Impact of physical training mesocycle on athletic and specific fitness of elite boxers

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Abstract

Background and Study Aim: The indices of boxers' athletic and special fitness are important structural components of sports fitness as they influence the acquisition of the sports form. Thus, it is relevant to study the changes in the indices of boxers' athletic fitness, special physical fitness and working capacity after the physical training mesocycle.

Material/Methods: The research participants were 10 elite boxers, candidates to the Lithuanian national boxing team, participants and prize winners at the Lithuanian boxing championships. Their mean age was 22.50±3.38 years. The physical training mesocycle lasted for four weeks in the preparation period. Special physical fitness and specific working capacity of boxers were tested using special diagnostic equipment "Kiktest-100" which consists of a standard boxing bag with a special device inside – dynamometer and a sensing element registering the impulses of blows; computer block registering the force of blows (kg), the number of blows, intervals between the blows, summative force of blows (kg) in a unit of time, and energy outlay (J).

Results: After the physical training mesocycle the indices of boxers' explosive strength, speed strength and quickness improved. The single blow force to the boxing bag improved as well. After the physical training mesocycle, the force of single blows of boxers with their main and front hand and the force of the straight blow with their main hand improved to 253.37±31.09 kg, the side blow – to 297.00±45.07 kg, and the low blow – to 303.62±42.18 kg. The average single blow power hitting the boxing bag 3×3 min increased from 76.72±29.71 kg to 82.54±33.41 kg.

Conclusions: Four-week physical training mesocycle, consisting of 40% of athletic training and 60% of special physical training, had a positive effect on the changes in indices of boxers' athletic fitness. There was an improvement observed in the indices of boxers' athletic fitness performing explosive strength, speed strength and speed exercises. The force of blows hitting the boxing bag with the main and front hand increased as well. There was an increase in the indices of special anaerobic alactatic working capacity: number of blows, summative force of blows, and energy outlay hitting the boxing bag for 3 s, 5 s, and 8 s.

Key words: boxers • athletic fitness • special physical fitness • energy outlay • force of blows • summative force

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Background

Competitive activities of boxers can be characterized by great dynamics of movements and changing situations, great mental tension, variety of blows and defensive actions [1–4]. The performance of specific actions of boxers is greatly influenced by the speed and the coordination of movements, the accuracy of movements during blows, the force of blows, and psychomotor abilities [3,5–7]. The fight of boxers in the ring demands speed, strength, endurance, agility, flexibility, and the complex expression of coordination abilities [7–11]. Nowadays elite boxers should demonstrate high levels of athletic and special physical fitness, good techniques, flexible and versatile tactics [8,12–15]. Athletic fitness is the level of the development of sport-specific (boxing) physical

Boxer – is an athlete in combat sports having mastered boxing technique and participating in boxing matches.

Athletic fitness – is the level of the development of sport-specific (boxing) physical fitness abilities (speed, strength, endurance, agility, flexibility) and functional systems of the human organism, which interacts with specific physical fitness and is efficient in contest activities. Athletic fitness is improved by general physical training exercises.

Special physical fitness – of boxers is the level of special working capacity and training of specific motor skills and functional powers of the human organism, influencing the results at boxing competitions. Specific physical fitness is developed using specific physical exercises which mostly correspond to boxer's movements in boxing in terms on movement biomechanics and the effort size of strength.

fitness abilities (speed, strength, endurance, agility, flexibility) and functional systems of the human organism, which interacts with specific physical fitness and is efficient in contest activities [1,8,12]. Athletic fitness is improved by general physical training exercises. Special physical fitness of boxers is the level of special working capacity and training of specific motor skills and functional powers of the human organism, influencing the results at boxing competitions [8,10,12]. Specific physical fitness is developed using specific physical exercises which mostly correspond to boxer's movements in boxing in terms on movement biomechanics and the effort size of strength. The up-to-date trend of training boxers is modeling boxing activities during the training sessions while preparing for the main competitions [1,3,6,10,16]. Models of training sessions during the mesocycles of a yearly training cycle impact on boxers' special working capacity [3,6,9,10,12]. The development of physical abilities and special physical fitness should be a constant process [12]. Athletic training of boxers should aim at a very high level of sports form [6,8,17].

Research literature still lacks evidence about the content and the structure of physical training models of elite boxers in the mesocycles during the different phases of a yearly training cycle. It would be worth analyzing the changes in the indices of elite boxers' athletic and special physical fitness and working capacity after the mesocycles of physical training.

The aim of the research was to investigate the impact of the physical training mesocycle on the changes in the indices of elite boxers' athletic fitness and specific physical fitness.

Material and Methods

We investigated the impact of the physical training sessions on the changes in the indices of elite boxers' athletic fitness and specific physical fitness. The research participants were 10 elite boxers, and their mean age (x ±SD) was 22.50±3.38 years. The subjects were candidates to the Lithuanian national boxing team, participants and prize winners at the Lithuanian boxing championships. All of them were right-handed. The physical training mesocycle lasted for four weeks (28 days) in the preparation period (in November – December, 2009). The mesocycle consisted of two microcycles of athletic training and two microcycles of specific physical training. Each microcycle included six days of training and one day of recovery (active rest). Forty percent of the mesocycle program was devoted to athletic training, and 60 percent – to specific physical training. The main emphasis was laid upon the development of explosive strength, speed strength, speed abilities. Physical exercises were performed repetitively. During the rest intervals between the exercises and the sets of exercises the boxers performed relaxation and flexibility exercises, exercises simulating boxing techniques, they ran at a low speed with their heart rate (HR) at 110–120 beats/min. during the days of recovery the boxers performed cyclic exercises for 40–80 min in an aerobic mode (walking, running, swimming) at low intensities, with their heart rate at 110–120 beats/min. During the first two microcycles we emphasized athletic training and during the following two microcycles – specific physical training. The exercise complexes of athletic and specific physical training and their methods are given in Tables 1 and 2.

The testing of athletic fitness and specific physical fitness was performed twice: before the beginning of the physical training mesocycle and after 5 days of active rest (recovery microcycle) after completing the mesocycle. We established the following indices of boxers' athletic fitness [1,8,16,18]: 30 m running from the start, standing long jump, high jump from a contact platform "New Test" with arm swings, hand grip strength of both right and left hands, 4 kg shot putting with both right and left hands, bending and stretching arms while lying for 15 s, raising legs to the bar hanging on it, sit ups, movement frequency (Tapping test) for 5 s and 30 s. Special physical fitness and specific working capacity of boxers were tested using special diagnostic equipment "Kiktest-100" [19] which consists of: 1) a standard boxing bag with a special device inside – dynamometer and a sensing element registering the impulses of blows; 2) computer block registering the force of blows (kg), the number of blows, intervals between the blows, summative force of blows (kg) in a unit of time, and energy outlay (J).

We established the following indices of boxers' special fitness [1,10]:

- The force (kg) of single blows to the bag with the main and the front hand. We registered the force of straight blows, side blows and low blows.
- The number of blows, the summative force of blows (kg) and the energy outlay (J) hitting the boxing bag for 3 s, 5 s, 8 s.
- The number of blows, the summative force of blows (kg) and the energy outlay (J) hitting the boxing bag for three rounds (3×3 min) with the intervals of one minute between the rounds. We registered the indices in each round and the summative indices of all three rounds.

The research data were processed using Microsoft Office Excel computer software. We calculated arithmetic means ($\bar{x}$), standard deviations (SD), and Student's *t* test to estimate differences between the research indices. The level of significance was set at $p<0.05$.

Table 1. Complexes of athletic training exercises and methods of their performance.

Physical exercises	Nature of physical load	Number of repetitions of exercises (times)	Number of sets	Rest breaks	
				Between the complexes of exercises	Between the sets of exercises
Exercises for the activation of muscle strengths					
1. Pressing the barbell-while lying	80–90% of maximal weight	2	2	5	3
2. Sit-ups with weight on the shoulders bending the legs to the angle of 90 degrees	80–90% of maximal weight	2	2	5	3
3. Twisting the waist with resistance on a special training machine	80–90% of maximal resistance	2	2	5	3
4. Tiptoes with weights	80–90% maximal weight	2	2	5	3
Exercises for the development of explosive strengths	Plyometric work mode				
1. Jumping down from a 60 cm height platform, and then jumping up	80% of strength 20% of speed	6–10	3	Between the repetitions of jumping, 30 s	3
2. Bending and stretching arms clasping hands while lying (press-ups)	70% of strength 30% of speed	6–10	3	5	3
3. Hitting while overcoming rubber resistance	60% of strength 40% of speed	6–10	3	5	3
Exercises for the development of speed strength					
1. Throwing the barbell rod neck or metal rod (weight – 5–6 kg) from the bowers fighting position	40% of strength effost 60% of speed	6–10	3	5	3
2. Pushing weight (3–5 kg) from the boxers' fighting position	30% of strength 70% of speed	6–10	3	5	3
3. Sets of hitting the air with 0.5 kg weight in hands	20% of strength 80% of speed, maximal frequency	5 s	3	5	3

Results

The height of the subjects in the research was 179.00±7.70 cm, and the body mass – 71.87±15.18 kg. Those indices did not change after the physical training mesocycle ($p>0.05$). After the physical training mesocycle the indices of athletic fitness (Table 3) – speed and explosive strength (30 m running from a start), explosive strength (standing long jump, standing high jump with arm swings), hand grip strength, abdominal muscle strength and strength endurance (raising legs to the bar hanging on it), flexibility and movement speed for 5 s and for 30 s (Tapping Test) – did not change ($p>0.05$).

Research data include the changes in the indices of boxers' special physical fitness and specific working capacity after the physical training mesocycle (Tables 4–6). After the physical training mesocycle we observed an increase in strength of single blows with the boxers' main and front hands (Table 4). There was a statistically significant increase in strength of straight and low blows with the boxers' main hand ($p<0.05$), side and low blows with the front hand ($p<0.05$).

Judging from the data of 3 s and 5 s blows to the boxing bag with maximal efforts (Table 5) we can evaluate boxers' anaerobic alactatic capacity (Table 5). The indices of hitting the boxing bag for 8 s indicate boxers' special anaerobic alactatic (creatine phosphate) endurance [8,10]. After the physical training mesocycle there was an increase in the indices of special anaerobic alactatic working capacity, though not all the changes in those indices were statistically significant (Table 5). The maximal number of blows in 3 s, 5 s, and 8 s increased, but the changes were not significant ($p>0.05$).

Changes in the indices of summative blow power and energy outlay hitting the boxing bag for 3 s, 5 s and 8 s show

Table 2. Complexes of special physical training exercises and methods of their performance.

Physical exercises	Nature of physical load	Number of repetitions of exercises (times)	Number of sets	Rest breaks	
				Between the complexes of exercises	Between the sets of exercises
Exercises for the development of explosive strength					
1. Pushing partner from the boxers' fighting position	80% of strength effort, 20% of speed	10	3	5	3
2. Jumping down from a 60 cm height platform, and then jumping up and hitting the boxing bag with the left or right hand (plyometric muscle work mode)	70% of strength effort, 30% of speed	10	3	5	3
3. Hitting while overcoming rubber resistance (stretching the rubber)	60% of strength effort, 40% of speed	10	3	5	3
Exercises for the development of speed strength					
1. Single straight blows to the boxing bag with 0.5–1 kg weights in hands	70% of speed effort, 30% of strength	10	3	5	3
2. Single low blows to the boxing bag with 0.5–1 kg weights in hands	70% of speed effort, 30% of strength	10	3	5	3
3. Single side blows to the boxing bag with 0.5-1 kg weights in hands	70% of speed effort, 30% of strength	10	3	5	3
4. Sets of blows to the boxing bag with 0.5–1 kg weights in hands	70% of speed effort, 30% of strength	5 s			
Exercises for the development of speed					
1. Simulating single straight blows to the air	70% of speed effort, 30% of strength	10	3	5	3
2. Simulating single low blows to the air	70% of speed effort, 30% of strength	10	3	5	3
3. Simulating single side blows to the air	70% of speed effort, 30% of strength	10	3	5	3
4. Sets of simulations of blows to the air (3 sets 5 blows in each of them)	80% of speed effort, 20% of strength of maximal frequency	5 s	3	5	3

Table 3. Effect of the physical training mesocycle on the indices of boxers' athletic fitness ($\bar{x}$±SD).

Research stages	30 m running from a standing position, s	Standing long jump, cm	Standing high jump with arm swings, cm	Hand grip strength, kg		4 kg shot put, m		Push-ups on the parallel bars, time	Bending and stretching arms in a lying position in 15 s (times)	Bending forward while sitting. cm	Frequency of movements (times)	
				Right	Left	Right	Left				In 5 s	In 30 s
1	4.82 ±0.18	225.75 ±11.25	41.68 ±3.03	53.88 ±10.51	52.5 ±9.17	9.85 ±1.37	9.09 ±1.96	14.50 ±5.73	24.13 ±1.96	30.75 ±12.96	38.32 ±3.42	192.5 ±12.09
2	4.76 ±0.18	239.75 ±12.69	43.60 ±4.35	58.50 ±12.14	56.75 ±9.44	10.19 ±1.53	9.44 ±1.77	17.13 ±5.82	24.50 ±2.01	32.63 ±19.39	37.5 ±3.74	199.38 ±25.48
p	<0.01	<0.01	<0.05	<0.05	<0.05	<0.05	<0.01	<0.05	>0.05	>0.05	>0.05	>0.05

the positive effect of mentioned above physical training mesocycle on the specific anaerobic alactatic working capacity of boxers. Boxers' specific working capacity can be characterized by the following indices of hitting the boxing bag during three rounds: number of blows, summative power of blows and energy outlay (Table 6).

Table 4. Effect of the physical training mesocycle on the power indices of boxers' single blows to the boxing bag ($\bar{x}$±SD).

Research stages	Power of blows with the main hand, kg			Power of blows with the front hand, kg		
	Straight blow	Side blow	Low blow	Straight blow	Side blow	Low blow
1	235.50±40.12	292.50±72.39	259.12±54.61	179.87±49.62	250.25±77.71	207.62±45.20
2	253.37±31.09	297.00±45.07	303.62±42.18	184.87±37.74	255.12±25.47	299.50±75.55
p	<0.05	>0.05	<0.05	>0.05	>0.05	<0.05

Table 5. Effect of the physical training mesocycle on the indices of boxers' special anaerobic alactatic working capacity ($\bar{x}$±SD).

Research stages	Maximal number of blows to the boxing bag (times)			Summative force of blows, kg			Energy outlay hitting the boxing bag. J		
	In 3 s	In 5 s	In 8 s	In 3 s	In 5 s	In 8 s	In 3 s	In 5 s	In 8 s
1	18.75 ±2.07	30.12 ±3.94	49.75 ±3.99	1548.62 ±382.55	2712.12 ±773.09	4305.15 ±1375.49	153.37 ±44.07	278.37 ±114.01	451.12 ±196.74
2	19.87 ±2.85	32.50 ±3.66	52.00 ±4.40	1775.75 ±489.23	3233.75 ±899.66	4658.75 ±1658.51	177.11 ±68.77	313.62 ±135.99	485.12 ±250.32
p	>0.05	>0.05	>0.05	>0.05	>0.05	>0.05	>0.05	>0.05	>0.05

Table 6. Effect of the physical training mesocycle on the indices of boxers' special working capacity ($\bar{x}$±SD).

Research stages	Hitting the boxing bag, 3 round 3 min each									
	Number of blows in 3 rounds, times	Summative force of blows, kg				Average force of one blow, kg	Energy outly, J			
		In 1 round	In 2 round	In 3 round	In total		In 1 round	In 2 round	In 3 round	In total
1	779.37 ±182.83	22239.00 ±10370.34	18707.88 ±7854.74	19987.75 ±8025.18	60949.38 ±25829.52	76.72 ±29.71	2466.87 ±1321.39	2022.87 ±1119.00	2084.37 ±1125.87	6578.37 ±3545.28
2	773.00 ±154.92	21719.50 ±6020.46	18034.38 ±5952.14	17922.75 ±5430.54	57674.13 ±16726.38	82.54 ±33.41	2137.25 ±1020.44	1746.12 ±910.07	2042.87 ±1108.55	5926.25 ±2761.04
p	>0.05	>0.05	>0.05	>0.05	>0.05	>0.05	>0.05	>0.05	>0.05	>0.05

After the physical training mesocycle the indices of boxers' specific working capacity hitting the boxing bag during three rounds were as follows: the number of blows, summative power of blows and energy outlay insignificantly decreased (p>0.05).

High indices of boxers' athletic fitness and power of blows with the main and front hands, as well as high specific anaerobic alactatic working capacity, is a good precondition to achieve high specific working capacity so necessary in boxing fights during competitions.

Discussion

Compared to other sports branches, there is little research on boxing indicating the factors that determine victory in this sport [13,15,20–22]. Research literature [22] contains evidence that boxers' age, the number of won and lost matches and the achieved results in previous competitions have a significant effect on sports results. Indices of elite boxers' athletic and special physical fitness are essential structural constituents of sports training: standing long jump, standing high jump, stretching and flexing arms in a lying position for 15 s, 4 kg shot put, hand-grip strength [1,3,8]. Research literature suggests that boxers' trapezium muscle in the back is the most active muscle in all fight actions [11]. Boxers' hand-grip strength is also an important index of physical fitness [5,8,11]. Hand-grip strength of the main hand correlates with the power of straight blow to the boxing bag (r=0.74) and of the side blow (r=0.63) [8]. Boxers' 4 kg shot put with the main hand results are closely linked to the power of the straight blow (r=0.83) [8]. Specific fight activities of boxers are influenced by movement speed and compatibility, speed of psychomotor reaction [11]. The frequency of movements in 5

Energy outlay – is energy which is needed for an athlete to perform physical activities. It depends on the duration and intensity of physical load, and it is measured in Joules (J).

Force of blows – is the force which appears at the moment of a blow, and it is a measure of the mechanical impact on the body that receives blows. It depends on the size and the acceleration of the hitting mass.

Summative force – is the sum of forces of repeated of blows.

s (Tapping test index) correlates (r=0.66) with the indices of stretching and flexing arms in a lying position for 15 s [8].The frequency of movements in 30 s of boxers in our research (Tapping test index) after the educational physical training mesocycle was 199.38±25.48 times (Table 3). There is evidence in research literature [5] that the places taken by boxers in the world amateur boxing rankings significantly correlate with the indices of maximal oxygen consumption (VO_2max), VO_2 indices at the anaerobic threshold and athletic fitness indices of upper limb muscle strength and hand grip strength [11]. Improvement in the indices of athletic fitness of elite boxers is a real precondition for improving their special physical working capacity [10,12,16].

Changes in boxers' special physical fitness and specific physical working capacity can be evaluated by the following informative indices: single blows to the boxing bag, number of blows, summative force of blows and energy outlay hitting the boxing bag 3 s, 5 s, 8 s and three rounds 3 min in each round with a break of 1 min [1,3,16]. The force of blows to the boxing bag with boxers' strong and weak hand is a very important component of special fitness [4,7,8,16]. In our research, the strong hand of boxers (according to the boxers' stance) was their main hand, and the weak hand – their front hand. After the physical training mesocycle, the force of single blows of boxers with their main and front hand and the force of the straight blow with their main hand improved from 235.50±40.12 to 253.37±31.09 kg, the side blow – from 292.50±72.39 to 297.00±45.07 kg, and the low blow – from 259.12±54.61 to 303.62±42.18 kg. Using the front hand, the major improvements were observed in the side blow force – from 207.62±45.2 to 299.50±75.55 kg. The training sessions in the physical training mesocycle had a positive effect on the improvement of boxers' force of single blows with their main and front hands. Research literature [1,3,4,8,9,23] contains evidence about the force, the power of blows to the boxing bag, but there are no possibilities to compare the achieved results because researchers have been using measuring devises of different constructions. The initiators of creating the mechanical system of boxing dynamometer were Fritsche [24], Joch et al. [14], Baagreo, Trachimovitch [25], Atha et al. [17], Karpilowski et al. [26].

According to the data in research literature [4], the power of straight blows of elite boxers' main hand amounts to 4800±227 N, in the group of moderate mastership boxers – 3722±133 N, and beginners – 2384±116 N. The power of straight blows with the front hand of those boxers is less ($p<0.01$), and it amounts to 2847±225 N, 2283±126 N, and 1604±97 N respectively in those groups of boxers. The power of straight blows of lightweight boxers was 2625±543 N, and of super heavyweight boxers – 4345±280 N [7]. The speed of movement of the hitting hand reaches 9.14±2.06 m/s [7]. In research literature [4,14,17,23,27], dispersion of indices single blow power is very high – from 1666 N to 6860 N.

After the physical training mesocycle, the indices of special speed and speed strength increased. Hitting the boxing bag for 3 s, 5 s, and 8 s, there was an increase in the number of blows, summative force of blows and energy outlay (Table 5). During the training sessions the speed and speed strength exercises increased energy production by anaerobic alactatic reactions. For elite boxers, the model number of blows in 5 s is from 27.8±4.79 to 32.4±3.14 [1]. Elite boxers perform 50±7.3 blows to the boxing bag during 8 s, and the summative force of al their blows is 4239±795.6 kg [10]. Boxers in the Lithuanian national team (n=11) performed from 32 to 67 blows in 8 s and the summative force of blows in 8 s was 5846 kg [8].

Research results (Table 6) showed that boxers, hitting the boxing bag 3×3 min during the first round, achieved greater summative force of blows compared to the second and the third rounds. The energy outlay during the second and the third rounds tended to decrease. After the physical training mesocycle, the average single blow power hitting the boxing bag 3×3 min increased from 76.72±29.71 kg to 82.54±33.41 kg.

Research literature [27–30] suggests that high anaerobic metabolism threshold of boxers could eliminate fatigue during the fights and allow to achieve greater intensity in further rounds avoiding deterioration in muscle activity.

The structure of athletic fitness of elite boxers includes five major factors: boxers' special working capacity, strength abilities, technical fitness, special abilities to perform certain movements linked to the power and number of blows [10]. Improvement in the indices of athletic fitness, increase in the power of blows and improvement in the indices of special anaerobic alactatic working capacity are preconditions for the improvement in boxers' specific working capacity and the achievement of specific sports form. For the achievement of high level of specific working capacity in a 3-round boxing fight boxers need to have a mesocycle of training special endurance after the physical training mesocycle.

The contents and structure of mesocycles effects the changes in special working capacity [6,9,10,12]. Analyses of changes in the indices of boxers' special physical fitness and working capacity after the physical training mesocycle makes it possible to evaluate the efficiency of training technologies and optimize the training

process emphasizing underdeveloped physical abilities so significant to boxers.

Conclusions

1. Four-week (28 days) physical training mesocycle, consisting of 40% of athletic training and 60% of special physical training, had a positive effect on the changes in indices of boxers' athletic fitness.

2. After the physical training mesocycle there was an improvement observed in the indices of boxers' athletic fitness performing explosive strength, speed strength and speed exercises. The force of blows hitting the boxing bag with the main and front hand increased as well.

3. There was an increase in the indices of special anaerobic alactatic working capacity: number of blows, summative force of blows, and energy outlay hitting the boxing bag for 3 s, 5 s, and 8 s.

4. The physical training mesocycle did not have any effect on the indices of boxers' special working capacity hitting the boxing bag for three rounds 3 min in each round.

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