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ASSESSMENT OF TRAINING STATUS IN ELITE BOXERS

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Abstract

Objective: To examine boxer's performance in a special exercise test in normoxia and moderate hypoxia, and to evaluate the usefulness of daily plasma urea concentration and creatine kinase activity estimation for monitoring of training in national level boxers.

Methods: The study included 18 healthy elite boxers, who performed a special exercise test under normobaric and hypobaric conditions. During the test, the heart rate and power output were monitored and the total mechanical work (TMW, kJ) was recorded. Every morning during nine days of training camp blood from earlobe was taken in preprandial state to assess urea level and creatine kinase activity.

Results: The boxer, whose training level was the highest, maintained higher values of the mean power (W) than the group, particularly in the second round of workload, both in normoxia and hypoxia conditions. The reduction of TMW for the whole group and the champion in both types of conditions was similar (25,5 and 25,4%, respectively). The direction of changes in the plasma urea level during the period of study was not dependent on the daily training loads and was similar for the whole group and the competitor with the highest oxygen consumption. The direction of changes in creatine kinase activity was similar for the whole group, the champion competitor, and the competitor with the highest $\dot{V}O_2$max.

Conclusions: Findings from the present study indicate that the results of a specific exercise test both in moderate hypoxia and in normoxia depended on the athlete's training status. Daily morning measurements of plasma CK activity appear to be a useful tool for monitoring training, despite a varied body response to effort stimuli, while process of changes in plasma urea concentration indicated the influence of factors other than the magnitude of training loads. Gathering data related to fitness and biochemical parameters can help coaches and athletes improve performance and prevent muscle overload.

***Key words**: boxers, physical performance, hypoxic conditions, special tests, biochemical markers*

Introduction

In contemporary boxing, fights are very intensive. This intensity is expressed, among other things, in the number of blows. Leading competitors deal about 300 blows during a fight (the important feature of a good boxer is the ability to fight at a distance). The analysis of movement structure in boxers during the defense showed that defending oneself using hands constitutes 49% of movement structure, using legs - 3%, and using torso - 18% [1].

In fighting sports, the more difficult is the rival the higher is the intensity of effort. In boxing, with the prevailing short-term endurance (2 min), the part of anaerobic energy sources (anaerobic glycolysis) determining force and speed is significant. Anaerobic metabolism causes oxygen debt growth and lactic acid production keeping high heart rate values [2,3]. For example, post-boxing fight lactate concentration achieved 17.1±1.6 mmol/l [4], and it depends on the rank of competition, order and frequency of fights, fight strategies, the competitor's weight category, and related to it fight tactic [1,5]. Guidetti et al. [6] established that both individual anaerobic threshold and maximal oxygen uptake were related to boxing performance.

Test results show that a boxer should be able to perform a short-term effort of great strength. It demands high efficiency of anaerobic metabolism (high anaerobic fitness) and the ability to continue work when the acidity of muscle and blood grows. It is also necessary to achieve high aerobic fitness conditioning, which results in greater work economization [7] and faster post-effort recovery processes [8]. These abilities are shaped and developed in a properly conducted training process. In order to estimate training effects (effort adaptation) various laboratory tests are used. The analysis of effort responses occurring during boxers' fight should be the deciding issue for the selection of adequate tests.

Physical exercise results in changes in blood biochemical profile. The scope and direction of these changes depend on numerous factors. These include both the duration and intensity of exercise, how well trained the subjects are, and the kind of muscle contractions (concentric, eccentric) [9]. It is generally believed that there is no single biochemical parameter that reflects the changes occurring when exercising or training [10]. The changes in cellular metabolism due to exercise, not compensated by sufficient rest, may entail the risk of overreaching or overtraining, and may result in long lasting physical performance decrement and fitness decline [11].

The changes in concentration of some biochemical indices in blood may also be caused by some factors unrelated to effort, for example diet. The diet components, especially carbohydrate content, are predictive of the direction of energetic changes in the body [12]. For example, marking the plasma urea level, indicating the extent of protein and amino acid catabolism, used while monitoring the training, requires simultaneous control of carbohydrate intake. It was determined that insufficient glycogen reserves in muscles result in protein degradation and utilization of amino acids for energy uptake [13].

It is worth emphasizing that there are few disciplines of sport where it is possible to predict physical fitness, that is, maximal capacity in a given time period, based on post-exercise changes in biochemical indices. It is especially difficult in acyclic sports, where an adequate level of technical and tactical actions is essential for sportsmen to succeed.

Physical effort induces changes in protein and amino acids metabolism in terms of their synthesis and degradation [14]. The final product of these changes is urea, produced in liver, when an amino group of an amino acid is removed. It is known that long-lasting effort causes an increase in urea concentration in blood, which reflects its increased production, growing with the duration of the effort [13].

Creatine kinase (EC 2.7.3.2) is an enzyme occurring in large quantities in skeletal muscle cells, and it is released into blood as a result of exercise induced muscle damage [15]. The activity of creatine kinase (CK) in plasma depends to a large degree on the character of muscle contractions, and it was determined that eccentric contractions are the stronger factor in muscle cell damage than the concentric contractions [16]. An elevated activity of CK in blood is commonly accepted as a marker of exercise-induced skeletal muscle damage [17].

The aim of the present study was to examine boxer's performance in a special exercise test in normoxia and moderate hypoxia, and to evaluate the usefulness of daily estimation of plasma urea concentration and creatine kinase activity for monitoring of training in national level boxers.

Methods

The study included 18 healthy elite boxers, aged 22.3 ± 3.3 years, with body weight and height of 67.0 ± 17.6 kg and 177.7 ± 8.2 cm, respectively. On the first day, they performed a special exercise test under normobaric conditions in a low pressure chamber (LPCh). On the second day, the subjects performed the exercise test at a simulated altitude of 3000 m above see level (a.s.l.), after a 20-min rest at that altitude. Each test consisted of the following stages: 1-min initial data registration; 3-min warming up at HR_{100}; 3-min workload first bouts at HR_{145}, 1-min rest, 3-min workload second bouts at HR_{150}, 1-min rest, 3-min workload third bouts at HR_{145}, 2-min recovery registration. The Fizjotest-801 made by Medipan (Poland) was applied to control the Elema-Schonander bicycle ergometer workloads. The heart rate and power output were monitored and the total mechanical work (TMW, kJ) was recorded.

Every morning during 9 days of training camp blood from earlobe was taken in preprandial state to assess urea (U) level and creatine kinase (CK) activity. Plasma urea concentration and CK activity were measured using respective commercial kits (Alpha Diagnostics, Poland). Measurements of CK activity was done in 25°C. The reference values was 2.5-6.3 mmol/l for urea concentration and <80 U/l for CK activity. This study was approved by The Human Research Ethics Committee.

Statistical analysis

The differences were assessed by two-way analysis of variance (ANOVA) for repeated measurements. When a significant difference was observed, Tukey's post hoc test was used to specify where the difference occurred. The level of statistical significance was set at $P < 0.05$.

Results

Figures 1 and 2 present the mean power of a champion class boxer in a group of average competitors under various conditions. For a boxer whose training level is the highest, it is characteristic to maintain higher values of the mean power (W) than the group, particularly in the second round of workload, both in normoxia and hypoxia conditions. The reduction of TMW for the whole group and the champion in both types of conditions was similar (25,5 and 25,4%, respectively).

Figure 3 presents values of urea concentration assessed every morning during 9 days of physical training in training camp. Plasma urea concentration for the whole group under study and for the champion-level competitor exceeded the high limit of accepted norm (6.3 mmol/l), however, for the competitor with the highest $\dot{V}O_2$max, between the second and the sixth day, it fell with the accepted limits. The direction of changes in the plasma urea level during the period of study was not dependent on the daily training loads and was similar for the whole group and the competitor with the highest oxygen consumption, however it was different for the champion competitor.

The highest activity of CK in plasma occurred in the fourth day of training, for the whole group, the champion competitor, and the competitor with the highest $\dot{V}O_2$max. For these two competitors, the CK activity on this day was lower compared with the values

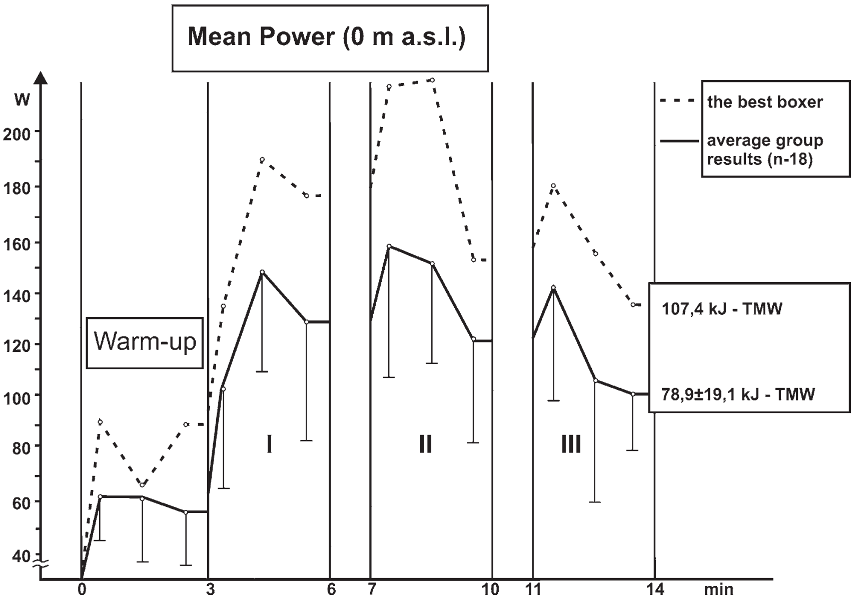

Fig. 1. *The mean power (W) of champion compare to group of boxers and TMW in normoxia*

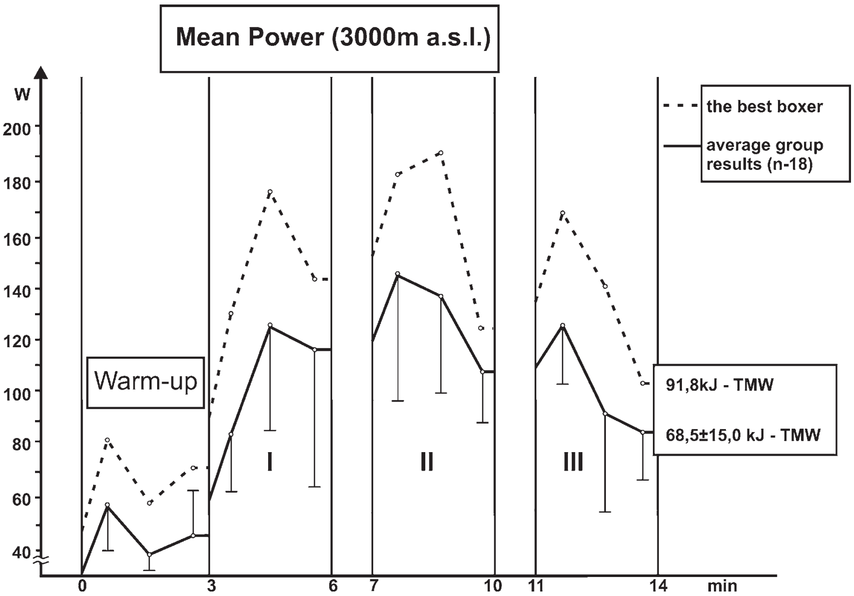

Fig. 2. *The mean power (W) of champion compare to group of boxers and TMW in hypoxia*

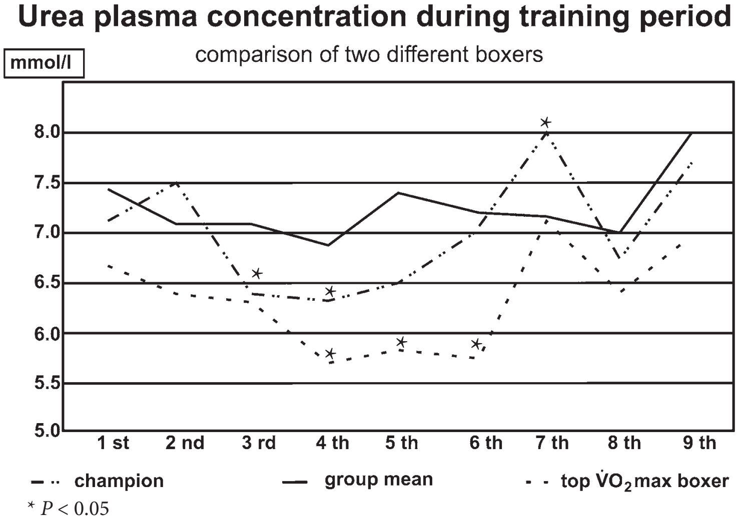

Fig. 3. *Plasma urea concentration during 9-day training period*

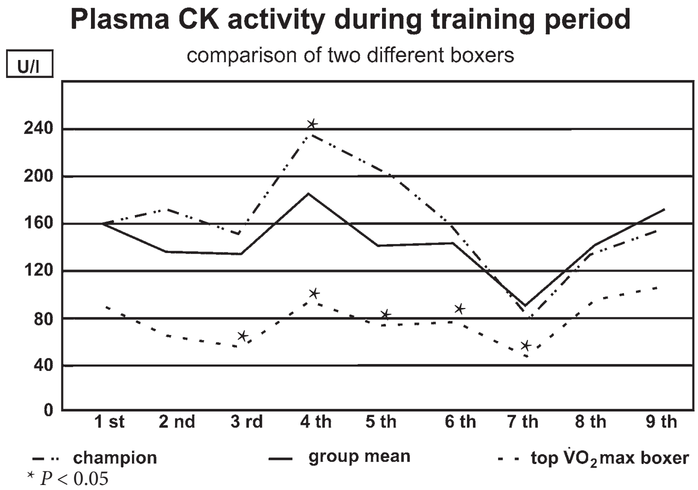

Fig. 4. *Plasma CK activity during 9-day training period*

measured in the whole group. It should be noted, that despite the differences in the activity of this enzyme, the direction of changes was similar for the whole group and the two distinct competitors. The activity of CK in plasma for the whole group of boxers and the champion competitor, at almost all times, exceeded to various degrees the high limit of accepted norm, while for the competitor with the highest $\dot{V}O_2max$ the activity of this enzyme exceeded the limit only on some days.

The present study has not revealed any correlation between the plasma CK activity and urea concentration during 9 days of training camp.

Discussion

During the preparation of exercise tests in moderate hypoxia, the following two correlations were considered. In boxers' fight, anaerobic metabolism is set in motion, engaging the anaerobic glycolysis and creating oxygen debt. Similarly, there is a correlation between oxygen debt produced as a result of effort and the effect of high altitude hypoxia. These phenomena are very similar, and some of them are even identical [1]. The results of ergometric tests in a low pressure chamber depend on training status.

Urea is the nitrogen compound produced when amino acids are catabolized for energy supply. Plasma urea concentration depends on many factors such as status of hydration, dietary protein and carbohydrates type as well as duration of exercise and presence of injury [18]. In athletes, the changes in plasma urea level reflected increased protein sources contributing to energy metabolism, especially during long-lasting exercise at low to moderate intensity and induced muscle tissue damage [19]. In the present study, the process of changes in plasma urea level was inconsistent and did not depend on daily training loads. In addition, Yang [20] found that urea assessment in plasma was of little value in monitoring the training loads.

One of the factors determining the degree to which plasma creatine kinase activity increases during and after exercise is athlete's training status [21, 22]. Vincent and Vincent [23] stated that the CK activity of higher fitness athletes was lower in comparison to ones with lower fitness. In sport training, intensity, volume and type of exercise are varied, and it is possible that this variation in the training program evokes muscle damage, because the athletes perform an unaccustomed exercise frequently [24].

The increase of CK activity in plasma may indicate the type of muscular activity (the type of contractions). Measuring the activity of creatine kinase (CK) in plasma every morning, was accepted as the indicator of skeletal muscle cells functional disturbances [21]. The increase of the CK activity in plasma was the result of physical effort made during the previous day. Low values of this indicator may be the evidence of high training status of a given athlete, or less training.

CK activity in the plasma was used as a specific and sensitive muscle lesion index [25]. Plasma CK activity measurements were conducted daily in the morning, after a night's rest. The marker reflected both the muscle response to exercise load during the previous day and the effect of rest between training sessions, and it aimed at determining the functional muscle condition and evaluation of overload risk [5].

The studies conducted on boxers in the national team showed a close correlation between plasma CK activity and exercise load applied within 13 days of boxer training, despite significant variations of this enzyme activity in the plasma in response to the same training stimulus [26]. Similar correlations were found in studies conducted on judokas [27] and wrestlers [28]. Lack of correlation between the magnitude of training loads and CK activity indicates an increased risk of muscle overload. Some authors emphasize that post-exercise plasma CK activity cannot be utilized for evaluation of the extent of muscular lesions and no correlation can be found between this activity and other indirect indices of lesions and disorders of muscular activity [29]. On the other hand, it is believed that plasma CK activity is a sensitive and specific marker of muscle damage and it could be a reliable indirect indicator of training induced muscle overload and fatigue [30].

In conclusion, findings from the present study indicate that the results of a specific exercise test both in hypoxia and in normoxia depended on training status. Every morning measurements of plasma CK activity seems to be a useful tool for monitoring training despite a varied body response to effort stimuli, while the process of changes in plasma urea concentration indicated influence of factors other than the magnitude of training loads. Gathering data related to fitness and biochemical parameters can help coaches and athletes improve performance and prevent muscle overload.

Recomendations

Based on our own, long lasting studies and literature data, we can present practical recommendations concerning training monitoring, using creatinin kinaze (CK) markers in the plasma. These include the following guidelines:

– activity should be measured in the morning, prior to consecutive training sessions;
– CK should be marked every day during the training, but this marking may be restricted to the day of rest on completion of the training micro cycle and the next day when the next micro cycle starts (we determine if there is any proportional correlation between exercise load and enzyme activity);
– we should consider individually varied responses to effort stimuli and evaluate the course of CK activity during consecutive days of training, not indirect activity of this enzyme;
– lack of marked decrease in CK activity (by about 50%) after a rest day may suggest muscle load (indicating the necessity of training load modification).
– in case of a very high CK activity (several thousand units), myocardial function control is recommended (e.g. ECG);
– most justified is monitoring the training prior to participation in important competitions (the period of direct preparation), since during this period there are no several days intervals during training that may cause the decrease in CK activity;
– for CK marking, blood can be taken from a finger bulb or an ear lobe (small blood volume). The results of marking are quickly obtained, before the competitors start their morning training session (this enables individualization of the magnitude and kind of load);
– in case of undesirable courses of CK activity changes or very high enzyme activity, it is the trainer who decides (as the trainer is better informed about exercise adaptation, psycho-emotional traits, the diet and the quality of rest of each participant).

The authors are aware that the evaluation of changes occurring within the human body due to the training specific for boxing, as well as preventing load syndromes or overtraining is the key problem in training control. Our present knowledge, however, requires further studies. A varied body response to effort stimuli and training load and the lack of standardized research procedures cause that the results are often inconsistent.

Declaration of interest

The authors report no conflicts of interest.

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