increase in the values of indicators of physical performance and physical fitness of MMA fighters of the control and experimental groups at the end of the research project is shown in Figure 1.

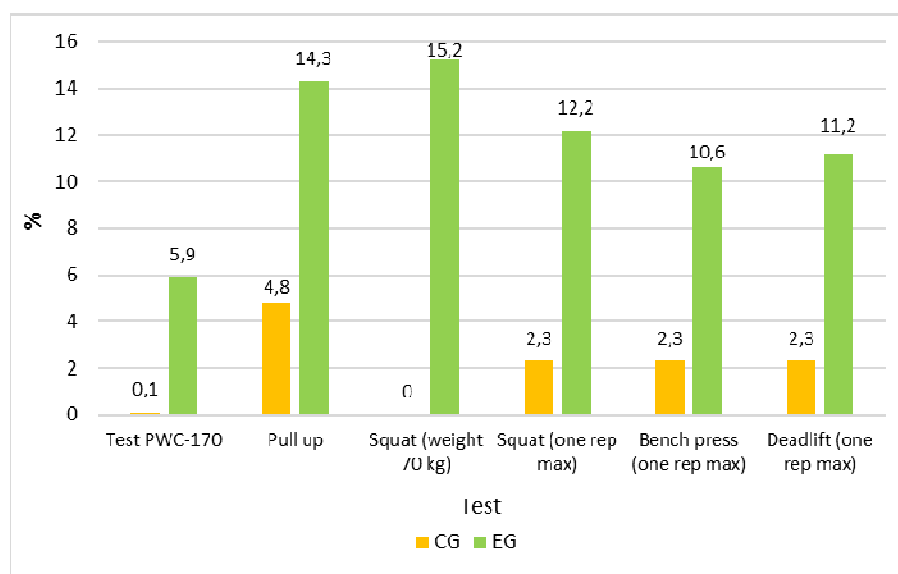


Fig. 1. The relative increase in the indicators values of physical performance, strength and conditioning of MMA fighters

It was found that the increase in the values of the physical performance indicator in the PWC₁₇₀ test and in all values of the indicators in control tests to test strength endurance in the pull-up tests, squat with a barbell weighing 70 kg (squat weight a 70 kg) and maximum strength in the tests (squat one per max), bench press (bench press one per max) for single-stroke maximum and deadlift (deadli one per max ft) athletes in EG had significantly more than those in CG.

Despite the fact that training on technical and tactical training of fighters in both groups was carried out according to the same program, a significant increase in the indicators of physical performance and physical fitness of EG athletes had a positive effect on the level of their technical and tactical readiness compared with the control group of athletes, $p < 0.05$. The activity of technical actions of EG fighters increased by 19.9%, the effectiveness of impact equipment increased by 43.0%, the effectiveness of wrestling equipment by 19.1% and the overall efficiency increased by 27.1%. An increase of 13.6% was found in the reliability index of protective actions.

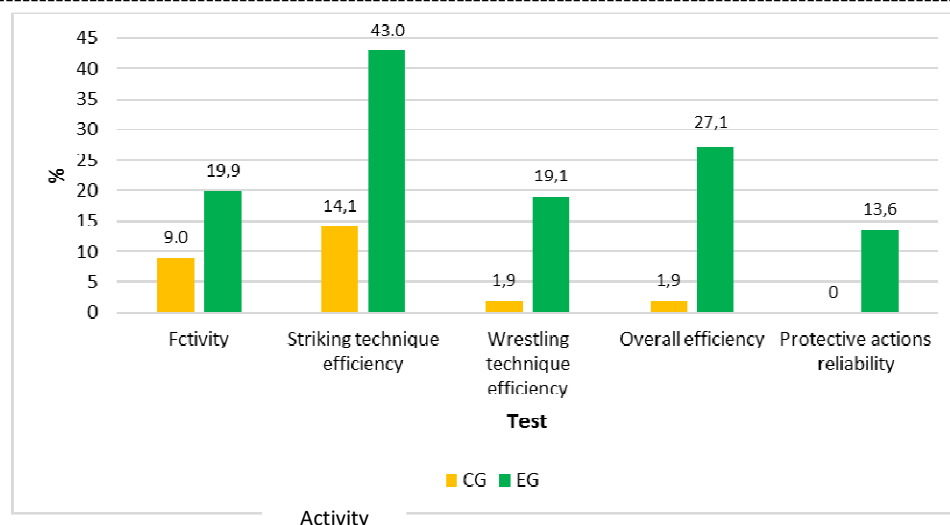


Fig. 2. Relative increase in the values of MMA fighters' technical and tactical readiness

It was taken into account that one of the main tasks of strength and conditioning training of MMA fighters is the development of physical abilities, which are necessary for the use of individual technical and tactical style of athletes' performance in bouts. The most pronounced relationship can be traced between strength indicators and technical and tactical indicators of the EG athletes' activity and their striking technique effectiveness. The MMA fighters of the experimental group began to use octagon movements 38.0% more actively and kick more often.

We consider the results of athletes' performances in professional bouts within 2 months after the completion of the training program developed by us to be an important criterion for an objective assessment of the experimental program effectiveness. It was found that the athletes of the control group won in 7 out of 12 fights (58.3%), while the athletes of the experimental group emerged victorious in 10 out of 12 fights (83.3%), which indicates the high effectiveness of the proposed training program

Dicussion

It is obvious that mixed martial arts are one of the most energy intensive kinds of sports (Bolotin et al., 2021; Davidenko et al., 2022). A number of research works confirm the conclusions that muscle strength indicators are of great importance (Mishchenko et al., 2021). However, there is no consensus among experts on the most effective means and methods of strength training for fighters, and the isolated development of muscle strength often negatively affects the indicators of aerobic ability, which are also important in martial arts (Bolotin & Bakaev, 2016; Lee & McGill, 2015).

During the research project, we found that in the first block of the program, strength training was mainly aimed at developing maximum strength. It was due to the fact that fighters during the off-season could afford to build muscle mass without adhering to the weight category limit. At the same time, according to coaches and other experts in the field of martial arts, strength training should be carried out in various modes of muscle work simulating the competitive load of shock and wrestling actions – in eccentric (yielding), isometric (static) and concentric (overcoming) modes. Therefore, the first block of the experimental program of strength and conditioning training, conducted during the preparatory period of the off-season, consisted of three consecutive mesocycles of strength orientation, as well as supportive aerobic and maximum aerobic power training. The eccentric load of the first mesocycle made it possible to adapt fighters to wrestling techniques that are associated with pushing off and push-ups of the opponent. The mesocycle of isometric loads was aimed at the static force development. It was taken into account that the fight against an opponent at the octagon net is often accompanied by a static load aimed at keeping the opponent in a certain position, activating the mechanisms of anaerobic glycolysis. Therefore, strength exercises were performed practically without relaxing the trained muscles. The concentric mesocycle was aimed at developing speed and strength abilities, which is necessary when performing «explosive» blows and attacking wrestling techniques.

A number of researchers recommend the use of circular crossfit training for conditioning training in martial arts (Osipov et al., 2017). The use of high-intensity interval training Tabata in martial arts is known (Mischenko et al., 2021). However, we have found that frequent use of this type of training leads to an increase in the lactate concentration in the blood (Bolotin et al., 2021). It leads to a decrease in concentration, deterioration of well-being, rapid decrease in performance and significantly increases recovery time after exertion (Coco et al., 2022). Therefore, the method of circular and interval training was used by us only in the final mesocycle of the second

training block. This type of training was used to directly prepare fighters for a certain fight schedule in 3 or 5 rounds with little rest.

During the fighters' training, it was taken into account that the specifics of mixed martial arts, compared with wrestling and impact sports, lies in a wider arsenal of techniques and their combinations. It has been found that mixed martial arts fighters perform better in choice reaction tests and nervous system adaptation tests (Romanenko et al., 2018). Therefore, mixed martial arts fighters must maintain a high level of concentration throughout the fight. To this end, in the course of the research, we determined the technical and tactical indicators of the protective actions reliability, which significantly increased in the experimental group. The increase in the functional capabilities of athletes, where the program we proposed was used, also made it possible to improve the effectiveness of punches and wrestling actions. Improving the effectiveness of the training process among the MMA fighters of the experimental group made it possible to significantly increase the effectiveness of their performance in competitions compared with the athletes of the control one.

Conclusions

The conducted research project results prove the effectiveness of the experimental program of strength and conditioning training of professional MMA athletes proposed by us. The total duration of the program we have developed is 18 weeks. It includes 2 blocks, each of which has three mesocycles. In the first block of athletes' training, training takes place 4 times a week, including exercises to develop aerobic ability, as well as maximum aerobic power and speed-strength qualities. The second block of athletes' training is held in the pre-competition period. Training takes place 3 times a week with a rest interval of 1 day. The main focus is on the development and improvement of maximum and «explosive» strength and strength endurance. The main means of training athletes are various exercises with a barbell and their own weight. Attention is paid to the eccentric, isometric and concentric phases of motion.

An increase in the indicators of physical performance, strength and conditioning training of athletes of the experimental group naturally led to an improvement in the quality and quantity of the fighters' technical and tactical actions. It also made it possible to effectively resist the attacks of rivals and maintain concentration throughout the fight. The experimental program of strength and conditioning training had a significant impact over the indicators of increasing strength endurance by 18% and maximum strength by 12%. It allowed professional MMA athletes to provide an advantage in carrying out punches and wrestling techniques by an average of 27.1%.

The research showed that this program can be implemented into the training system of most types of mixed martial arts, such as hand-to-hand combat, combat sambo, pankration and others. According to the authors, the issue of the relationship between strength condition and technical and tactical training in mixed martial arts has not yet been sufficiently studied, which determines the prospects for further research in this area.

Conflicts of interest. The authors declare no conflict of interest.

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