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Section III – Sports Training

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The Effects of Conditioning Training on Body Build, Aerobic and Anaerobic Performance in Elite Mixed Martial Arts Athletes

by
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The aim of the study was: 1. to evaluate the effects of conditioning training on body build and physical fitness in elite mixed martial athletes, 2. to investigate the training load structure and assess body build as well as the physiological profile of mixed martial arts athletes. Fifteen MMA male athletes (body mass: 79.8 ± 3.9 kg; body height: 178.7 ± 7.9 cm; body fat: 13.4 ± 1.6%) were involved in the study. The average training experience of athletes equalled 11 ± 1.1 years. Body composition, upper limb peak anaerobic power and aerobic performance were assessed before and after the preparatory phase. During each evaluation, athletes underwent two stress tests: the Wingate test for the upper limbs (upper limb anaerobic peak power measurement) and the graded exercise test until volitional exhaustion (maximal oxygen uptake measurement and second ventilatory threshold determination). Training means were investigated for the workload type, intensity and exercise metabolism. In the follow-up, body fat mass decreased, while anaerobic peak power and aerobic performance improved. Improvement in the time to obtain and maintain peak power in the upper limbs was noted. Training periodization resulted in advantageous body composition changes and improved physical fitness of the MMA athletes.

Key words: *performance, physical fitness, aerobic capacity, anaerobic power.*

Introduction

The popularity of mixed martial arts (MMA) in recent years has aroused much interest in training and physical fitness evaluation for this sport discipline. Periodization of the training system in MMA is characterized by the complexity of developing speed-strength and endurance abilities, as well as technical and tactical skills (Gronek et al., 2015). The control and monitoring of physiological indices with consideration of the implemented training loads allow to indicate the current level of endurance and speed-strength abilities, and, at the same time, to adjust training loads to the athlete's sports potential (Alm and Ji-Guo, 2013; Amtmann et al., 2008; Pałka et al., 2010; Tota et al., 2014; Gołaś et al., 2017).

Despite the growing popularity of MMA, there is still no uniform training system which could serve coaches and instructors as an indicator when planning and preparing specific training loads (Lahti, 2016). For the optimal preparation of an athlete, whose fight most often requires 3–5 rounds, 5 minutes each, with 60-s rest intervals between the rounds, sports training must include balanced development of aerobic and anaerobic fitness, with reference to both the upper and lower limbs (Amtmann et al., 2008; Bounty et al., 2011). The complexity of the MMA training system, considering technical, tactical and capacity-related issues, is very challenging for the coaches.

To the best of our knowledge, there are no studies that attempted to broadly characterize the profile of MMA athletes. In previous studies (Alm and Ji-Guo, 2013; Braswell et al., 2010; Schick et al., 2010), the physiological profile and body build of MMA athletes were assessed among small

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sample sizes and only in single measurements; these, however, did not analyse the implemented training loads. In this paper, not only the physiological profile and body build, but also the training loads of elite Polish MMA athletes were analysed. The paper also presents the effects of implemented training on physical fitness of MMA athletes. The aim of our study was to investigate training loads during a 14-week training period, as well as to assess body build and the physiological profile of MMA athletes.

Methods

Ethical considerations

The design of the study was approved by the ethical committee of the regional medical chamber. The participants were informed of the objectives of research, and provided their written informed consent to participate in the study. They underwent proper medical examinations, which was one of the inclusion criterion for the stress tests. The treadmill tests were performed under the constant supervision of a physician.

Study design

Anthropometric measurements and stress tests were performed at the beginning and at the end of the preparatory period regarding a fight scheduled for 3 rounds, 5 minutes each. The preparatory period lasted 14 weeks.

Stress tests and somatic measurements were carried out twice in the course of a training season: at the beginning of the preparatory period (before training) and after the completion of that period. During each evaluation, athletes underwent two stress tests: the Wingate test for the upper limbs (upper limb anaerobic peak power measurement) and the graded exercise test until volitional exhaustion (maximal oxygen uptake measurement and second ventilatory threshold determination). The stress tests were carried out with a 1-day rest in-between, beginning with the Wingate test. Training loads implemented by the athletes were registered during the 14-week training period.

Participants

A total of 15 MMA male athletes were involved in the study. The average training experience of the athletes equalled 11 ± 1.1 years. The participants were competitors from, among others, the Ultimate Fighting Championship, the Pro MMA Challenge, the Martial Arts Confrontation, MMA Attack 3, Fight Exclusive Night and Fight Club Berlin.

Anthropometric measurements

The following anthropometric measurements were taken: body height, body mass, fat mass and lean body mass. Body mass and composition were established using the method of bioelectrical impedance, with a body composition analyser (IOI 353, Jawon Medical, Korea), whereas body height was assessed using a Martin type (USA) anthropometer with 1 mm accuracy.

Graded exercise test

This test, performed on a treadmill (Saturn 250/100R, h/p/Cosmos, Germany), allowed to determine maximal oxygen uptake (VO_{2max}) and the second ventilatory threshold (VT_2). The effort started with a 4-min warm-up at a speed of 8 km·h^{-1} and the deck inclination of 1°. Then, running speed was increased by 1 km·h^{-1} every 2 min. The trial was performed until the athlete reported volitional exhaustion and refused to continue the test.

During the test, the following variables were registered using an ergospirometer (START 2000M, MES, Poland): pulmonary ventilation, the percentage of carbon dioxide in exhaled air, oxygen uptake, carbon dioxide production, a respiratory exchange ratio and ventilatory equivalent to carbon dioxide. For heart rate (HR) measurements, a pulsometer (Suunto Ambit 4, Finland) was used.

In order to determine the VT_2 value, changes in respiratory indices were analysed along with the increase in work intensity. The criteria for VT_2 determination were as follows: a) the percentage of CO_2 in exhaled air reached its maximal value and then started to decrease; b) the ventilatory equivalent for carbon dioxide reached its minimal value and then began to increase; c) beyond the VT_2, a non-linear longer increase in pulmonary ventilation was observed (Bhambhani and Singh, 1985; Binder et al., 2008). The highest reported VO_{2max} was assumed as VO_{2max}.

The Wingate Test for upper limbs

The purpose of the test was to measure anaerobic peak power of the upper limbs. The Wingate Test in the 20-s version was performed with a load of 4.5% of body mass (Bar-Or, 1987). Before the test, participants performed a 5-min warm-up on a cycloergometer with a load of 1 kg;

the pedalling rate during the warm-up equalled 60 rev/min. After the 2nd and the 4th minute of the warm-up, athletes completed two 3-s maximal accelerations, and then went back to the former pedalling rate of 60 rev/min. The proper test was accomplished 2 min after the warm-up. The participants were instructed to reach the maximal pedalling rate as fast as possible and then maintain it for as long as possible. The test was carried out on a specially adapted cycloergometer (Monark 834E, Sweden), equipped with an instrument connected to a PC that measured the time of each single revolution. The ergometer was positioned on a special stand so that the level of the connecting rod axis was at the height of the seated participant's shoulders. The ergometer pedals were replaced with handles used for the upper limbs. The distance between the chest and the handles was adjusted in such a way as to allow the elbow joint to remain in slight flexion at maximal extension. The participant's trunk was stabilized for the duration of the test. The applied software (MCE 5.2, JBA Staniak, Poland) allowed to register the following indices: mean anaerobic power (MP), total work (TW), peak anaerobic power (PP), time to obtain peak anaerobic power (TOPP) and time of maintaining peak anaerobic power (TMPP).

Implemented training characteristics

Analysis of training loads was performed on the basis of training records provided by athletes and coaches. Training intensity was monitored using a pulsometer (Suunto Ambit 4, Finland). Training loads were assessed by methods of training-load reporting, taking training means applied in martial arts into account (Amtmann, 2004; Bounty et al., 2011; Lachlan et al., 2013; Lahti, 2016). In the paper, data referring to specific training load characteristics were summarized in separate 7-day microcycles, including 8 training units each with 2 sessions on Monday and Friday and 1 day off (Sunday) Within each microcycle, to facilitate recovery in athletes, a massage and a dry sauna were used (Saturday).

The intensity zones were determined in accordance with the schedule by Rooney (2008) and a modification by Tota et al. (2014) (Table 2).

Endurance training was implemented with heart rates individually determined on the basis of the results obtained in the graded exercise test: below VT_2 (below HR at VT_2), at the VT_2 level (HR at VT_2 ± 3 beats·min^{-1}) and above VT_2 (above HR at VT_2). In strength and power training implemented in the subsequent microcycles, the load was also individualized and adjusted to the one repetition maximum of each athlete (1RM).

Specific training means were divided according to the workout type. In data collection, the following types were differentiated: a) a general workout (including running), b) a specific workout, i.e. exercises dedicated to specific fighting styles (Brazilian Jiu-Jitsu, Muay Thai, wrestling, sambo, judo, kickboxing); and c) a pre-competitive workout, consisting of the mentioned style techniques, as well as learning and improving positions: strikes, takedowns, and tapouts.

In the division of training means, work intensity (exercise metabolism) was also taken into account. A detailed description of the implemented training is presented in Table 3.

Stretching exercises were not included in the report on the implemented training loads as they constituted an integral part of the warm-up and cool down.

Statistical analysis and presentation of results

The results of the study are presented as arithmetical means and standard deviations. The consistency of distribution regarding the assessed indices with normal distribution was investigated with the Shapiro-Wilk test. Changes in the assessed somatic and physiological indices were evaluated using the Wilcoxon signed-rank test. Statistical analysis of the results was performed using Statistica 10.0 software (StatSoft) for Windows.

The differences in all the analysed indices were considered statistically significant at the level of $p < 0.05$.

Results

After the 14-week training period, advantageous changes were observed in body mass and composition, as well as in indices characterizing aerobic and anaerobic fitness. Body mass of athletes decreased by about 2.7 kg (from 79.8 ± 9.9 to 77.1 ± 6.8 kg; $p = 0.03$) in the follow-up period (Table 3).

Following the preparatory period, VO_{2max} significantly improved during the graded exercise test (from 55.1 ± 4.1 to 59.7 ± 6.0 mL·kg^{-1}·min^{-1}; $p <$

0.001). Work intensity at VT_2 also increased (from 77.3 ± 6.2 to 86.9 ± 5.7%VO_{2max}; $p < 0.001$). After 14 weeks of the preparatory period, anaerobic peak power increased relatively to body mass ($p < 0.001$), with shortened TOPP and prolonged TMPP. The detailed changes in somatic and physiological variables during the follow-up are presented in Table 3.

During the 14-week preparation phase, the study participants completed 112 training units. Their total duration equalled 167.1 hours, including 51% for aerobic, 22.4% for aerobic-anaerobic, 16.2% for anaerobic lactic and 10.4% for anaerobic alactic energy metabolism. Table 5 presents a detailed analysis of the training loads during the 14-week study period.

Table 1

Intensity of reported training loads

Range of intensity	Energy system	Percentage of maximum capability	Duration (min:s)
1	Aerobic	≤ 80	≥ 3:00
2	Aerobic-anaerobic	81–90	1:30–2:59
3	Anaerobic lactic	91–100	0:11–1:29
4	Anaerobic alactic		≤ 0:10

Table 2

Changes of chosen somatic and physiological indices in the studied Mixed Martial Arts athletes.

Somatic indices

Index	Before	After	p
BM (kg)	79.8 ± 3.9	77.1 ± 3.1	*p=0.03*
BH (cm)	178.7 ± 7.9		
LBM (kg)	69.1 ± 3.7	68.9 ± 3.2	*p=0.18*
FM (kg)	10.7 ± 1.5	8.3 ± 1.1	*p<0.001*
F (%)	13.4 ± 1.6	10.8 ± 1.2	*p<0.001*

Aerobic performance

	Before max	After max	p	Before VT_2	After VT_2	p
t (min)	19.1 ± 1.5	19.7 ± 1.0	*p=0.91*	10.1 ± 1.0	12.0 ± 0.7	*p=0.80*
v ($km \cdot h^{-1}$)	15.7 ± 0.8	16.2 ± 0.7	*p=0.03*	11.0 ± 0.6	12.0 ± 0.4	*p=0.49*
HR ($beats \cdot min^{-1}$)	182 ± 6.2	182 ± 6.5	*p=0.55*	153.8 ± 8.2	164.0 ± 5.0	*p=0.01*
VO_{2max} ($L \cdot min^{-1}$)	4.4 ± 0.2	4.6 ± 0.3	*p=0.04*	3.4 ± 0.6	4.0 ± 0.6	*p=0.11*
VO_{2max} ($mL \cdot kg^{-1} \cdot min^{-1}$)	55.1 ± 4.1	59.7 ± 6.0	*p<0.001*	42.6 ± 3.3	51.9 ± 3.5	*p<0.001*
VE ($L \cdot min^{-1}$)	142.0 ± 19.4	147.5 ± 17.2	*p<0.001*	75.1 ± 14.2	94.2 ± 16.0	*p<0.001*
%VO_{2max}	–	–	--	77.3 ± 6.2	86.9 ± 5.7	*p<0.001*
%HR_{max}	–	–	--	84.3 ± 2.9	90.0 ± 2.4	*p<0.001*
Distance (m)	3787.3 ± 228.9	3874.7 ± 172.4	*p=0.13*	–	–	

Anaerobic performance

	Before	After	p
MP (W)	860.3 ± 102.0	886.3 ± 86.2	*p=0.61*
MP ($W \cdot kg^{-1}$)	10.8 ± 0.6	11.5 ± 1.0	*p=0.19*
PP (W)	1014.9 ± 134.2	1082.3 ± 120.8	*p=0.49*
PP ($W \cdot kg^{-1}$)	12.7 ± 0.6	14.0 ± 1.1	*p<0.001*
TOPP (s)	3.6 ± 0.5	3.1 ± 0.2	*p=0.16*
TMPP (s)	2.9 ± 0.4	3.3 ± 0.4	*p=0.87*

before, after *= laboratory tests performed before and directly after the 14-week training program;* ***max*** *= maximal level of the index;* ***BM*** *= body mass;* ***BH*** *= body height;* ***LBM****= lean body mass;* ***FM*** *= fat mass;* ***%F*** *= percentage of fat in body mass;* ***VT_2*** *= second ventilatory threshold;* ***t*** *= time of work in the graded exercise test;* ***v*** *= running speed during the test;* ***HR*** *= heart rate;* ***VO_{2max}*** *= maximal oxygen uptake;* ***VE*** *= pulmonary ventilation;* ***MP*** *= mean power;* ***PP*** *= peak power;* ***TOPP*** *= time to obtain peak power;* ***TMPP*** *= time to maintain peak power*

Table 3

Characteristics of the training cycle

Microcycle	Preparatory						Intensity (Energy metabolism)							
	General		Specific		Pre-Competitive		Aerobic		Aerobic-anaerobic		Anaerobic lactic		Anaerobic alactic	
	min	%	min	%	min	%	min	%	min	%	min	%	min	%
1	300	58.8	150	29.4	60	11.8	331.5	65	102	20	51	10	25.5	5
2	300	57.1	150	28.6	75	14.3	367.5	70	78.75	15	52.5	10	26.25	5
3	350	50.7	240	34.8	100	14.5	483	70	103.5	15	69	10	34.5	5
4	350	50.7	240	34.8	100	14.5	414	60	158.7	23	69	10	48.3	7
5	360	46.2	300	38.5	120	15.4	468	60	179.4	23	78	10	54.6	7
6	360	45.6	300	38.0	130	16.5	474	60	118.5	15	118.5	15	79	10
7	350	43.2	310	38.3	150	18.5	486	60	121.5	15	121.5	15	81	10
8	350	42.2	300	36.1	180	21.7	498	60	166	20	83	10	83	10
9	250	27.5	350	38.5	310	34.1	409.5	45	273	30	136.5	15	91	10
10	210	23.1	375	41.2	325	35.7	364	40	273	30	182	20	91	10
11	180	21.4	330	39.3	330	39.3	268.8	32	168	20	252	30	151.2	18
12	180	21.4	350	41.7	310	36.9	252	30	193.2	23	226.8	27	168	20
13	90	16.8	195	36.4	250	46.7	160.5	30	214	40	107	20	53.5	10
14	45	12.3	120	32.9	200	54.8	146	40	91.25	25	73	20	54.75	15
Total	3675		3710		2640		5122.8		2240.8		1619.8		1041.6	

Discussion

The aim of the performed study was to analyse training loads, as well as to assess body build and the physiological profile of MMA athletes. Studies investigating training loads together with training effects expressed as changes in somatic variables as well as characterizing aerobic and anaerobic fitness in MMA athletes are rare. Our paper is addressed to coaches, instructors and athletes pursuing optimization of training loads in MMA.

MMA is a sport discipline demanding a prescribed body mass (weight class) during competitions (Lahti, 2016), to make fights more spectacular and minimize the risk of injuries. As in other combat sports requiring weight limits, the dangerous phenomenon of rapid body mass loss in the days preceding the official weigh-in has been observed in numerous athletes (Jetton et al., 2013). This most often results from water loss and dehydration linked with excessive physical effort (Jetton et al., 2013). Many authors emphasize the necessity to lose body mass through systematic reduction of fat mass, which does not negatively affect the level of physical fitness as opposed to losing body mass because of rapid dehydration (Jetton et al., 2013; Marinho et al., 2011). It has been shown that from among 822 athletes training judo, 86% declared a 5% weight loss before competitions (Artioli et al., 2010). In the present study, we observed a decrease in fat content from 13.5 ± 1.6% to 10.8 ± 1.2% as a result of the 14-week training program. Many studies demonstrate that in combat sport athletes, a low level of fat is preferable: 12.25 ± 0.54% in MMA (Alm and Ji-Guo, 2013), 14.5 ± 1.5% in boxing (Guidetti et al., 2002) and 7.4 ± 1.2% in wrestling (Demirkan et al., 2015).

Competition demands universal physical fitness preparation from MMA athletes, allowing to conduct an effective fight in all planes (Souza-

Junior et al., 2015). Laboratory tests provide the assessment of metabolic process efficiency during subsequent macrocycles and mezocycles; on this basis, it becomes possible to individualize training loads. Anaerobic fitness of combat sport athletes is usually determined using the Wingate test for the upper limbs (Pałka et al., 2013). In this study, anaerobic peak power obtained with the Wingate test performed for the upper limbs equalled 10.8 ± 0.6 $W \cdot kg^{-1}$ in the first trial and 11.5 ± 1.0 $W \cdot kg^{-1}$ in the second one.

Generally speaking, duration of a sports fight in a competition varies between 15 and 25 minutes, meaning that a high level of aerobic capacity is required from athletes (Alm and Ji-Guo, 2013). A short, 60 s rest interval between rounds forces the athlete to fight under conditions of significant fatigue (Lech et al., 2010). A high level of aerobic capacity determines fast recovery and allows to maintain proper fight intensity throughout its duration (Rooney, 2008). As evidenced in previous research, VO_{2max} of 58 $mL \cdot kg^{-1} \cdot min^{-1}$ is indispensable in MMA athletes (Lahti, 2016). In our study participants, 14-week training significantly improved VO_{2max} (55.1 ± 4.1 vs. 59.7 ± 6.0 $mL \cdot kg^{-1} \cdot min^{-1}$), reflecting athletes' good aerobic fitness, as well as appropriate adjustment of training means. Results of tests determining VO_{2max} in amateur and professional MMA athletes indicated the range of 57–62 $mL \cdot kg^{-1} \cdot min^{-1}$ (Alm and Ji-Guo, 2013; Schick et al., 2010). In other, similar sport disciplines, the mean maximal oxygen uptake equals 56.8 ± 3.8 $mL \cdot kg^{-1} \cdot min^{-1}$ (wrestling) (Barbas et al., 2011), 53.8 $mL \cdot kg^{-1} \cdot min^{-1}$ (judo) (Little, 1991), and 63.8 ± 4.8 $mL \cdot kg^{-1} \cdot min–1$ (boxing) (Smith, 2006). The studied athletes also presented apparent improvement in indices at the second ventilatory threshold level. The heart rate at the VT2 increased (153.8 ± 8.2 vs. 164.0 ± 5.0 $beats \cdot min^{-1}$), as well as work intensity at VT2 (from 77.3 ± 6.2% to 86.9 ± 5.7% HRmax).

During the preparatory phase, periodization of training involved training means focused on technical, aerobic and anaerobic fitness along with tactical preparation. For recovery facilitation, massage and sauna baths were also included. Running training was implemented in individually assigned ranges of intensity (below and above the VT2 intensity). The individualization of strength training in the study group resulted from the adjustment of training loads to 1RM. Within the 14-week preparatory period, the general preparation phase, specific preparation and pre-competition phases, as well as super-compensation and match phases were distinguished (Lachlan et al., 2013). The first stage in training periodization was the general preparation phase, which lasted 5 weeks. When planning training loads for this phase, special attention was paid to aerobic exercises, acquainting athletes with new fighting techniques, and improving the already known ones; strength training was also introduced. The volume of aerobic training was continuously increased, but its low intensity was maintained. In the specific preparatory stage and the pre-competition phase (5 weeks), the intensity of training sessions was continuously increased, while training volume decreased. Sparring matches and interval training were introduced to develop strength endurance and power. The last periodization stage was the pre-competition phase. Its duration was strongly individualized and remained within the range of 8–14 days. Lowering the volume and intensity of implemented training was characteristic of this phase.

In the physical fitness preparation of MMA athletes, strength training plays an important role; it improves local strength endurance and movement economy. Optimization in planning subsequent microcycles consists in competent planning of strength and power training. When preparing a training unit, special attention should be paid to the proportion of concentric, eccentric and isometric contractions (Bompa and Buzzichelli, 2015).

In the 14-week training program, periodization of training included maximal strength training (heavy and moderate; loads in the range of 65–100% 1RM), supplemented with isometric training, as well as explosive strength training (ballistic training, plyometrics, sprinting, agility; loads within the range of 80% 1RM) (Lahti, 2016). The results of a previous study confirmed improvement in strength endurance after strength training (Jung, 2003). Yet, researchers are still seeking optimal training that would most efficiently prepare an MMA athlete for a fight (Lahti, 2016). In our study, maximal strength training units were implemented in each microcycle, and their volume was systematically increased until week 12 of the preparatory period. Moreover, isometric exercises were included in training.

The individualization of aerobic training in the studied athletes was based on determining workloads at VT2, and the subsequent implementation of specific tasks with optimal intensity. Aerobic capacity also plays an important role in combat sport athletes (Tota et al., 2014). In the studied group, aerobic training was implemented in the form of running at different intensities (below and above VT2 intensity), depending on the training cycle. A notable element of our training program worth emphasizing was the initial phase of athletes' training devoted to low-intensity but long-duration exercises. Many authors indicate the importance of training with an intensity above VT2, and then at perithreshold intensity during aerobic training, therefore, pointing to the possibility to increase training volume without the risk of overtraining (Seiler and Tønnessen, 2009). Interestingly, it has been demonstrated in some studies that improvement in aerobic fitness increases the rate of phosphocreatine re-synthesis (Forbes et al., 2008), an important substrate during MMA sports fights. Training at such intensity was implemented in the whole preparatory period; however, until the 8th microcycle, the volume of these units first increased, and later decreased, while the proportion of high intensity training in a microcycle was elevated.

In the middle of the preparatory phase, high intensity training (above VT2) was introduced in the form of running and circuit (functional) training. To a certain degree, it resembled an interval workout; the tasks performed in the specific circuits were to reflect a ring fight and included various fighting techniques. They involved sprint and maximal isometric efforts (wrestling). During this period, there was also a decrease in the volume of the implemented training units with an intensity above VT2. These units most often supplemented technical training of specific fighting styles.

To a considerable degree, the course of an MMA fight is based on intervals of various duration (attack, recovery, attack). Therefore, when planning high intensity training units of both lactic and alactic intensity, the authors aimed at developing similar exercise protocols. In these exercises, the authors attempted to combine maximal strikes (strikes and takedowns) with maximal isometric intensity (i.e. wrestling efforts), which were often separated by exercise focused on technique development. The main purpose of these training units was to increase buffering capacity and tolerance to metabolic acidosis (Hawley, 2008).

In a year-long training cycle, a professional mixed martial athlete plans 3–5 fights every 6–12 weeks (Bounty et al., 2011). Therefore, optimizing the training process in order to include periods of improving aerobic and anaerobic energy pathways, as well as recovery (super-compensation), is extremely complex. Many authors emphasize the significance of individualization in planning training loads, thus, criticizing the frequently encountered and applied "one size fits all" method (Kiely, 2012). In this study, the authors did their best to make the individualization of the training process the priority in planning and implementing training loads. The individually determined heart rate zones for developing aerobic fitness resulted in improvement of most indices for both VT2 and maximal intensity. The indication of the maximal workload and implementation of training loads in relation to 1RM improved all the variables assessed in the Wingate test.

Conclusions

In conclusion, MMA is a versatile discipline, demanding individual training plans prepared on the basis of physiological test results. As in other sports disciplines, there is no universal training plan for MMA that could be implemented to equally improve aerobic and anaerobic (alactic and lactic) fitness. Therefore, it is recommended to elaborate individual training protocols that would improve the described physiological variables in an optimal way and allow to fully develop athletes' physical fitness. Implementing new training methods and perfecting the former ones will help optimize training. The proposed and implemented 14-week training program resulted in advantageous changes in participants' body composition, as well as improvement in the upper limb anaerobic peak power and aerobic fitness of the MMA athletes.

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