ORIGINAL ARTICLE
EXTREME SPORTS

Effects of interval training modes on development of special physical qualities of athletes involved in hand-to-hand fighting

Authors' Contribution:
A Study Design
B Data Collection
C Statistical Analysis
D Manuscript Preparation
E Funds Collection

Xiaoquan Zhang[1BCE], Sergey Maximovich Ashkinazi[2ACDE], Evgeniy Alexadrovich Bavykin[3ABCD] Konstantin Valerevich Klimov[2BCD]

[1] Wuhan Sports University Key Lab of Training Control and Evaluation, Hubei, China
[2] Lesgaft National State University of Physical Education, Sport and Health, St. Petersburg, Russia
[3] National Mineral Resources University, St. Petersburg, Russia

Source of support: Departmental sources

Received: 05 August 2016; **Accepted:** 18 August 2016; **Published online:** 24 August 2016

AoBID: 11356

Abstract

Background & Study Aim: The analysis of scientific researches on the issues of developing hand-to-hand fighting athletes' physical qualities has shown that in recent times the specialists in the field of sports have focused their attention on studying and selecting the most effective tools and methods of physical training that make higher demands on the functional systems of the athlete's organism the capabilities of which determine the success of competitive activity. The purpose of the research are the cumulative effects of different variants of physical loads on physical fitness of the athletes engaged in hand-to-hand fighting and recommendation for the most efficient work modes aimed at developing special physical qualities.

Material & Methods: In 6-week experiment participated 60 students of 16-18 years old specialists in different styles of martial arts: sports combat sambo, hand-to-hand fight, universal fight, jiu-jitsu. The control group (CG, n = 30) and the experimental one group (EG, n = 30) trained 2 times a week by different methods. In EG work was carried out with the exception of loads of glycolytic direction, with weights of 70% of the conditional maximum (CMax), with a small number of repetitions (3 to 5), with rest intervals (1 min) and with a large number of rounds (10 to 15). For the CG the main method of training was a circular one. The time of exercise was 30 s, the weight was 70% of the CMax for basic exercises (barbell squat, deadlifts, clean and jerk) and from 30% to 40% of the maximum for isolated exercises (barbell stretching and bending of arms), a rest between exercises was 30 s, the number of rounds was 4 to 5, a rest between rounds was 2 to 3 min.

Results: The experimental methods allowed significantly better compared with the traditional methods to improve strength endurance of muscles of legs, back and shoulders of the athletes and to increase their recovery rate after exercise.

Conclusions: When implementing the complex of exercises for development of speed-strength abilities, it should be taken into account that effective implementation of methods is possible with a weight of 70% of CMax, with a low number of repetitions (3 to 5), a rest interval (1 min) and a large number of rounds (10 to 15). The intensity of the exercise and the weight should correspond to the performance model of the approximately maximal exercise in which work is carried out with the participation of fast muscle fibres, and the duration of the exercise needs to match ATP and CRP consumption in fast muscle fibres.

Key words: endurance • maximum strength • microcycle • strength • strength training

Author's address: Xiaoquan Zhang, Wuhan Sports University Key Lab of Training Control and Evaluation, 461 Luoy Road, Hongshan District, Wuhan City, Hubei Province, China; e-mail: 65276567@qq.com

Martial arts – *plural noun* any of various systems of combat and self-defence, e.g. judo or karate, developed especially in Japan and Korea and now usually practised as a sport [4].

Martial arts – systems including physical practises and elements from ancient combats created for self-defending purposes and in nowadays for competitive condition [5].

Martial Arts – are systems of fight practices (practiced in many reasons: self-defence, competition, self-improvement, physical health and fitness, mental and physical development) [6].

Martial arts – systems of codified practices and traditions of combat, initially created for warrior purposes, and nowadays practiced for a variety of reasons, including self-defence, competition, physical conditioning etc. [7].

Olympic Movement – *noun* all the international sporting federations who abide by the rules of the Olympic Charter [4].

Sambo – is a Russian martial art and combat sport. The word "SAMBO" is an acronym for ***SAM****ozashchita* ***B****ez* ***O****ruzhiya*, which literally translates as "self-defence without weapons". Sambo is relatively modern since its development began in the early 1920s by the Soviet Red Army to improve their hand-to-hand combat abilities It was intended to be a merger of the most effective techniques of other martial arts. The pioneers of Sambo were Viktor Spiridonov and Vasili Oshchepkov. Oshchepkov died in prison as a result of the Great Purge after being accused of being a Japanese spy. Oshchepkov spent several years living in Japan +and training in judo under its founder Jigoro Kano [*Wikipedia*].

Training load – "A simple mathematical model of training load can be defined as the product of qualitative and quantitative factor. This reasoning may became unclear whenever the quantitative factor is called 'workload volume' or 'training volume' interchangeably with 'volume of physical activity'. Various units have been adopted as measures i.e. the number of repetitions, kilometres, tons, kilocalories, etc. as well as various units of time (seconds, minutes, hours) (…) As in the real world nothing happens beyond the time, the

Introduction

Genesis the most of martial arts reach military, gladiatorial and ludic tradition of hand to hand fighting [1-3]. At the end of twentieth century in popularity gained the name of "martial arts" similarly defined by different authors [4-7]. According to the theory of martial arts "every combat sport is martial arts but not vice versa" [8]. Similarly, not every self-defence in martial art – e.g. aikido is not a continuation of martial arts [1, 9, 10]. In reference to a new combat sport UNIFIGHT [11-13] an argument is justified that self-defence stays in closely relations with group of combat sports which meet the criteria of the Olympic Sports that is becoming part of Olympic Movement [14]. Unabated popularity of martial arts, combat sports and self-defence art and generic name for these physical activity "hand-to hand fighting" is justified. Researchers analyse the phenomenon from different perspectives – philosophy, psychology, pedagogy, sociology, biomechanics, physiology, motor control, kinesiology etc. or in an interdisciplinary perspective. Regardless of the formula – from editorial to professional (unfortunately disseminated also as neogladiatorship [1]) – hand to hand fighting does not qualify to an extreme form of physical activity (EFPA) or extreme sports [15, 16].

The analysis of scientific researches on the issues of developing hand-to hand fighting athletes' physical qualities has shown that in recent times the specialists in the field of sports have focused their attention on studying and selecting the most effective tools and methods of physical training that make higher demands on the functional systems of the athlete's organism the capabilities of which determine the success of competitive activity [12, 17-31].

Summarizing and analysing the literature show that nowadays there are some different concepts of development of the athletes' special physical qualities.

The traditional method involves constructing a process of special physical fitness on the basis of intensive training loads of the anaerobic glycolytic direction [12, 26, 27]. At the same time, another view on the process developing special physical qualities of hand-to-hand fighting athletes has been justified. The studies carried out at molecular level have provided some new information about the physiological mechanisms of strength and endurance being localized in the depths of muscle cells. It has been shown that the development of strength and speed requires hypertrophy of myofibrils and developing endurance needs hyperplasia of mitochondria [17, 20].

The purpose of the research are the cumulative effects of different variants of physical loads on physical fitness of the athletes engaged in hand-to-hand fighting and recommendation for the most efficient work modes aimed at developing special physical qualities.

Material and methods

Participants

For the purpose of evaluating experimentally the modes contributing to the development of special physical qualities of hand-to-hand fighting athletes, we conducted a 6-week experiment: 60 students of 16-18 years old (members of the teams of the National Mineral Resources University in Saint-Petersburg practicing different styles of martial arts: sports combat sambo, hand-to-hand fight, universal fight, jiu-jitsu). Among athletes 3 of them being Masters of Sports of Russia, 10 people being Candidates for Master of Sports and 47 athletes having the first grade and the second one.

Anthropometric measurements of the control group (CG, n = 30) were: height 184.6 ±3.4cm; weight 84.1 ±3.2kg; chest circumference during quiet breathing (cm) 96.1 ±3.1 and experimental group (EG, n = 30): height 184.1 ±4.1cm; weight 83.3 ±2.2 kg; chest circumference during quiet breathing 95.4 ±2.7cm.

Organization of research

The control group and the experimental one trained 2 times a week by different methods. In the CG developing special physical qualities was realized by the methods described in the training program for Youth Sports Schools, Specialized Children and Youth Sports Schools of the Olympic Reserve, Universal Fight Sports Training Centres [12]. The main method of training was a circular one. The time of exercise was 30 s, the weight was 70% of the conditional maximum (CMax) for basic exercises (barbell squat, deadlifts, clean and jerk) and from 30 to 40% of the maximum for isolated exercises (barbell stretching and bending of arms), a rest between exercises was 30 s, the number of rounds was 4 to 5, a rest between rounds was 2 to 3 min. An example of such circuit training is given in Table 1.

We suggested that the athletes of the EG should use high-intensity means, the task of which is to improve the athlete's ability to be mobilized for manifesting a highly concentrated explosive effort and raising functional capabilities of the organism to a new level of operating strains.

Table 1. Circuit training used in the control group for developing special qualities of hand-to-hand fighters.

No.	Exercises	Purpose
1	Barbell squats	Leg strength endurance building exercise
2	Crossbar pull-ups	Shoulder strength endurance building exercise
3	Deadlift	Long muscles back exercise
4	Bar dip-ups	Shoulder strength endurance building exercise
5	Jumping squats	Leg strength endurance building exercise
6	Barbell stretching and bending of arms	Arm strength endurance building exercise
7	Sit-ups from a lying position	Stomach exercise
8	Clean and jerk	Shoulder exercise

To determine the special conditioning exercises that would be compatible with the character of hand-to-hand fighting we conducted a survey of hand-to-hand fighting coaches: 18 coaches were surveyed in total, 4 of them being Honoured Trainers of the Russian Federation, 3 people being Masters of Sports of International Level and 11 coaches being Masters of Sports.

The result was the selection of the following exercises: 1) barbell squat – basic leg building exercise; 2) deadlift – basic back exercise, the closest one in the structure of performance to the practice of hand-to-hand fighting; 3) clean (lifting the bar to chest) – exercise for the development of explosive force of back and leg muscles, a high degree of its transferring to the practice of hand-to-hand fighting; 4) clean and jerk (from rack) – basic exercise for the development of explosive force of shoulder girdle muscles, the exercise is applicable to representatives of wrestling and boxing due to its biomechanics; 5) bar dip ups – basic shoulder exercise; 6) jumping squats – exercise for the development of explosive force of leg muscles.

When planning the training process of the experimental group, we were guided by the concept of Verkhoshansky [17]: short intense work being no more than 10 to 15 s and a rest interval of 45 to 60 s for the same group of muscles slightly activate glycolysis, which creates prerequisites for enhancing the aerobic capacity of the muscles.

Seluyanov [20] emphasizes that it is necessary to activate fast muscle fibres, i.e. the intensity of muscle contraction should be in the range of 60% to 80% of maximum, hydrogen ions must not be accumulated above a certain optimum in fast muscle fibres, the blood must have a sufficient amount of oxygen. These conditions correspond exactly to the performance models of exercise being approximately maximal, but with one important limitation – the duration of the exercise needs to match ATP (adenosine triphosphate) and CRP (creatinine phosphate) consumption in fast muscle fibers and exercising must op since the advent of easy local fatigue [20].

During the 1st, 3rd and 5th weeks of training the athletes of the EG performed the basic training work of developing character. Within a 1-week microcycle the training work for the development of special physical qualities was divided into two training days (Table 2). The exercises were structured in such a way that muscle-antagonists were involved in the training work.

The main method of training was a circular one. The weight was 70% CMax, the number of repetitions was from 3 to 5, the number of rounds was 15, intervals of rest between circles lasted 1 min.

Table 2. Distribution of training load during 1st, 3rd and 5th weeks.

Training day No.1	Training day No.2	Weight	Number of reps
Clean	Deadlift	70% of CMax	3-5
Barbell squats	Clean and jerk (from rack)		
Bar dip-ups	Jumping squats	Without weight	5

During the 2nd, 4th and 6th weeks the training load for the development of speed-strength abilities were tonic in nature and was limited to two basic exercises (Table 3**)**.

basic procedure of improvement of workload measurement should logically start with separation of the time factor from the set of phenomena so far classified together as '*workload volume*'. (…) Due to the fact that the heart rate (HR) is commonly accepted as the universal measure of workload intensity, the product of effort duration and HR seems to be the general indicator of *training load* defined as the amount of workload. It is useful in analyses with a high level of generality. (…)In current research and training practice the product of effort duration and HR was referred to as conventional units' or further calculations have been made to convert it into points." [37, p. 238].

Exercise intensity – in order to improve physical fitness, exercise must be hard enough to require more effort than usual. The method of estimating appropriate training intensity levels varies with each fitness component. Cardiovascular fitness, for example, requires elevating the heart-rate above normal [49].

Microcycle – shortest training cycle is characterising by the dynamic of loads occurring in 5 to 9 days (usually a week).

EFPA – "extreme form of physical activity are extreme sports, often classified according to the environment in which they are performed (water, land, air), extreme form of physical recreation as well as gainful activity or voluntary service, and all varieties of physical activity that meet at least one classification criterion of the feature associated either with extreme risk of injury or death, or extreme body burden with high level of effort, or extreme coordination difficulty" [15, p. 19].

Table 3. Distribution of training load during 2nd, 4rd and 6th weeks.

Training day		Weight	Number of		Rest between attempts
No.1	No.2		attempts	reps	
Barbell squats	Deadlift	70% of CMax	5	5	2-3 min

At the beginning and end of the study testing the basic physique and special physical preparedness was conducted to identify the impact of the experimental methods on various aspects of physical fitness of the athletes.

Statistical analysis

Arithmetic means and standard deviations were calculated. In order to determine the significance of the differences between the two means (results man CG and man EG), at test for independent samples was used. Statistically significant difference was assumed for minimum $p<0.05$.

Results

Overall physical fitness (OPF)

The analysis of test results at the OPF between the EG and the CG before and after the experiment indicates no significant differences (Tables 4 and 5). This allows to conclude that the methods by which both groups had been trained equally affected the structure of the overall physical fitness of the athletes.

Strength endurance and recovery rate after exercise

As has been shown by the test results, before the experiment, the level of strength endurance and recovery rate were not significantly different in the control and experimental groups (Table 6). At the end of the experiment the athletes of both groups were tested to determine increasing the indicators of strength endurance and improving recovery rate after the exercise. To this end, we invited the athletes to perform the exercises: barbell squats, deadlifts and clean and jerk with a weight that was recorded at a preliminary stage and was at that time 70% of CMax. We noted a quantitative increase of indicators in those exercises, of both experimental and control groups (Table 7). Results for barbell squats, deadlifts and clean and jerk were significantly very higher ($p<0.001$) in the experimental group. Recovery rate indicators had also significant differences between the two groups after performing exercise by method "to failure". The result of the test: HR after performing a series of double jab + throw within 1 min showed that both groups are equally susceptible to fatigue after performing a specific load, but the recovery rate in the experimental group was significantly higher than recovery rate in the control one.

The maximum strength of muscles

In addition to increasing strength endurance and recovery rate after performing exercise by method "to failure", we recorded an increase in indicators of the maximum strength, in both control group and experimental one (Tables 8 and 9). This partly explains the quantitative increase of indicators and growth of strength endurance when performing exercise characterizing the level of strength endurance of muscles of legs, back and shoulder girdle. The differences between the two groups were statistically significant ($p<0.01$ and $p<0.001$) when performing exercises: barbell squats, dead lifts and clean and jerk (Table 9).

Table 4. Comparative analysis of OPF of control and experimental groups before experiment.

Exercise	Group of subjects		Differences	t
	CG (n = 30)	EG (n = 30)		
Dip ups within 30 s	29.4 ±0.3	28.2 ±0.6	1.2	1.789
Crossbar pull-ups (number of reps)	17 ±0.8	19 ±1.1	2.0	1.470
Crossbar hanging leg raises (number of reps)	16 ±0.6	16.7 ±0.6	0.7	0.825
Standing long jump (cm)	253.5 ±0.6	252.1 ±1.1	1.4	1.117

Table 5. Comparative analysis of OPF of control and experimental groups after experiment.

Exercise	Group of subjects		Differences	t
	CG (n = 30)	EG (n = 30)		
Dip ups within 30 s	29.9 ±0.2	29.6 ±0.4	03.	0.894
Crossbar pull-ups (number of reps)	20.5 ±0.6	21.1 ±0.9	0.6	0.555
Crossbar hanging leg raises (number of reps)	18 ±0.7	18.8 ±0.4	0.8	0.992
Standing long jump (cm)	254.6 ±0.5	253.6 ±0.8	1.0	1.060

Table 6. Comparative analysis of indicators of strength endurance and recovery rate in control and experimental groups before experiment.

Exercise	Group of subjects		Differences	t
	CG (n = 30)	EG (n = 30)		
Barbell squats with a weight of 70% of CMax (number of reps)	11.3 ±0.2	11.5 ±0.1	0.2	0.894
HR (heart rate) immediately	154 ±0.4	153 ±0.4	1.0	1.414
HR 1 min after	136 ±1	134 ±1	2.0	1.344
HR 2 min after	121 ±1.9	120 ±1.1	1.0	0.638
HR 3 min after	100 ±0.4	100 ±0.5	0	0.156
Deadlift with a weight of 70% of CMax (number of reps)	10.8 ±0.2	11 ±0.1	0.2	0.894
HR immediately	151 ±0.3	152 ±0.3	1.0	0.236
HR 1 min after	136 ±1	137 ±0.8	1.0	0.469
HR 2 min after	119 ±1.6	121 ±1.2	2.0	0.7
HR 3 min after	101 ±0.4	99.9 ±0.3	1.1	1.237
Clean and jerk with a weight of 70% of CMax (number of reps)	11 ±0.2	11.1 ±0.2	0.1	0.354
HR immediately	135 ±1.1	132 ±0.8	3.0	1.691
HR 1 min after	118 ±1.3	119 ±0.4	1.0	0.735
HR 2 min after	102 ±1.4	103 ±0.8	1.0	0.124
HR 3 min after	91.7 ±1.1	91.3 ±1	0.6	0.269
HR immediately after performing series: double jab + throw within 1 min	141 ±1.1	142 ±1.4	1.0	0.225
HR 2 min after performing series: double jab + throw	108.6 ±1.5	107.9 ±2.1	0.7	0.271

Table 7. Comparative analysis of indicators of strength endurance and recovery rate in control and experimental groups after experiment.

Exercise	Group of subjects		Differences	t
	CG (n = 30)	EG (n = 30)		
Barbell squats with a weight of 70% of CMax (number of reps)	13 ±0.2	17.2 ±0.1	**4.2**	18.917***
HR immediately	151 ±0.3	151 ±0.4	0	0.800
HR 1 min after	135 ±0.9	129 ±1.1	**6.0**	3.870***
HR 2 min after	117 ±1.2	109 ±1.8	**8.0**	3.698***
HR 3 min after	99.8 ±0.2	90.6 ±1.3	**9.2**	6.995***
Deadlift with a weight of 70% of CMax (number of reps)	13.3 ±0.3	16 ±0.4	**2.7**	6.037***
HR immediately	151 ±0.3	155 ±0.5	**4.0**	5.659***
HR 1 min after	137.1 ±0.9	121 ±1.2	**16.1**	10.733***
HR 2 min after	117.8 ±1.2	100 ±0.9	**17.8**	11.867***
HR 3 min after	100.8 ±0.4	88.1 ±0.6	**12.7**	17.612***
Clean and jerk with a weight of 70% of CMax	13.4 ±0.1	15.4 ±0.2	**2.0**	8.944***
HR immediately	135 ±0.8	122 ±1.4	**13.0**	7.690***
HR 1 min after	121 ±1.4	106 ±1.1	**5.0**	8.425***
HR 2 min after	102 ±1.4	94.8 ±0.8	**7.2**	4.465***
HR 3 min after	92.9 ±1.1	84.7 ±0.3	**8.2**	7.192***
HR immediately after performing series: double jab + throw within 1 min	141 ±1	13 9 ±1.1	2.0	1.345
HR 2 min after performing series: double jab + throw	99.9 ±0.9	92.6 ±1.4	**7.3**	4.386***

***p<0.001

Discussion

The results shown by the athletes of the CG and the EG in the exercises with the weight being equal to 70% CMax seem to be somewhat overstated since it is known that the number of reps should be from 8 to 10 when working with this intensity [32]. Thus, we can conclude that the athletes did not get a proper motivation and so they did not show their maximum because of lack of competitive environment, but we have noted that the athletes of the CG and the EG were in absolutely equal conditions in the testing. Therefore, the result shown in the exercise to determine the maximum muscle strength would be correct to be called the **conditional maximum (CMax)**. In the future, we began to use this term.

The result of the test: HR after performing a series of double jab + throw within 1 min showed that both groups are equally susceptible to fatigue after performing a specific load, but the recovery rate in the experimental group was significantly higher than recovery rate in the control one. This suggests that the experimental methods can increase recovery rate after exercise in addition to increasing strength endurance. This fact is a significant one for hand-to-hand fighting.

The experimental methods allowed significantly better compared with the traditional methods to improve strength endurance of muscles of legs, back and shoulders of the athletes, and to increase their recovery rate after exercise.

The intensity of the exercise and the weight should correspond to the performance model of the approximately maximal exercise in which work is carried out

Table 8. Comparative analysis of maximum strength in CG and EG before experiment.

Exercise	Group of subjects		Differences	t
	CG (n= 30)	EG (n = 30)		
Barbell squats (kg)	117 ±0.6	116 ±1.9	1.0	0.452
Deadlift (kg)	123.5 ±1.8	123 ±1.7	0.5	0.202
Clean and jerk (kg)	74.8 ±1	74.7 ±1.2	0.1	0.064

Table 9. Comparative analysis of maximum strength in CG and EG after experiment.

Exercise	Group of subjects		Differences	t
	CG (n = 30)	EG (n = 30)		
Barbell squats (kg)	125 ±1.5	132 ±1.8	**7.0**	3.158**
Deadlift (kg)	130.2 ±0.9	142.1 ±0.7	**11.9**	10.437**
Clean and jerk (kg)	77.9 ±1.3	87.2 ±1	**9.3**	5.607***

**p<0.01 ***p<0.001

with the participation of fast muscle fibres, and the duration of the exercise needs to match ATP and CRP consumption in fast muscle fibres [20].

When implementing the complex of exercises for development of speed-strength abilities, it should be taken into account that effective implementation of methods is possible with a weight of 70% of CMax, with a low number of repetitions (3 to 5), a rest interval (1 min) and a large number of rounds (10 to 15) [29-31].

Rest intervals are necessary to create conditions for enhancing the aerobic capacity of the muscles, in this case, exercise can have "anti-glycolytic orientation". It becomes possible to continuously improve both strength abilities and aerobic one of hand-to-hand fighting athletes in the form of hyperplastic myofibrils and mitochondria [17].

The recently published results of research concerning the broadly defined area of practice hand-to-hand fighting are not only expanding the knowledge of the phenomena which we are analysing in our experiment in the relationship of "causes – effects" in physiological and motor meaning [33, 34]. They also concern psychological (mental) aspects [35, 36]. A separate group constitute an important work organizing both the training means, which is to make sure that they remain in compliance with relationship to the sport effects [37-39], and reveal the talent into this category of physical activity [40-42]. Still open is the question of providing scientific argument about the practice of hand-to-hand fighting (optimizing resources, methods, structure, long-term training, etc.) in relation to the extending of the quality of life by increasing the opportunities for self-defence [43-45] of the greatest number of people and strengthening all the dimensions of health [46-48].

Conclusions

When implementing the complex of exercises for development of speed-strength abilities, it should be taken into account that effective implementation of methods is possible with a weight of 70% of CMax, with a low number of repetitions (3 to 5), a rest interval (1 min) and a large number of rounds (10 to 15). The intensity of the exercise and the weight should correspond to the performance model of the approximately maximal exercise in which work is carried out with the participation of fast muscle fibres, and the duration of the exercise needs to match ATP and CRP consumption in fast muscle fibres.

Competing interests

The authors declare that they have no competing interests.

References

1. Kalina RM, Barczyński BJ. Long way to the Czestochowa Declarations 2015: HMA against MMA. In: Kalina RM (ed.) Proceedings of the 1st World Congress on Health and Martial Arts in Interdisciplinary Approach, HMA 2015, 17–19 September 2015, Czestochowa, Poland.Warsaw: Archives of Budo; 2015: 1-11
2. Grant M. Gladiators. London: Weidenfeld and Nicolson; 1967
3. Jagiełło W, Kalina RM, Klimczak J et al. Fun forms of martial arts in positive enhancement of alldimensions of health and survival abilities. In: Kalina RM (ed.) Proceedings of the 1st World Congress on Health and Martial Arts in Interdisciplinary Approach, HMA 2015, 17–19 September 2015, Czestochowa, Poland. Warsaw: Archives of Budo; 2015: 32-39
4. Dictionary of Sport and Exercise Science. Over 5,000 Terms Clearly Defined. London: A & B Black; 2006
5. Zaggelidis G, Lazaridis SN, Malkogiorgos A et al. Differences in vertical jumping performance between untrained males and advanced Greek judokas. Arch Budo 2012; 8(2): 87-90
6. Biernat E, Boguszewski D. The level of physical activity of the working inhabitants of Warsaw practising martial arts and combat sports. Arch Budo 2015; 11: 69-77
7. Franchini E, Julio UF, Gonçalves Panissa VL et al. Short-term low-volume high-intensity intermittent training improves judo-specific performance. Arch Budo 2016; 12: 219-229
8. Kalina RM. Teoria sportów walki. Warszawa: COS; 2000 [in Polish]
9. Shishida F. Counter techniques against Judo: the process of forming Aikido in 1930s. Arch Budo 2008; 4: 4-8
10. Shishida F. Why can a little lady throw down a strong man using only a finger? The mechanism of soft *atemi-waza*. In: Kalina RM (ed.) Proceedings of the 1st World Congress on Health and Martial Arts in Interdisciplinary Approach, HMA 2015, 17–19 September 2015, Czestochowa, Poland. Warsaw: Archives of Budo; 2015: 49-58
11. Aszkinazi S, Jagiełło W, Kalina RM. Pewne przesłanki uzasadniające rozwijanie nowych odmian sportów walki w obszarze szkolenia formacji obronnych i na poziomie sportu olimpijskiego. In: Rakowski A, Chodała A, Kalina RM, editors. Sporty ekstremalne w przygotowaniu żołnierzy i formacji antyterrorystycznych. Warszawa: PTNKF; 2003: 42-48 [in Polish]
12. Ashkinazi SM. Universal fight (UNIFIGHT): Curriculum for SCSS, SCSSOR, SPC. St. Petersburg: Olimp-Spb; 2012 [in Russian]
13. Harasymowicz J, Novikov S. Axiological, ethical and utilitarian benefits of UNIFIGHT. Arch Budo 2013; 4: 227-232
14. International Olympic Committee. Olympic Charter in force as from 8 December 2014. Lausanne: DidWeDo S.à.r.l.; 2014
15. Bąk R. Definition of extreme physical activity determined through the Delphi method. Arch Budo Sci Martial Art Extreme Sport 2013; 9: 17-22
16. Bąk R, Kalina RM. Extreme Sports Perceived by Students of Faculties of the Physical Education, Tourisms and Recreation (P252). The Engineering of Sport 2008; 7(2): 551-556
17. Verhoshanskiy YUV. Fundamentals of special physical preparation of athletes. Moskva: Fizkul'tura i sport; 1988 [in Russian]
18. Jiang Chuan-yin, Qiu Pixiang, Chen Yangsheng. Evaluation on Training Intensity of Sanda in Wushu. J Phys Edu 2004; 24(8): 64-69
19. Ashkinazi S, Jagiełło W, Kalina RM et al. The importance of hand-to-hand fights for determining psychomotor competence of antiterrorists. Arch Budo 2005; 1(1): 8-12
20. Seluyanov VN. Modern approaches of building physical training in combat sports. Sektsiya sambo 2005; 6 (17): 22-23 [in Russian]
21. Zhao Guangsheng. Study on Training Theory and Practice of Sanda in Pre-competition. J Phys Edu 2006; 26(7): 82-95
22. Zhao Guangsheng, Gao Binghong, Guo Yucheng. Research on Characteristic of Anaerobic Metabolism Capacity of Elite Sanda Athletes. China Sport Sci 2006; 26(3): 46-49
23. Ashkinazi S. The experience of the scientific basing of the time resources for military service men training in hand-to-hand fighting. Arch Budo 2007; 3(3): 35-41
24. Ye Ming, LI Junping, Wang Zhiqiang. Application of intermittent hypoxic training in sports practice. J Phys Edu 2010; 17(7): 100-104
25. Hu Yonghong. Theory and Application of the Intermittent Hypoxic Training. Zhejiang Sport Sci 2012; 34(1): 68-70
26. Yuas H, Atilov AA, Ahmetov SM et al. Hand-to-hand fight and complex martial arts: training methodology. Krasnodar; 2012 [in Russian]
27. Obvintsev AA, Ashkinazi SM, Pashuta VL. Hand-to-hand fight development in Russia as a segment of training the military personnel. Nauchnyy retsenziruemyy zhurnal 2013; 2(1): 67-75 [in Russian]
28. Su Zhan. Experimental Research on Aerobic Capacity of Man Sanda Athletes. Sport Sci Tech 2013; 34(05): 81-83
29. Ashkinazi SM. Improvement of System of Special Physical Training of Athletes of Complex (Mixed) Martial Arts. Teoriya i praktika fizicheskoy kul'tury 2014; 6: 94-98 [in Russian]
30. Bavykin EA. Speed and Strength Training as a Base of Special Physical Training in Complex Martial Arts. Teoriya i praktika fiz. kul'tury 2014; 2: 20-22 [in Russian]
31. Bavykin EA. Methodology experimental research results of the development of sport-oriented physical qualities of the athletes involved in mixed martial arts. Aktual'nye problemy fizicheskoy i spetsial'noy podgotovki silovyh struktur 2016; 1: 118-128 [in Russian]
32. Samsonova AV. Hypertrophy of human skeletal muscles: monograph. St. Peterburg: Nats gos un-t fiz kul'tury, sporta i zdorov'ya im PF Lesgafta; 2011 [in Russian]
33. Noce F, Costa VT, Szmuchrowski LA et al. Psychological indicators of overtraining in high level judo athletes in pre – and post-competition periods. Arch Budo 2014; 10: 245-251
34. Iermakov SS, Arziutov GN, Jagiełło W. Quick training of students to judo techniques. Arch Budo 2016; 12: 15-24
35. Bliznevsky AA, Kudryavtsev MD, Iermakov SS et al. Formation of active-effective attitude of 12-13 years' judo athletes to sports functioning in competition period. Arch Budo 2016; 12: 101-115
36. Jung HC, Lee S, Kang HJ et al. Taekwondo training improves CVD risk factors in obese male adolescents. Arch Budo 2016; 12: 85-92
37. Kalina RM. Methodology of measurement, documentation and programming optimal workload continuous with variable intensity – applications in sports medicine, physiotherapy, geriatrics, health-related training, sport for all. Arch Budo 2012; 8(4): 235-249
38. Dias da Silva RA, Motta Drummond MD, Couto BP et al. Content validation of training means for taekwondo. Arch Budo 2015; 11: 305-317
39. Pedrosa GF, Soares YM, Gonçalves R et al. Content validation of a catalog of exercises for judo. Percept Mot Skills 2016; 122(3): 933-955
40. Lidor R, Melnik Y, Bilkevitz A et al. Measurement of talent in judo using a unique, judo-specific ability test. J Sports Med Phys Fitness 2005; 45: 32-37
41. Pion J, Fransen J, Lenoir M et al. The value of non-sport-specific characteristics for talent orientation in young male judo, karate and taekwondo athletes. Arch Budo 2014; 10: 147-154
42. Kalina RM, Jagiełło W, Chodała A. The result of "testing fights in a vertical posture" as a criterion of talent for combat sports and self-defence – secondary validation (part I: the reliability). Arch Budo Sci Martial Art Extreme Sport 2015; 11: 229-238
43. Harasymowicz J, Kalina RM. Training of psychomotor adaptation – a key factor in teaching self-defence. Arch Budo 2005; 1(1): 19-26
44. Kalina RM, Jagiełło W, Wiktorek P. Motor competence in self-defence of students of a detectives' school during their course of studies. Arch Budo 2007; 3(3): 1-6
45. Čihounková J, Skotáková A, Bugala M et al. Different approach analysis of self–defence for people with physical disability.In: Kalina RM (ed.) Proceedings of the 1st World Congress on Health and Martial Arts in Interdisciplinary Approach, HMA 2015,17–19 September 2015, Czestochowa, Poland. Warsaw: Archives of Budo; 2015: 40-43
46. Kaiser A, Sokołowski M, Mrozkowiak M. Effects of a 90-minute wrestling training on the selected features of the shape of spine and pelvis under load. Arch Budo 2014; 10: 57-65
47. Mosler D. Usability of non-apparatus and quasi apparatus flexibility tests based on self-perception participants in health-related judo training. Arch Budo Sci Martial Art Extreme Sport 2015; 11: 189-197
48. Borba-Pinheiro CJ, Martin Dantas EH, Pereira de Jesus F et al. Adapted karate training on functional autonomy, muscle strength and quality of life of elderly man with osteoporosis: a clinical case. Arch Budo Sci Martial Art Extreme Sport 2016; 12: 71-76
49. Kent M. The Oxford Dictionary of Sports Science and Medicine. Oxford-New York-Tokyo: Oxford University Press; 1994

Cite this article as: Zhang X, Ashkinazi SM, Bavykin EA et al. Effects of interval training modes on development of special physical qualities of athletes involved in hand-to-hand fighting. Arch Budo Sci Martial Art Extreme Sport 2016; 12: 131-138