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High intensity interval training for boxing: Case study

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Abstract
In this paper we present design and methodology for assessing the measured specific high intensity interval training protocol (HIIT) for boxers and evaluate the physiological response of the organism. Suggested load was compared with the training fight in term of heart rate and blood lactate level. HIIT protocol is an identical time to a competitive boxing match of 3x3 min. with a minute pause and consisted of a repeated execution of motion sequence. The motion sequence consisted of push-up, followed by a fast movement to 3 meters and back, and then one repetiton of power clean. We recorded the time of palm contact with the floor during push-up, time of the fast movement in seconds and the performance in power clean in watts. From the physiological parameters we recorded the heart rate and blood lactate level. In statistical processing we compared the values by anova single factor and the performance decrease (fatigue index) was evaluated using the linear trend in percentage. In the first round 11 sequences were performed, the average time of contact during the push-up was 0,89s, time of fast movement 2,63s and the performance in power clean was 770,64 W. In the second round, 9 sequences were performed, time of the contact was 0,93s, time of the movement was 2,88s and the power clean performance 726,67 W. In the third round, 9 sequences, time of contact 1,03s, time of the movement was 3,17s and the performance 717,33 W. Decrease in performance was reflected in all three monitored parameters on the level of 23,18% for the contact time, 38,37% for the fast movement and 11,46% for the power clean. The highest heart rate during HIIT has been achieved in the first round 171 bpm and the lactate level after the load 13,5mmol and during training fight 171 bpm in third round and 13,1 mmol lactate level. When comparing the load with the training match, the overall heart rate values were not significantly different $p>0.05$ and similarity was 82,3%. The motion program created similar response of organism as the training fight. It can be used as training and diagnostic device. We suggest deeper analysis of its effectiveness on success in the competitive fight. The research is part of the grant task VEGA 1/0482/21 "Standardization of specific short-interval load as a motor test of strength-endurance abilities for combat sports."

Keywords: Boxing, motion program, power-endurance, diagnostics, fatigue index

Introduction
Boxing is a combat sport whose history dates back to ancient Egypt and is one of the oldest martial arts (Jordan, 2008) [10]. Training program in the boxing includes basic as well as complex skills (El Ashker, 2011) [12] and training sparings that imitate a competition fight are also essential part in training process (Thomson, 2017) [19]. The boxer must be capable of repeated explosive movements throughout the fight, with the least possible drop in performance while the body's internal blood lactate response is in the range of 11-14 mmol and the heart rate remains in the submaximal to maximum range (Arseneau, 2011; Ghosh, 2010; Hanon, 2015) [1, 7, 8]. The explosive movements are mostly of different nature, but due to many studies the ratio of high-intensity and low-intensity intervals alternation is approximately 1:1 to 1:2 and the duration of the high-intensity intervals is on average 1 to 2 seconds up to a maximum of 5 seconds (Oeurgui, 2014; Davis, 2015; Šiška, 2016) [12, 5, 15]. The overall nature of the load in the boxing can be described as a combination of dynamic force represented by a mixture of punches, evasive maneuvers and moving around the ring with a static force characterized by defense, where the boxer resists the punches of the opponent. It is therefore necessary to develop both components and preferably in endurance mode. Many authors stated (Wilson, 1993; Cepulenas, 2011; Bruzas, 2015) [20, 3, 23] there are clear recommendations for weightlifting and multi-joint exercises in area of conditional preparation. We must prefer a short-interval, high-intensity, complex exercises and combine them together with regard to kinematic and dynamic boxing charcteristics. Frequently used in boxing preparation is also strength training, where is the most effective strength development with involvement of fast glycolysis fibers in the spectrum higher than the 90%

of maximum power (Cormie, 2007) [4]. By its nature, this type of training is beneficial as prevention of injuries but especially from its ability to transform into the speed in motion. With this in mind, it is desirable to deal with the creation of short training-movement programs in identical duration of a competitive match. In terms of content and exercise choices we find for example push-ups and fast movement over a short distance, where is the similarity in muscle group involvement with boxing. From strength exercises, for example power clean, which build not just strength, but full-body power and the ability to move weight quickly. Their continuity may resemble a combination of dynamic and static forces. The advantage is that these exercises are also used in the process of diagnostics (Podstawski, 2016; Zalleg, 2018; Pennington, 2010) [14, 21, 13], which gives us the possibility to create a measured short-interval high-intensity load. The aim of this paper was to design high intensity interval training protocol, which would be useful both as a training tool and as a diagnostic tool and compare the physiological response of the body with a training match.

Methods

Subject

The research was attended by a single sportsman aged 37, height 172 cm, weight 70kg, HR max. 175 bpm. The total sports age of the sportsman is 30 years. Proband realized from 3 to 5 training units a week focused on athletics and kickboxing, and is a multiple medalist from the Slovak Championship in these sports. In training process of the proband there were strength exercises such as power clean, which was part of the HIIT protocol, therefore was no problem with its execution.

HIIT description

The HIIT protocol was identical to the timing of a boxing match, i.e. 3 x 3 minutes, with a 1 minute break between the rounds. The principle of the load was repeated execution of the motion sequence on probands own impulse. The participant started from a standing position by performing a push-up, immediately standing up and then followed by a fast movement to the side to 2.5 meters and back. After fast movement, he performed one repetition of power clean from the ground, where the dumbbell was placed in the immediate vicinity but not obstructing fast movement. Throughout the motion sequence, emphasis was placed on the execution of the exercises with the maximum effort. The participant tried to perform as many motion sequences as possible within a 3 minute round (fig. 1).

Fig 1: Sequence execution

Measures

The contact time values of the palms with the floor during the push-up and the time of the fast movement were monitored during the load with the Fitronic Jumper. The jumper contact plate was placed on the floor at a distance of 2.5 meters from the wall. The time of the fast movement started by interrupting the contact of the palms with the plate when standing up from the push-up, followed by a movement towards the wall where the proband had to touch the wall with the hand and ended by pressing the contact plate with the foot after moving backwards from the wall. The power values of the power clean in watts were diagnosed by the Tendo power analyzer as a multiple of the speed during exercise and barbell weight. The weight of the dumbbell 55 kg was determined based on the performance in the diagnostic series of power clean with maximal effort in the concentric phase of the movement. The test began with a weight of 20 kg and continued with a 30, 40, 50, 55, 60, 65, 70kg weight and the chosen weight was the lowest at which the power performance was in the range above 90% of the maximum. The average power values in the concentric phase of exercise were taken into account. From the physiological parameters, we recorded the heart rate with the SUUNTO, which scans the values every second and the lactate level with the Lactate scout at 1, 2, 3 minutes after the HIIT protocol, with blood samples taken from the finger of the hand. The training fight was the same time as the competitive 3x3 min. at a rest interval of 1min. between rounds and took place in a training ring which dimensions were identical to the classic competition ring. The conditions were adapted to follow the course of the real match as much as possible with the coach assist as the referee. The oponent boxer was chosen from the same weight category and similar performance level. The training match was realized 5 days after the HIIT protocol.

Statistical analysis

The results recorded in the test are described using the basic descriptive statistics, average time and performance value of the exercises in each round. Statistical significant

differences of mean values between individual rounds are expressed by analysis of variance at 5% significance level. Subsequently, the values of the individual repetitions are shown in a bar graph and overlaid by a linear trend line. The decrease of performance (index of fatigue) is expressed as a percentage difference of the best and worst value on the linear trend line with regard to the best value. Similarity of heart rate during exercise and training match was evaluated by ICC correlation coefficient.

Results

Table 1: Performance parameters achieved in HIIT protocol

Parameter	I. Round	II. Round	III. Round	overall
Number of sequences (n)	11	9	9	29
Contact time (s)	0.89±0.06	0.93±0.06	1.03±0.09	0.95±0.09
Best linear value	0.82	0.88	1.00	0.85
Worst linear value	0.97	0.98	1.05	1.04
Index of fatigue (%)	17.74	10.82	-5.45	23.18
Movement time (s)	2.63±0.31	2.88±0.25	3.17±0.22	2.88±0.34
Best linear value	2.20	2.54	3.06	2.41
Worst linear value	3.06	3.22	3.29	3.34
Index of fatigue (%)	38.91	26.99	7.55	38.37
Power clean (W)	770.64±30,13	726.67±23.35	717.33±20.44	740.45±34.5
Best linear value	783.91	751.33	714.87	780.57
Worst linear value	757.36	702.00	719.80	700.32
Index of fatigue (%)	3.50	7.03	-0.69	11.46

For the palm contact time with the floor during the push-up, the average performance in the first round was 0.89s, in the second round 0.93s and in the third round 1.03s. In the first and second round the performance did not differ statistically F (1, 18) = 1.77, p = .20, worsening was observed in the third round compared to the first F (1, 18) = 14.68, p = .00 and compared to the second round F (1 16) = 7.39, p = .02. Decrease in performance in individual rounds was 17.74% and 10.82% for the first and second rounds, while in the third round there was an improvement of 5.54% but with worse average performance. The overall performance drop over the entire load was 23.18%.

The average time of 2.5 m fast movement was 2.63s in the first round, 2.88s in the second round and 3.17s in the third round. In the first and second round the performance did not differ statistically F (1, 18) = 3.62, p = .07, the worsening was observed in the third round compared to the first F (1, 18) = 19.16, p = .00 and compared to the second round F (1 16) = 6.89, p = .01. The decrease in performance in each round was 38.91% and 26.99% and 7.55%. Total performance drop was 38.37%.

The average performance of power clean was 770.64W in the first round, 726.67W in the second round and 717.33W in the third round. Statistically significant differences were observed in the first round versus the other two F (1, 18) = 12.81, p = .00 and F (1, 18) = 20.37, p = .00, performance was the same in the second and third rounds F (1, 18) 16) = 0.81, p = .38. Decrease in performance in individual rounds was 3.5% and 7.03% for the first and second round, while in the third round there was an improvement of 0.69% but with worse average performance. The overall performance drop over the entire load was 11.46% (tab. 1, fig. 2).

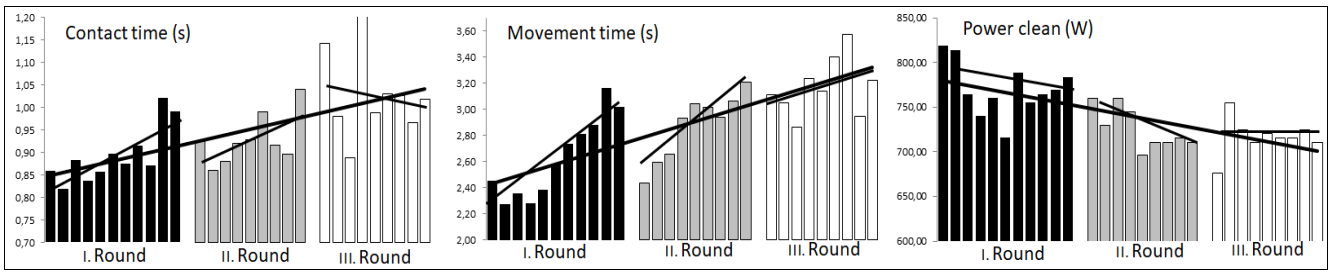

Fig 2: Individual repetitons and linear trends in monitored parameters during HIIT protocol

In terms of similarity of heart rate during the specific load and training fight, achieved values did not differ statistically in the second round F (1, 356) = 0.00, p = .96, in the first and third round were different F (1, 356) = 30.84, p = .00, F (1,356) = 56.83, p = .00. When comparing all values, including minute breaks, the values did not differ statistically F (1, 1320) = 0.19, p = .66. Similarity of heart rate values was 82.30% (ICC = 0.823, 95% CI: 0.793 - 0.848, $p<0.01$) (Fig. 3).

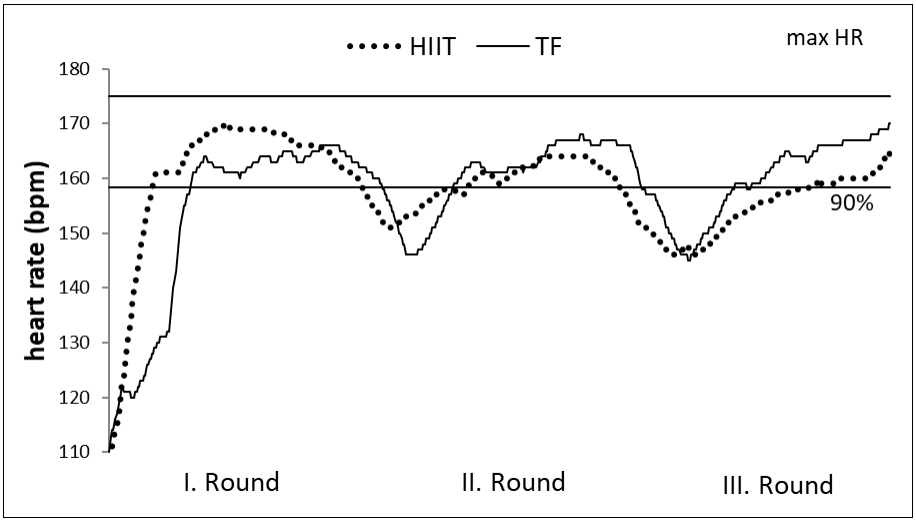

Fig 3: Course of heart rate during the HIIT protocol and training fight

Blood lactate values had an increasing character from the first to the second minute after the HIIT protocol and decreased in the third minute. After the training match the values increased from the first to the third minute (tab. 2).

Table 2: Blood lactate values after the HIIT protocol and training fight

	1st min.	2nd min.	3rd min.
HIIT protocol	11.5	13.5	10.6
Training fight	11.2	12.7	13.1

Discusion

Boxing can be clearly ranked among strength - endurance sports and therefore this kind of preparation will be one of the decisive factors. The proposed specific load can be considered in two levels. In terms of sports training, several authors proceeded in a similar way and tried to propose a training device that coincided with the competition fight. Hatfield (2003) [9] designed a short three-minute drill for professional boxer Evander Holyfield. Drill was a combination of forward and backward sprints, push-ups and own weight exercises and confirmed the justification of these short movement program in the training preparation of top athletes. Ouergui (2015) [11] proposed a specific program directly based on analysis of competitive match, which was identical to the timing of a kickboxing match (Ouergui, 2014) [12]. Specific movements such as boxing bag punches, sideways movements and other to simulate a match was used in the load and then the pecific program was compared through the parameters such as heart rate, lactate and cortisol levels,counter movement jump height with the training match. We have also been inspired by this research and can conclude that the achieved values are similar to those in other works. Lactate levels of 13mmol are reported in addition to the research mentioned above, which dealt with similar issues (Ghosh, 2010; Hanon, 2015) [7, 8]. Also, the heart rate was found in the submaximal range above 90% of the maximum as reported for sparing loads (Arsenau, 2011) [1]. When comparing the load we propose with the training fight, the heart rate values were the same in the second round and different in the first and third rounds. When comparing the whole course including minute breaks, the values did not differ statistically and their similarity was more than 80%. It can be stated that in the first round higher values of heart rate were achieved in HIIT protocol compared with training fight. Subsequently, in the next rounds, sparing values increased and in HIIT protocol decreased. Also the intensity in terms of performance in the individual parameters of the HIIT protocol had a decreasing character and this fact can explain to us the level of special endurance. With a more balanced performance development, the heart rate may not have a downward trend and if we take it from a performance perspective, the higher the heart rate, the higher the performance. We consider it positive that the increase in heart rate at the beginning of the load was similar to that of sparring. In previous researches (Šiška, 2017; 2017; 2017) [16, 17, 18] we examined each parameter separately and the increase in heart rate was not as fast as in this case. Likewise, lactate values are similar in HIIT protocol and training fight. When we look at the actual results achieved during the HIIT protocol, we can see that there is a decrease in performance in each parameter. In the first and second round, there was similar performance in contact and movement times, and only in the third round there was a significant decrease in performance. On the other hand in power clean a significant decrease in performance occurred in the second round. The highest fatigue index was about 38% at the time of movement and the lowest in power clean about 11%. At the time of contact and power clean in the third round the performance increased but at a lower average performance than in the second round. Overall, in terms of the fatigue index or performance drop, we have a clear presumption we expect that a higher sequence intensity and lower fatigue index achieved in the test may determine the success of a competitive match. This assumption must be verified by a targeted intervention program during the training cycle. In terms of diagnostics, we have not seen research in a similar direction yet. In most cases the basic parameters of explosive strength (vertical jump), anaerobic performance (wingate) or aerobic performance (VO2max) are evaluated, but we lack a comprehensive strength-endurance test in which similar muscle parts are involved as in a competitive match and could assess intensity and its decrease during the whole load. The exercises we choose are commonly used in both the training and diagnostics process (Cepulenas, 2011; Bruzas, 2015; Zalleg, 2018; Pennington, 2010) [3, 23, 21, 13] but no one has linked them into one movement sequence yet in terms of boxing needs. Their advantage is that they are easy to measure, comply with the analysis (Šiška, 2016) [15]

according to which we designed the load and can affect the level of required fitness potential needed for success in the match. In the future, therefore, we need to focus on the long-term effect of the load as a training tool in terms of better sports performance as well as the possibility of standardizing the load as a diagnostic test.

Conclusion

In conclusion we can say that we were able to propose a specific load coinciding with the boxing competition, which, in response to physiological parameters, imitates a training match, resp. sparing load, so we can recommend it as a training tool. We have seen a decrease in the performance of the monitored parameters and in terms of diagnostics it is necessary to subject the proposed load to more detailed research if better results achieved in the load can indicate the readiness of the boxer to give a more valuable sport performance.

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