

# Optimization of physical training of the qualified muay thai athletes of light weight categories

## Authors' Contribution:

- ✍ A Study Design
- 📁 B Data Collection
- 📊 C Statistical Analysis
- 📄 D Manuscript Preparation
- 📁 E Funds Collection

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## Abstract

### Background and Study Aim:

The muay thai (martial art originally from Thailand) characterized by the combined use of fists, elbows, knees, shins and feet. The purpose of the research is to increase in efficiency of qualified athletes' physical training of muay thai light weight categories on the basis of the developed technique.

### Material and Methods:

Forty muay thai athletes (the I sports category) of light weight categories participated in a research (12 category up to 51 kg; 14 category up to 54 kg; 14 category up to 57 kg). Experimental group (n = 20) age 21 ±1.58 year; control group (n = 20) age 21 ±1.43 year.

### Results:

It is developed the assessment scales of athletes' general and special physical fitness which take into consider sports qualification and weight categories of athletes. It is developed the physical training technique of muay thai athletes of light weight categories (based on the integrated assessment of athletes' physical fitness by means of the battery of tests). The athletes of the experimental group have shown significant improvement of indicators in all tests of the general and special working capacity. It was determined the significant improvement in tests of the control group: reproduction 50% of force of the right and left hand with the visual analyser; standing long jump; two-sided combinations of strikes by elbows. It is defined the positive change of the general level and integrated assessment of athletes' fitness of the experimental group (the basis is harmonious development of physical fitness indicators). The high success of athletes of this group is confirmed by results at prestigious competitions.

### Conclusions:

The technique of integrated assessment of physical fitness includes the complex of pedagogical tests; the differentiated rating scales; the algorithm of test conducting and identification of athletes' fitness level. It is performed the gradation of athletes' physical fitness by absolute and relative assessments. It allows to correct the training process directed to increase in the level of athletes' physical fitness.

### Key words:

control • evaluation criteria • physical fitness • technique • training process

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**Muay thai** – or *thai boxing*, originates from southern Asia (not only from Thailand, but also from Burma, Cambodia, Vietnam and Malaysia). It was inspired by fighting skills used on battle fields during wars conducted by the Thais in the twelfth and thirteenth century AD. Apart from a fight with use of various weapons, during hand-to-hand fighting warriors used *kaad chuek* (wrappings around hand and fore-arm) which were hardened and studded with gravel to cause the greatest damage possible martial art originally from Thailand characterized by the combined use of fists, elbows, knees, shins and feet [35].

**Control** – *noun* skill in using something or in performing [36].

**abs** – *plural noun* the abdominal muscles, or exercises done to firm them (*informal*) [36].

**Condition** *noun* 1. the particular state of someone or something 2. a particular illness, injury or disorder • *verb* to undertake a fitness plan to improve general health, appearance or physical performance [36].

**Microcycle** – *noun* a training cycle that typically lasts for one week [36].

**Technique** – *noun* a way of performing an action [36].

**Technique** – specific procedures to move one's body to perform the task that needs to be accomplished [37].

**Tactics** – decisions and actions of players in the contest to gain an advantage over the opposing players [37].

**INTRODUCTION**

Martial arts and combat sports are characterized by high prevalence and popularity all around the world. In this regard, all of them more often is a subject of scientific research and discussions in various publications. Single combats are applied both as sports and as means of a recreation.

Researches of other authors have confirmed the efficiency of occupations muay thai for increase in physical activity and normalization of cardiovascular system indicators [1]. Other authors applied the program for improvement and normalization of body weight of muay thai athletes [2]. It is defined as the significantly reliable improvement of athletes' morphofunctional indicators. Also, it is proposed to apply training techniques of college's students in the Brazilian jujitsu, boxing, muay thai, kickboxing and fight [3].

The comparative biomechanical analysis of kicks in muay thai, karate and taekwondo determined the similarity and differences of a number of indicators [4]. Muay thai athletes were characterized by a smaller time of striking but had the smaller amplitude of the knee joint motion. Other authors analysed features of traumatism in martial arts. The head and face injuries prevail in boxing, karate and muay thai [5]. The high prevalence of joint damages is observed in the Brazilian jujitsu, judo, and fight.

Rather a large number of works of the physical training and sports experts are devoted to the assessment of athletes' physical fitness of in shock types of single combats: boxing [6], kickboxing [7, 8], taekwondo [9], kyokushin kaikan karate [10, 11]. They include the significant pedagogical tests. The applying of such tests gives the opportunity to obtain information concerning the development of physical qualities of athletes [12]. The rating scales demonstrated in some sources allow estimating objectively and comprehensively the level of athletes' physical fitness [7].

The analysis of the literature devoted to combat sports and mix martial arts (neogladiatorship) was performed in other research [13]. It is

emphasized the essential physiological differences of fight and shock single combats and also dependence on the level of athletes' skill. The most indicative qualities are anaerobic opportunities. They are proposed to be applied as a success predictor.

The essential component of effective selection and the prediction of athletes' sports success are the analysis and assessment of adaptation potential. Results of researches confirmed the importance of cardiovascular system indicators in the monitoring of the functional condition of kickboxing athletes [14]. Other authors suggested to apply heart rate at rest and its maximum value as the reaction indicator to competitive loads in single combats [15]. The application of the genetic analysis allowed to allocate the groups of genes connected with high success in single combats [16]. Other researches confirmed the importance of psychophysiological qualities for success in judo [17]. It is determined the existence of connections of these qualities and motivation levels.

It is proposed to apply choice reaction time as the screening test at the selection of prospective athletes in shock types of single combats – karate, taekwondo, hand-to-hand fighting [18]. Training of muay thai athletes in many respects is similar to boxing training process [19]. However, this type of single combats has the specifics. It provides the essential differences in the system of athletes' training.

The technical and tactical training of athletes are the most important [20]. However, there are practically no data concerning corrections of a training load. It is based on the objective information on athletes' physical fitness development. Muay thai experts specified that athletes' physical training is the basis [21]. The insignificant number of works devoted to directly physical training of muay thai athletes [19, 22, 23]. The leading quality of muay thai athletes is strength [24]. The force preparation of muay thai athletes has to be aimed

at the development of fast strength, strength endurance and high-speed and power abilities [22]. It is defined that strength of strikes depends on indicators of the fast strength of muscles of extremities and body.

The comparative analysis of muay thai athletes' training features is presented in other research [25, 26]. It is shown that the combination of dynamic and isometric exercises is most effective for increase in strength and speed of extremities. The comparison of athletes with a different level of training shown the efficiency of isometric training in qualified athletes.

Conducting testing of the general and special athletes' physical fitness is an integral part of athletes' training process of shock types of single combats [27]. The informative tests and informative criteria for physical fitness assessment are necessary for the practice of athletes training [28]. However, there are no informative, available and valid techniques directed to the assessment of athletes' physical training in muay thai. There are no developed tests for different stages of qualification. There is no monitoring model of athletes' functional condition.

All the above mentioned specified the relevance of performed research. The purpose of the research is to increase in efficiency of qualified athletes' physical training of muay thai light weight categories on the basis of the developed technique.

## MATERIAL AND METHODS

### Participants

The fourth muay thai athletes (the I sports category) of light weight categories participated in a research (12 category up to 51 kg; 14 category up to 54 kg; 14 category up to 57 kg). The experimental group (n = 20), age  $21 \pm 1.58$  year; control group (n = 20), age  $2 \pm 1.43$  year). The age range of athletes was 19-22 years (more in Table 1). The athletes at were almost healthy in the time of research performing. All athletes gave the informed consent to participation in the research. The value of variation coefficient doesn't exceed 10% that testify to the homogeneity of groups of the examined athletes.

### Design of research

The research was performed at The Ammosov North-Eastern Federal University (Yakutsk, Russia). The research for light weight categories of muay thai athletes has two stages. First, the technique of physical training. The rating scales (for determination the level of the general and special physical fitness) were developed on the basis of the received results of the battery of tests for integrated assessment of physical fitness. Second, the efficiency assessment of this technique. Introduction of the developed technique in the training process in three steps: 1 – primary testing; 2 – application of the developed technique within three months in the experimental group (the control group athletes trained by the standard technique; there was no emphasis on the development of the lag components of physical fitness); 3 – repeated assessment of physical fitness.

**Table 1.** The characteristic of light weight categories of muay thai athletes, participating in research.

Statistical indicators	Age (years)	Experience (years)	Body length (cm)	Body weight (kg)
Experimental group (n = 20)				
Average mean	21	5	175	54
Standard deviation	1.58	0.36	6.54	2.15
Variation coefficient	7.52	7.20	3.74	3.98
Control group (n = 20)				
Average mean	21	5	174	54
Standard deviation	1.43	0.48	5.27	2.36
Variation coefficient	6.81	8.20	3.03	4.37

The analysis of competitive activity results of all athletes over a period of January – May. Athletes participated in the championship of Sakha Republic (Russia, Yakutsk, January, 2017), the championship of Far Eastern Federal District (Russia, Yakutsk, February, 2017), Russian Cup (Russia, Krasnoyarsk, February, 2017), the International Tournament (Russia, Yakutsk, April, 2017).

Determination of physical fitness level is performed three times: at the beginning of the all-preparatory step, at the end of a special preparatory step and in the competitive period. The research takes two days: the level of physical qualities development is defined at the first day, the lag components of all-physical fitness are also revealed, the level of special physical fitness is defined at the second day. The level of physical fitness in absolute and relative values is estimated on the basis of the obtained results.

The complex of tests for determination of the general physical fitness included the following exercises: • 30, 150 m run /in motion/ (s) and 1000 m run standing start (min: s); • jumps: standing long jump (m), standing triple jump (m), a 5-fold standing jump separately on the right and left leg (m), standing vertical jump /estimated separately touch with the right and left hand by a measuring ruler/, (cm), backward jump (m); • shot put 4 kg /directions of put flight: from below – forward and from below – back), (m); • bar press (/the athlete lies on the back/) (kg); • pull up (quantity); • reproduction 50% of force of the right and left hands with visual and without visual analyser (kg); • body inclination /the athlete sits, hands forward/ (cm); • body forward /the athlete stand on a gymnastic bench/, (cm).

The developed combined 3-minute test was applied for the assessment of special physical fitness. It included 9 exercises: • two-sided double punches: straight left hand jab – body straight right knee strike (quantity of combinations); • two-sided double punches: right hand jab – body straight left knee strike (quantity of combinations); • one-sided combinations of a straight right knee, left knee strikes (number of strikes); • two-sided combinations of straight knee strikes (number of strikes); • three-punches combinations of hands: straight left hand punch – straight right hand punch – side left hand punch (quantity of combinations); • one-sided combinations of side strikes by left leg, by right leg (quantity of combinations); • two-sided

combinations of strikes by elbows: straight strikes by the left elbow – by the right elbow – side strikes by the left elbow – by the right elbow – side roundhouse strike by the right elbow (quantity of combinations).

### Statistical analysis

The statistical analysis of data is performed by means of the licensed MS Excel. It was defined the indicators of descriptive statistics: arithmetic mean value ( $X_i$ ), standard deviation ( $\sigma$  or  $\pm$ ) and error of mean ( $m$ ), variation coefficient ( $C$ ). The significance of differences in groups was estimated by means of Student's test ( $t$ ) and Rosenbaum Q criterion. ( $Q$ ).

The rating scales of sigma deviations are developed for determination of level of athletes' physical fitness on the basis of the obtained data. It was applied the 5-point evaluation system of muay thai athletes: 1 point – low level; 2 – below average level; 3 – average; 4 – above average level; 5 – high level.

The following assessment scale was applied for evaluation of special physical fitness in all tests, except run (the more time spent, the worse the result) and coordination tests: • low level  $X_i \leq (X - 1.5\sigma)$ ; • below average level  $(X - 1.5\sigma) < X_i \leq (X - 0.5\sigma)$ ; • average level  $(X - 0.5\sigma) < X_i \leq (X + 0.5\sigma)$ ; • above average level  $(X + 0.5\sigma) < X_i \leq (X + 1.5\sigma)$ ; • high level:  $(X + 1.5\sigma) < X_i$ .

Where:  $X$  mean value;  $X_i$  test result.

The following grading scale was applied for grading scales in **running** and **coordination** tests:

• low level  $(X + 1.5\sigma) < X_i$ ; • below average level  $(X + 0.5\sigma) < X_i \leq (X + 1.5\sigma)$ ; • average level  $(X - 0.5\sigma) < X_i \leq (X + 0.5\sigma)$ ; • above average level  $(X - 1.5\sigma) < X_i \leq (X - 0.5\sigma)$ ; • high level  $X_i \leq (X - 1.5\sigma)$ .

The final score is an average, rounded to an integer. In this case, the five-point grading scale does not fully reflect the true state of the athletes. So, athletes with a rating in the range from 4.5 to 4.9 points belong to the group with a rating of 5.0. Athletes with a rating in the range of 4.1 and up to 4.4 points belong to the group with a rating of 4.0. The same situation with other levels - from low to above average. A more accurate estimate can be obtained by using the percentage values of the indicators. Therefore, the following approach is proposed.

The overall level of physical fitness was expressed in percentage, based on the ratio 5 points = 100%. The following level grades were applied: • low level (from 1 to 1.4 points) from 20% to 29%; • below average level (from 1.5 to 2.4 points) from 30% to 49%; • average level (from 2.5 to 3.4 points) from 50% to 69%; • above average (from 3.5 to 4.4 points) from 70% to 89%; • high level (4.5 to 5 points) from 90% to 100%.

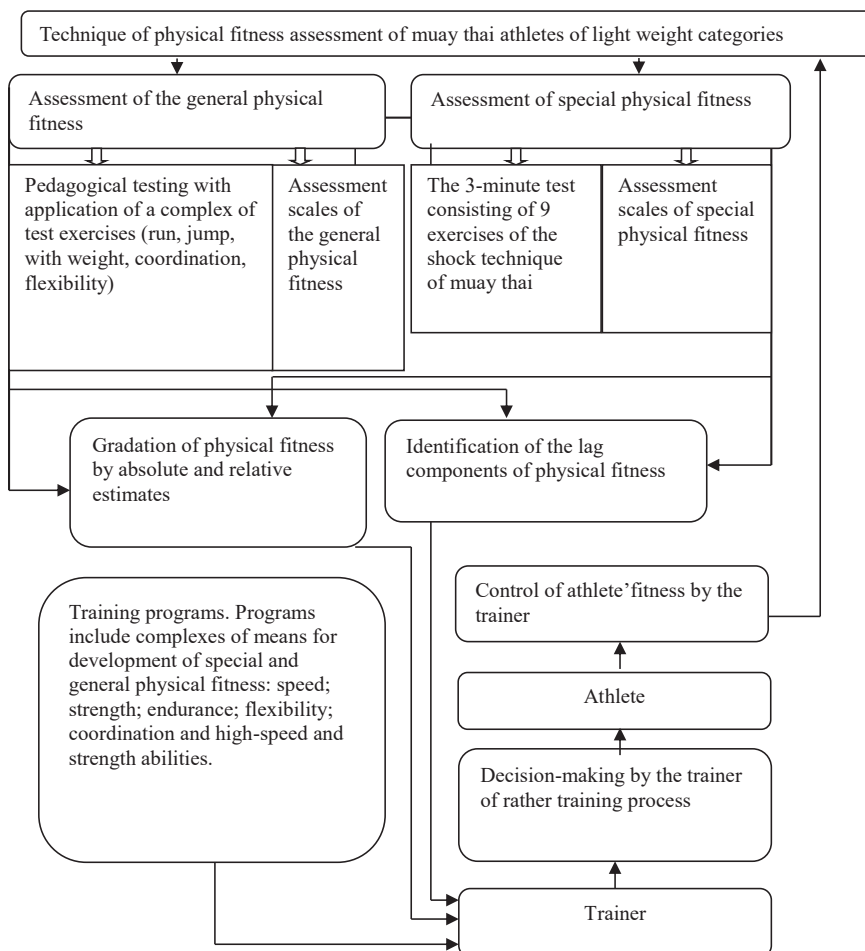
**RESULTS**

The structure of the developed technique of physical training of light weight categories muay thai athletes is provided on Figure1.

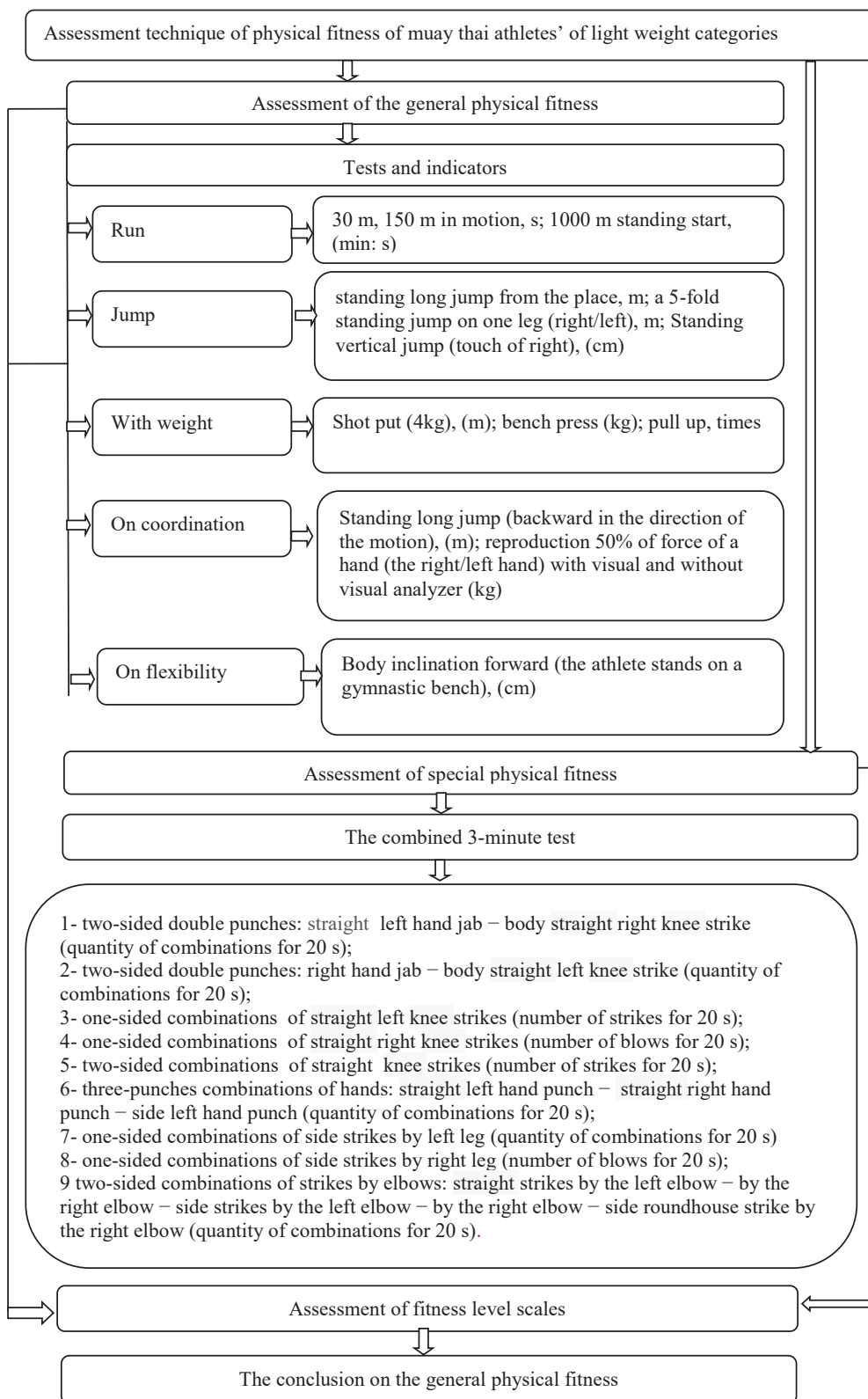
The algorithm of technique realization consists in the consecutive solution of the following tasks: • determination of physical fitness level of muay thai athletes; • correction of the lag components; • increase in fitness level in general. Integrated assessment technique of muay thai athletes' physical fitness takes the central place in the developed technique (Figure 2).

Assessment scales of the general and special physical fitness are developed considering sports qualification and weight category of athletes (Tables 2 and 3).

At the beginning of the pedagogical experiment indicators of testing of physical fitness in groups have no significant differences ( $p > 0.05$ ). The



**Figure 1.** Structure of physical training technique of light weight categories in muay thai athletes' at training stage.



**Figure 2.** Structure of an integrated assessment of physical fitness technique of muay thai athletes of light weight categories.



**Table 2.** Assessment of the general physical fitness of muay thai athletes (n = 40) of light weight categories.

Test (indicator)	General physical fitness levels				
	low	below average	average	above average	high
30 m run (in motion) (s)	>4.63	4.41÷4.63	4.18÷4.40	3.95÷4.17	≤3.94
150 m run (in motion) (s)	>22.16	21.31 ÷22.16	20.44÷21.30	19.57÷20.43	≤19.56
1000 m run standing start (min: s)	>3:08	2:59÷3:08	2:48÷2:58	2:38÷2:47	≤2:37
Standing long jump (m)	≤2.21	2.22÷2.31	2.32÷2.41	2.42÷2.51	>2.51
5-fold standing jump on the right leg (m)	≤10.71	10.72÷11.43	11.44÷12.16	12.17÷12.88	>12.88
5-fold standing jump on the left leg (m)	≤10.42	10.43÷11.21	11.21÷12.00	12.01÷12.79	>12.79
Standing vertical jump (touch with the right hand of a measuring ruler) (cm)	≤36	37÷41	42÷46	47÷51	>51
Shot put below forward (4 kg) (m)	≤9.86	9.87÷10.73	10.74÷11.61	11.62÷12.49	>12.49
The bar press weight relation (the athlete lies on a back) to the body weight (relative units)	≤0.91	0.92÷0.98	0.99÷1.05	1.06÷1.11	>1.11
Pull up on a high bar (abs)	≤10	11÷14	15÷19	20÷24	>24
Reproduction of 50% of force of the right hand with the visual analyser (kg)	>6	5÷6	3÷4	1÷2	≤0
Reproduction of 50% of force of the left hand with the visual analyser (kg)	>6	5÷6	3÷4	1÷2	≤0
Reproduction of 50% of force of the right hand without visual analyser (kg)	>9	7÷9	5÷6	2÷4	≤1
Reproduction of 50% of force of the left hand without visual analyser (kg)	>9	8÷9	6÷7	4÷5	≤3
Standing long jump backward in the direction of the motion (m)	≤1.23	1.24÷1.31	1.32÷1.39	1.40÷1.47	>1.47
Body inclination forward (the athlete stand on a gymnastic bench) (cm)	≤16	17÷18	19÷21	22÷23	>23

performed analysis show significant improvement of indicators of the general and special physical fitness of athletes (Tables 4 and 5). Change is confirmed both by means of parametrical and nonparametric criteria. According to Student's t-test. 15 of 16 applied tests have confirmed an increase in the general efficiency of athletes. It is determined the tendency to the reliability of differences only in the test pull up on high bar ( $p < 0.1$ ). The significant improvement of indicators is confirmed in all special working capacity tests.

Application of Rosenbaum Q criterion determined significant improvement of indicators in all special tests and the vast majority of tests for the general working capacity (see Table 4). Only in one test (reproduction of 50% of force of the left hand without visual analyser). significant changes ( $p > 0.05$ ) aren't confirmed.

It is revealed the significant improvement of only one indicator according to Student's t-test in the course of fitness. It was test results of reproduction 50% of force of the left hand with the visual analyser. The application of Rosenbaum Q criterion has shown more expressed changes. Results of standing long jump ( $Q = 7, p < 0.05$ ), reproduction 50% of force with the visual analyser of the right hand ( $Q = 7, p < 0.05$ ) and time of two-sided combinations of strikes by elbows have significantly improved ( $Q = 7, p < 0.05$ ).

The individual assessment of athletes' condition was performed along with the definition of group indicators of physical fitness. In the experimental group of athletes before the experiment. 9 persons (45%) had the average level of physical fitness. 7 persons – below average (35%) and 4 persons – above average (20%). Development of physical fitness components was inharmonious. For example: the athlete, who had a serial

**Table 3.** Assessment of special physical fitness levels of muay thai athletes (n = 40) of light weight categories.

Test (indicator)	General physical fitness level				
	low	below average	average	above average	high
Two-sided double punches: left hand jab – body straight right knee strike (abs for 20 s)	≤14	15÷16	17÷18	19 ÷ 21	>21
Two-sided double punches: right hand jab – body straight left knee strike (abs for 20 s)	≤9	10÷13	14÷17	18 ÷ 20	>21
One-sided combinations of straight right knee strikes (abs for 20 s)	≤20	21÷23	24÷25	26 ÷ 28	>29
One-sided combinations of straight left knee strikes (abs for 20 s)	≤19	20÷21	22÷24	25 ÷ 26	>27
One-sided combinations of straight left knee strikes (abs for 20 s)	≤18	19÷23	24÷28	29 ÷ 33	>33
Three-shock series hands: direct stroke by the left hand – direct stroke by the right hand – side left- hand blow (abs)	≤7	8÷11	12÷14	15 ÷ 18	>18
One-sided combinations of straight left leg strikes (number of blows for 20 s)	≤17	18÷20	21÷22	23÷25	>25
One-sided combinations of straight right leg strikes in 20 s	≤17	18÷19	20÷22	23÷24	>24
Two-sided combinations of strikes by elbows: straight strikes by the left elbow – by the right elbow – side strikes by the left elbow – by the right elbow – side roundhouse strike by the right elbow (abs for 20 s)	≤2	3÷4	5÷6	7÷8	>8

number 1 (experimental group list), had above average level of fitness (4 points and 72% from maximum possible physical fitness). Other indicators of the athlete number 1: speed corresponded to a low level (1 point. 20%); the endurance; high-speed and power abilities; coordination; flexibility – are estimated on 4 points; the special physical fitness corresponded to the average level (3 points, 60%). That is this level of physical fitness has been reached by means of 5 components of physical fitness. One of the components (speed) considerably lags. Level of special physical fitness is also insufficiently developed.

The developed technique of physical training was directed to harmonization of development of physical training components. Repeated testing of the experimental group athletes confirmed the growth of physical fitness level and change of specific weight of athletes with various fitness level. It was revealed 2 athletes (10%) with the high level of physical fitness. The quantity of muay thai athletes with above average level has grown to 10 persons (50%). Specific weight of athletes with the average level was 8 athletes (40%). The relative assessment of physical fitness has increased in all participants. It is determined

positive change of the general level and integrated assessment of athletes' fitness due to the harmonious development of physical fitness components.

In control group 5 athletes (25%) had a level of physical fitness above average, 8 athletes average level (40%), 7 athletes below average level (35%). They demonstrated the inharmonious development of physical fitness components as well as representatives of the experimental group at the beginning of the experiment. The number of athletes with above average level of physical fitness has increased up to 35% at the end of the experiment. Specific weight of muay thai athletes with an average level of physical fitness has considerably increased up to 60%. Specific weight of athletes with below average level was reduced up to 5%. There were no athletes with high level and also with the harmonious development of physical fitness components.

## DISCUSSION

Our observations entitle us to a lot of desensitization related to the practice of muay thai training.



**Table 4.** Results of testing of physical fitness of athletes muay thai light weight categories of experimental group (n = 20) in dynamics of an experiment.

Test (indicator)	Before experiment	After experiment	t	Q
30 m run (in motion) (s)	4:38 ±0.05	4:14 ±0.06	3.16	8
150 m run (in motion) (s)	20:87 ±0.24	19:88 ±0.18	3.32	13
1000 m run from high start (min: s)	2:53 ±0.03	2:41 ±0.01	3.96	17
Standing long jump (m)	2.37 ±0.02	2.51 ±0.02	-4.40	17
5-fold standing jump on the right leg ( m)	11.73 ±0.18	12.41 ±0.17	-2.74	10
5-fold standing jump on the left leg ( m)	11.59 ±0.19	12.69 ±0.18	-4.13	18
Standing vertical jump (touch with the right hand of a measuring ruler) (cm)	43.20 ±1.14	46.50 ±1.06	-2.12	14
Shot put below forward (4 kg) ( m)	11.72 ±0.17	12.57 ±0.19	-3.44	16
The bar press weight relation (the athlete lies on a back) to the body weight (relative units)	1.02 ±0.01	1.10 ±0.01	-4.02	17
Pull up on a high bar (abs)	17.55 ±1.06	20.25 ±1.06	-1.81	7
Reproduction of 50% of force of the right hand with the visual analyser (kg)	1.32 ±0.02	1.42 ±0.02	-3.44	11
Reproduction of 50% of force of the left hand with the visual analyser (kg)	0.95 ±0.14	0.30 ±0.11	3.79	17
Reproduction of 50% of force of the right hand without visual analyser (kg)	1.15 ±0.18	0.35 ±0.11	3.77	19
Reproduction of 50% of force of the left hand without visual analyser (kg)	4.45 ±0.49	2.90 ±0.32	2.66	4
Standing long jump backward in the direction of the motion. m	5.15 ±0.41	3.50 ±0.36	3.05	7
Body inclination forward (the athlete stand on a gymnastic bench) (cm)	18.90 ±0.41	23.45 ±0.69	-5.69	22
Two-sided double punches: left hand jab – body straight right knee strike (abs for 20 s)	18.00 ±0.64	20.85 ±0.60	-3.23	9
Two-sided double punches: right hand jab – body straight left knee strike (abs for 20 s)	16.40 ±1.09	19.75 ±0.89	-2.38	13
one-sided combinations of straight right knee strikes (abs for 20 s)	23.45 ±0.55	26.90 ±0.59	-4.26	18
one-sided combinations of straight left knee strikes (abs for 20 s)	20.30 ±0.66	26.30 ±0.62	-6.62	18
one-sided combinations of straight left knee strikes (abs for 20 s)	24.95 ±0.65	26.30 ±0.69	-3.85	20
Three-shock series hands: direct stroke by the left hand – direct stroke by the right hand – side left-hand blow (abs)	13.65 ±0.70	16.30 ±0.75	-2.59	10
one-sided combinations of straight left leg strikes (number of blows for 20 s)	18.65 ±0.53	24.40 ±0.50	-7.82	33
one-sided combinations of straight right leg strikes in 20 s	19.00 ±0.68	23.90 ±0.43	-6.12	28
two-sided combinations of strikes by elbows: straight strikes by the left elbow – by the right elbow – side strikes by the left elbow – by the right elbow – side roundhouse strike by the right elbow (abs for 20 s)	4.20 ±0.24	7.45 ±0.28	-8.95	34

The following component in physical training technique of muay thai athletes light weight categories development of recommendations to trainers is: complexes for the development of speed, force, endurance, flexibility, coordination and high-speed and power abilities became their contents.

Training microcycle in muay thai consists of 6 educational and training occupations and day of rest (Sunday). Three days a week (Tuesday, Thursday and Saturday) are devoted to the development of physical qualities and abilities. It is applied the orientation no more than on two physical qualities in one day. Tuesday is a day of special physical fitness, high-speed, power

abilities and flexibility development. Thursday is a day of special physical fitness, endurance and coordination development. Saturday is a day of development of special physical fitness, speed and strength.

The analysis of competitive activity demonstrated the best success of experimental group athletes with high and above average level of physical fitness. They won competitions more often than control group athletes with above average fitness level.

All 20 athletes of the experimental group throughout the competitive period participated

**Table 5.** Results of physical fitness testing of muay thai athletes of light weight categories of control group (n = 20) in dynamics of an experiment.

Test (indicator)	Testing results ( $\bar{x} \pm m$ )		
	before experiment	after experiment	t
30 m run (in motion) (s)	4:38 $\pm$ 0.03	4:34 $\pm$ 0.03	0.87
150 m run (in motion) (s)	20:86 $\pm$ 0.23	21:02 $\pm$ 0.18	-0.53
1000 m run from high start (min: s)	2:53 $\pm$ 0.04	2:51 $\pm$ 0.01	0.43
Standing long jump (m)	2.38 $\pm$ 0.02	2.40 $\pm$ 0.02	-0.62
5-fold standing jump on the right leg (m)	11.70 $\pm$ 0.15	11.75 $\pm$ 0.15	-0.22
5-fold standing jump on the left leg (m)	11.61 $\pm$ 0.20	11.68 $\pm$ 0.17	-0.28
Standing vertical jump (touch with the right hand of a measuring ruler) (cm)	42.85 $\pm$ 1.30	43.25 $\pm$ 1.32	-0.22
Shot put below forward (4 kg) (m)	11.73 $\pm$ 0.18	11.81 $\pm$ 0.17	-0.32
The bar press weight relation (the athlete lies on a back) to the body weight (c.u.)	1.02 $\pm$ 0.01	1.03 $\pm$ 0.01	-0.55
Pull up on a high bar (abs)	17.60 $\pm$ 1.08	18.15 $\pm$ 1.02	-0.37
Reproduction of 50% of force of the right hand with the visual analyser (kg)	1.31 $\pm$ 0.03	1.32 $\pm$ 0.02	-0.25
Reproduction of 50% of force of the left hand with the visual analyser (kg)	0.85 $\pm$ 0.13	0.35 $\pm$ 0.15	2.51
Reproduction of 50% of force of the right hand without visual analyser (kg)	1.10 $\pm$ 0.12	0.85 $\pm$ 0.15	1.29
Reproduction of 50% of force of the left hand without visual analyser (kg)	4.40 $\pm$ 0.35	3.80 $\pm$ 0.33	1.25
Standing long jump backward in the direction of the motion (m)	5.20 $\pm$ 0.29	4.55 $\pm$ 0.26	1.69
Body inclination forward (the athlete stand on a gymnastic bench) (cm)	18.80 $\pm$ 0.41	19.00 $\pm$ 0.37	-0.36
Two-sided double punches: left hand jab – body straight right knee strike (abs for 20 s)	18.15 $\pm$ 0.62	18.30 $\pm$ 0.59	-0.18
Two-sided double punches: right hand jab – body straight left knee strike (abs for 20 s)	16.00 $\pm$ 0.89	16.30 $\pm$ 0.81	-0.25
One-sided combinations of straight right knee strikes (abs for 20 s)	23.80 $\pm$ 0.54	24.15 $\pm$ 0.50	-0.48
One-sided combinations of straight left knee strikes (abs for 20 s)	20.40 $\pm$ 0.78	21.10 $\pm$ 0.58	-0.72
One-sided combinations of straight left knee strikes (abs for 20 s)	25.10 $\pm$ 0.84	25.80 $\pm$ 0.84	-0.59
Three-shock series hands: direct stroke by the left hand – direct stroke by the right hand – side left – hand blow (abs)	13.45 $\pm$ 0.71	13.65 $\pm$ 0.62	-0.21
One-sided combinations of straight left leg strikes (number of blows for 20 s)	18.95 $\pm$ 0.68	19.30 $\pm$ 0.68	-0.36
One-sided combinations of straight right leg strikes (number of blows for 20 s)	19.55 $\pm$ 0.53	19.95 $\pm$ 0.47	-0.57
Two-sided combinations of strikes by elbows: straight strikes by the left elbow – by the right elbow – side strikes by the left elbow – by the right elbow – side roundhouse strike by the right elbow (abs for 20 s)	4.13 $\pm$ 0.24	4.85 $\pm$ 0.26	-2.03

in two competitions (championship of Sakha Republic and the International Tournament, Russia). Eight athletes of this group have participated in the championship of Far Eastern Federal District (Russia). One athlete participated in the Russian Cup. All control group athletes couldn't participate in one competition because of injuries. One athlete with below average level was injured prior to the performance. Three athletes with the average level were injured during the first competitions – the championship of the Sakha Republic (Russia) and couldn't participate

in the next tournaments. In this group there were no participants of the Russian Cup. Seven athletes have participated in the championship of Far Eastern Federal District.

The experimental group athletes with the high fitness level of readiness have successfully spent the competitive period. The athlete, who had a serial number 1 (experimental group list), performed in weight category up to 54 kg has won first place in three competitions – the championship of Sakha Republic, the championship of Far Eastern Federal

District, the International Tournament in Russian Cup has won a bronze award. The athlete, who had a serial number 3 (experimental group list) (up to 57 kg) has won three competitions – championship of the Sakha Republic, Far Eastern Federal District and the International Tournament. Nine athletes with above average level of physical fitness successfully participated in two competitions – championships of Sakha Republic and Far Eastern Federal District. In the championship of the Sakha Republic in weight category up to 51 kg two athletes won the third places. In weight category up to 54 kg athletes won one second and two third places. In category up to 57 kg athletes won one second, two third places. In championship of Far Eastern Federal District they won 4 medals which includes one silver [the athlete, who had a serial number 5 (experimental group list), up to 54 kg], three bronze [the athlete, who had a serial number 2 (experimental group list) – category up to 51 kg; the athlete, who had a serial number 6 (experimental group list) – category up to 54 kg; the athlete, who had a serial number 4 (experimental group list) – category up to 57 kg]. The experimental group athletes with the average fitness level (9 people) participated in the championship of Sakha Republic but lose.

Representatives of control group with above an average fitness level (7 people) in the championship of the Sakha Republic won three prizes: the second – in weight category up to 51 kg [the athlete, who had a serial number 3 (experimental group list)]; the third – in category up to 54 kg [the athlete, who had a serial number 1 (experimental group list)]; the second – in weight category up to 57 kg [the athlete, who had a serial number 13 (experimental group list)]. Two athletes were included into the prize-winning three in the championship of Far Eastern Federal District – the athlete, who had a serial number 3 (experimental group list) (the 2nd place) and the athlete, who had a serial number 13 (experimental group list) (the 3rd place).

Optimization of selection and prediction of athletes' success is a relevant scientific and practical task of sports science. Various approaches and techniques are applied to its solving. An integrated approach and adequate statistical analysis become the key issues of such researches.

It was confirmed the necessity of an integrated approach at the successful prediction in

kickboxing [29]. The athletes' morphological and functional indicators at rest and at the reaction to load were applied for the prediction. The assessment scales of the general and special physical fitness were created on the basis of the obtained results. They are based on the method of sigma deviations. This method is a standard assessment of physical development and physical fitness. However other techniques are also applied nowadays.

Thus, the special centile tables are developed on the basis of results of tests implementation and indicators restoration after loads considering athletes' gender and age [30]. The technique of successful prediction in kickboxing is based on consecutive Wald analysis [29]. The following design is applied in the research – the division of athletes with an identical level of skill into the groups with different fitness level.

The absence of significant differences at the beginning of the research points to the homogeneity of the examined groups of athletes. The similarity of working capacity indicators in groups confirms the proximity of the functional level of muay thai athletes.

The similar approach was applied in other research [31]. Authors applied the battery of tests to an assessment of the general and special efficiency of muay thai athletes. It is defined the existence of interrelations between the studied indicators. It is confirmed the validity and informational content of the applied tests. The importance of specific tests for the monitoring of a functional condition of athletes is emphasized in another research [30].

The developed technique of integrated assessment of the physical fitness of muay thai athletes of light weight categories includes pedagogical tests and estimate indicators of the rating scales. The technique is available to the application in the training process without additional equipment. The technique allows to obtain necessary operational information about the current state of athletes and to carry out the comprehensive complex assessment of the general and special physical fitness. Such approach allows: to pay attention to the development of the lag components of physical fitness; to make corrections in the creation of training occupations and plans of sports

training; to predict sports results, duration and success of a performance throughout all sports career. Also allows to reveal "leaders" among the athletes capable to achieve high results and subsequently to keep them at all next stages. The technique allows to improve the control system and selection of muay thai athletes. In this aspect. our research supplements work of other authors [21, 23] and expand knowledge of training features of muay thai athletes [32].

The strong and fast strikes is a major factor of success in muay thai. Therefore tests for assessment of special working capacity are based on the performance of combinations and strikes. It allows to consider them specific for muay thai. The available data confirm the legitimacy of this assumption.

The analysis of the biomechanical indicators of the roundhouse kick of muay thai athletes with a different level of skill is carried out in other research [33]. Athletes-beginners were characterized by the existence of asymmetry between the left and right legs, a difference of speed and amplitude of the joints movement. The importance of sufficient strength of extremities muscles and flexibility of joints for striking blows in kickboxing is confirmed in other research [34].

Distribution of athletes according to the level of physical fitness by means of the developed rating scales allows to individualize loads of muay thai athletes. The received results allow to confirm that the applied experimental program promoted the improvement of the general and special physical training of muay thai athletes of light weight categories. The approbation of the experimental program confirmed its high efficiency. The improvement of practically all indicators of the general and special working capacity was determined in the experimental group. It testifies of high informational content and specificity of the applied batteries of tests. Changes in the control group were expressed much less.

It is defined the positive influence of the developed technique of physical training of muay thai athletes of light weight categories. The improvement has expressed an increase in the level of athletes physical fitness, harmonious development of physical fitness components and also effective carrying out the competitive period. Throughout 4 competitions (Championships of Sakha Republic, Far Eastern Federal District, International Tournament. Russian Cup) athletes have won 6 gold, 3 silver and 10 bronze medals.

## CONCLUSIONS

The conducted researches confirmed efficiency of the developed technique for optimization of physical training of the qualified muay thai athletes of light weight categories. The central link of the technique is integrated assessment of physical fitness of athletes by means of the battery of tests. Athletes of experimental group demonstrated significant improvement of indicators practically in all tests of the general and special working capacity. Results of athletes of control group were significantly worse. The analysis of competitive activity of athletes confirmed high success of participants of experimental group.

The developed technique of integrated assessment of physical fitness includes a complex of pedagogical tests, the differentiated rating scales, an algorithm of conducting testing and identification of athletes' fitness level. The gradation of physical fitness of muay thai athletes by absolute and relative estimates for correction of the training process directed to increase in level of physical fitness of athletes is carried out.

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