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Nutritional status in short-term overtraining boxers

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Abstract: *The diet is essential to the recovery process in athletes, especially those undergoing intensive training. The continuous imbalance between loading and recovery leads to development of overtraining syndrome. The purpose of this study was to establish the changes in the nutritional status of short-term overtrained athletes. Twelve boxers from the team of National Sports Academy Sofia, Bulgaria during their preparation for the National Championship 2016 were studied. The measurements were conducted three times:in the beginning of preparation (T1), 22 days later (2) and 10 days after (32 days after first measurement), in the beginning of the recovery period, one week prior the competition (T3).The measurements included basic anthropometric data,overtraining questionnaire RESTQ-Sport and nutrition questionnaire, plasma concentration of testosterone and cortisol.On the data of dietary survey the percent proportion and the amount of daily consumed proteins, fats and carbohydrates were defined and the energy intake of the tested athletes was calculated. According to the RESTQ-Sport a significant decrease in the ratio stress/recovery was observed in the period with the heaviest training load T2, and an increase was estimated in the pre-competition recovery period T3. It was found a typical for the overtraining syndrome decrease in the concentration of testosterone and the ratio of testosterone/cortisol in T3. In some respondents a reduction in carbohydrates and proteins intake was observed in T2 and especially in T3, which correlates with the hormonal changes. In this work the diet changes was discussed as a possible consequence and/or a cause of the overtraining syndrome.*

Keywords: *cortisol, nutrition, overtraining, sports, testosterone*

Introduction

Underperformance due to training fatigue is common in athletes. Fatigue is a transient state that is overcome with rest and recovery of the body's energy and metabolic balance. Theprolonged imbalance between the intensity of training loads and recovery processes could lead to overtraining. The main feature of overtraining is a performance decrement that required days to weeks for recovery. This stateoccurs more and more often in the recent years in the athletes because of the higher performance demands. The coaches and sports specialists differ short-term overtraining (overreaching) where recovery lasts from several days to two weeks and long–term overtraining (overtraining) with a recovery period of several weeks to months [1]. In overtraining changes in a number of psychological, biochemical, physiological and immunology indexes are observed. It is accompanied by a variety of symptoms as mood swings, sleep disorders, depression, and persistent fatigue. These discomforts could be explored by various psychological tests such as RESTQ-Sport (Recovery Stress Questionary for Athletes), POMS (Profile of Mood States), that are accepted as good tools for overtraining diagnostics[2].Overtraining is characterized also with disturbances in the central mechanisms of

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DE GRUYTER OPEN
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hormonal regulation, manifested by a decrease in testosterone blood concentration, increase of cortisol concentration and a reduction in the testosterone/cortisol ratio. The latter is used as an indicator of the anabolic/catabolic balance. It has been demonstrated that this ratio decreases with the rise of the intensity and duration of physical exercise, as well as during periods of intense training or repetitive competition, and can be reversed by recovery measures[3].

One of the risk factors for overtraining is related to the diet and include poor or inadequate nutrition; possibly inadequate caloric intake (especially carbohydrates); potential nutrient, vitamin, or mineral deficiency; iron deficiency and dehydration [4]. The diet is essential to the recovery process, especially in athletes undergoing intense training regime. The question of diet, ensuring optimal recovery in sports such as gymnastics and strength sports with weight categories (wrestling, boxing, karate, judo, etc.) is very difficult because these sports requires strict weight maintenance [4] and at the same time the energy expendituresduring training are very high. Among different sports boxing is one of the activities with the biggest energy costs[5].Based on the above considerations, our interest was aimed at tracking changes in the diet of boxerswith short-termovertraining symptoms.The understandingof theovertraining appearance mechanisms will be helpful in its evaluationand proper management.

Materials and methods

Statement

Thisresearch was performed in accordance with the Declaration of Helsinki for Human Researches (World Medical Association Declaration of Helsinki - Ethical principles for medical research involving human subjects. 59th WMA General Assembly, Seoul, Republic of Korea (2008)).

Participants

In the study took part 12 athletes from the National Sports Academy boxing team at mean age of 21.33 ± 1.37 years and mean height 176.42 ± 6.75 cm.

All participants received details on the study at the information meeting in the beginning of the investigation and signed an informed consent form.

Study design

The studied parameters were measured three times in the course of preparation of boxers for the Republican Championship 2016: in the beginning of the preparation (T1), 22 days later (T2) in the period of the most intensive training and 10 days after T2 (32 days after the first examination) at the beginning of the week prior to the competition, the recovery period (T3). The Recovery-Stress Questionnaire for Athletes (RESTQ-Sport) [6]and dietary questionnaire [7] were completed by each participant. On the basis of the dietary questionnaires the proteins, fats and carbohydrates intake were identified, and the energy intake was calculated.

Measurements

Weight, fat mass percent (FM%) and muscle mass percent (MM%) were determined via bioelectrical impedance analysis using Body Composition Monitor BF511 (Omron Corporation, Japan). Stature was determined with a precision of 1 cm by a stadiometer. Body mass index (BMI) was calculated using the formula BMI = weight (kg) / height (m^2).

Venous blood samples (3 mL) were taken from the athletes for measurement of plasma concentrations of testosterone and cortisol by immunofluorescence analysis using I-Chroma (Bodytech MED Inc., Korea).

Statistical analysis

The data were processed with Graph Pad Prism 5.0 program. The test of Shapiro-Wilk did not show a normal distribution of anthropometric parameters. Thus a non-parametric test to check the significance of differences in mean values of more than two dependent samples (Significance Tests for

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ASN, Vol 4, No 1, Pages 76-83, 2017

More Than Two Dependent Samples of Friedman, Kendall's W, Cochran's Anne Q) and the post hoc test of Dunn were used. For all other data ANOVA for dependent samples and Bonferroni post hoc test were applied. In the text and tables the mean values were presented with the standard deviation and in the graphics with the standard error.

Results

The basic anthropometric date of the tested persons showed that the average values for FM% (about 13%) and for MM% (44%) were typical for athletes of strength sports (Table 1). There was only one exception (tested person №10 with body weight of 103.8 kg, BMI 33.51 kg/m^2 and FM% - 29.4%) where first degree of obesity was detected.

The statistical analysis of the tested anthropometric parameters did not show significantly different average values in all three collecting points T1, T2 and T3 (Table 1).The observed minor changes in the weight of the athletes in the course of the study were accompanied by reciprocal, nonsignificant changes in adipose tissue, which decreased whereas the muscle tissue mass increased.

Table 1. Basic anthropometric date of the tested athletes (n=12).

	T1	T2	T3
Wight (kg)	74.29 ± 11.81	74.10 ± 11.89	73.69 ± 12.11
BMI (kg/m^2)	23.83 ± 3.33	23.77 ± 3.31	23.55 ± 3.29
FM%	13.03 ± 6.80	13.77 ± 5.91	11.87 ± 5.16
MM%	44.38 ± 3.99	43.87 ± 3.52	45.03 ± 3.34

Test results for overtraining (RESTQ-Sport) showed a significant reduction of the recovery/stress ratio in T2, followed by a significant rise in T3, the period just before the competition (Fig. 1).

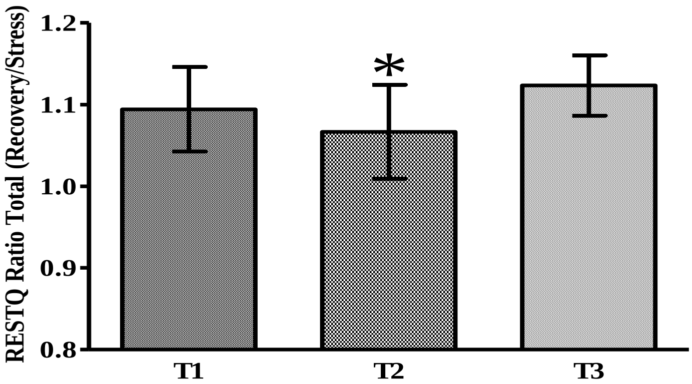

Figure1. Recovery/loading (stress) ratio according to **RESTQ-Sport**. * - $p < 0.05$ versus T3

The data on testosterone and cortisol levels, along with the resulting ratio testosterone/cortisol are presented on Fig.2. A significant reduction in the concentration of testosterone and the ratio testosterone/cortisol in T3 were observed. The cortisol level showed a statistically significant increase in T3 (Fig. 2).

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DE GRUYTER OPEN
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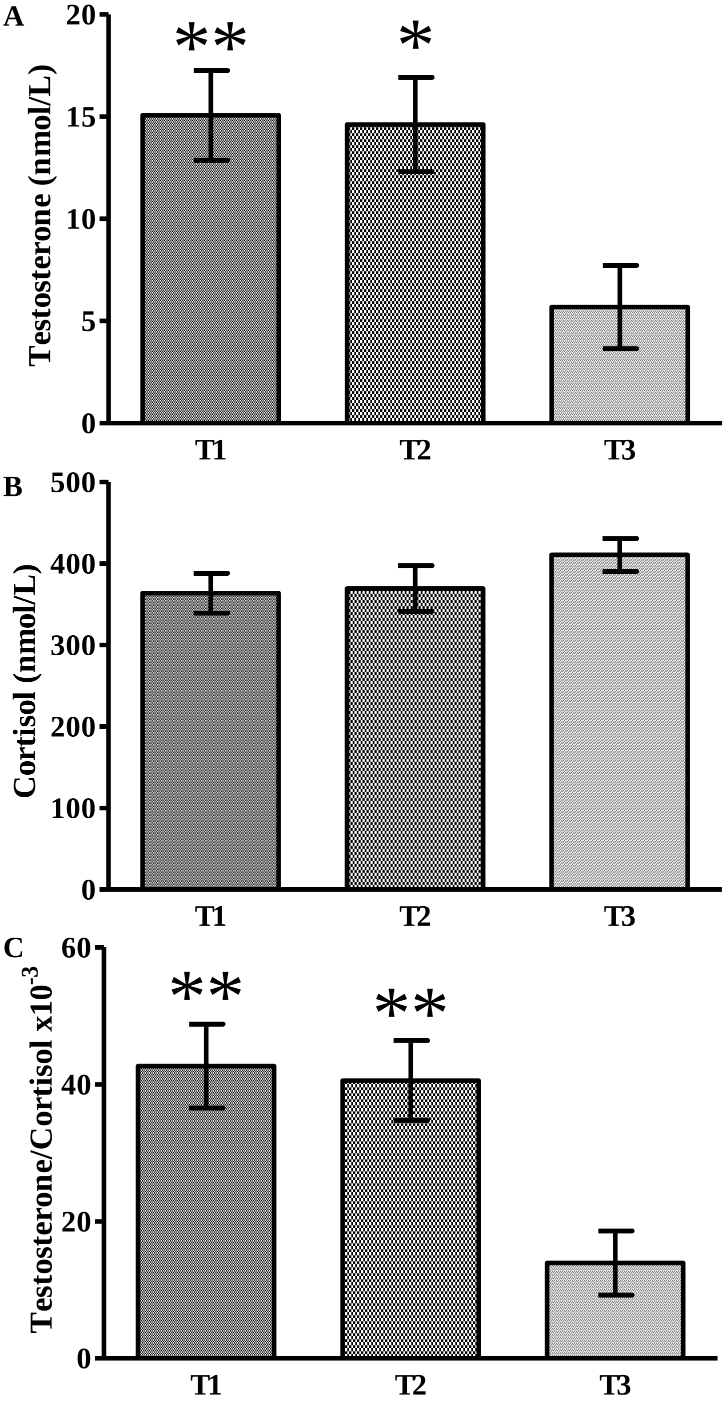

Figure 2. Concentration oftestosterone (A), cortisol (B) and testosterone/cortisol ratio (C).
* - p < 0.05 versus T3, ** - p < 0.01 versus T3

The relative participation of key nutrients in energy intake was within the norm limits 15% protein, 33% fat and about 52% of carbohydrates. The protein intake was slightly higher, about 17% which is typical for athletes of strength sports. In the T3 period a decreased carbohydrate intake (44.6%; 3.9 g/kg) was observed, related to the forthcoming participation in the competition and the need to weight reduction to the desired category (Table 2).

Table 2. Dynamics of the nutrient status of the tested athletes.

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DE GRUYTER OPEN

ASN, Vol 4, No 1, Pages 76-83, 2017

	T1	T2	T3
DEN (kcal/kg/24h)	44.0 ± 4.0	46.0 ± 4.0	45.0 ± 4.0
Proteins (E%)	16.0 ± 2.31	17.4 ± 3.11	17.9 ± 3.44*
Lipids (E%)	34.0 ± 6.7	33.0 ± 6.0	35.5 ± 8.8
Carbohydrates (E%)	50.0 ±6.2	50.0 ± 5.0	44.6 ± 7.1*
DEI (kcal/kg/24h)	49.0 ± 16.0	35.0 ± 9.0***	34.8 ± 13.3**
Proteins (g/kg)	2.0 ± 0.75	1.6 ± 0.58**	1.6 ± 0.62*
Lipids (g/kg)	1.8 ± 0.6	1.2 ± 0.2*	1.5 ± 0.53*
Carbohydrates (g/kg)	6.2 ± 2.35	4.4 ± 1.58**	3.9 ± 1.75***†

DEN – dailyenergyneeds; DET – dailyenergyintake

* - p < 0.05 versus T1, ** - p < 0.01 versus T1; *** - p < 0.001 versus T1; † - p < 0.05 versus T2

Discussion

It is well known that the energy balance that includes sufficient carbohydrate and protein intake is essential for the recovery process. This study was aimed to track the changes in the nutritional status of boxers along the training mesocycleprior an important competition. Because of the intensive loading we expected occurrence of overreaching symptoms in the tested athletes. The used by us test for overtraining evaluation, RESTQ-Sport, is based on the assessment of physical and mental stress of athletes on one hand and the process of recovery on the other hand. In overtraining/overreaching, stress dominates over the recovery processes [8]. Our results showed a decrease in the ratio stress/recovery in T2, the period with the heaviest training load in which turned four hard training and a lighter, whereas and in T3, the pre-competition recovery period, in which turns two light trainings and a heavy one a significant increase was estimated. Similar observations have been described by other authors [8, 9]. It is noteworthy the dynamics of recovery/stress ratio in the most successful boxer of the competition - the champion in 69 kg category. The calculated ratio for him was 0.94, 0.87 and 0.99 in T1, T2 and T3, correspondingly. This indicates a great exercise load up to the point of short-term overtraining and a very good recovery in T3. In addition to the RESTQ-Sport test we measured also the testosterone/cortisol ratio as an index of overtraining. According to some authors [3] the testosterone/cortisol ratio indicates the actual physiological strain in training, rather than overtraining syndrome. However, in our study, the lowest testosterone levels and thus the lowest testosterone/cortisol ratio was observed not in the phase of the greatest stress (T2), but at the beginning of the recovery pre-competition period (T3). It seems more likely that the reduction in the concentration of testosterone and testosterone/cortisol ratio in T3 is due to the heavy loads in the previous training period (T2) and thus actually reflects the state of short-term overreaching. Similarly to our findings other authors [10] established a negative significant correlation (r = -0.53; p <0.05) between the levels of cortisol and testosterone in the recovery period after loading. They did not found a correlation between the levels of cortisol and testosterone at rest (r <0.01; p> 0.05) and the possibility of a negative impact of cortisol on the concentration of testosterone was discussed.

In regards to the diet of the tested athletes we observed a reduction of nutrients intake. In the course of our research we observed a significant progressive reduction in the average carbohydrate intake (6.2 ± 2.35 g/kg/24h in T1, 4.4 ± 1.58 g/kg/24h in T2 and 3.9 ± 1.75 g/kg/24h in T3). Both

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DE GRUYTER OPEN

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protein and fat intakes also decreased in T2 and T3, and a significant reduction in total energy intake respectively was calculated (Table 2). However our results indicated minor changes in the weight of the tested subjects in the end of the investigation. It was observed decrease in FM% and increases in MM%. These trends are characteristic of the training process and the accompanying muscle hypertrophy. An increase in skeletal muscle mass may directly lead to reduced body fat composition [11].

In strength sports with weight categories, usually the athletes decrease mostly the carbohydrates intake in the pre-competition period aiming entry into a lower weight class[12].

The reduced carbohydrate intake and consecutive days of extensive exercise have been shown to cause muscle glycogen depletion leading to fatigue and decrements in performance. Thus, the question rises whether the low muscle glycogen can lead to not only to peripheral and central fatigue but also to overtraining [13]. The decrease in glycogen storages is one of the oldest discussed reasons for the short- and long- term overtraining.

Low muscle glycogen levels could also lead to oxidation of the branched chain amino acids (BCAA) and central fatigue [13]. The mechanisms of central fatigue during exercise are less well known in contrast to the peripheral fatigue. One of the factors that have been suggested to cause central fatigue is the change in the brain serotonin (5-hydroxytryptamine) level. The rate-limiting step in the synthesis of serotonin is the transport of tryptophan across the blood-brain barrier. Therefore the tryptophan amount available for transport into the brain, as well as the concentration of large neutral amino acids, including the branched chain amino acids (BCAAs), which are transported via the same carrier system impacts this process. In has been demonstrated that during endurance exercise tryptophan is taken up by the brain because of increase of plasma ratio of free tryptophan (unbound to albumin)/BCAAs and therefore rise in serotonin synthesis in the brain could be expected. The ingestion of carbohydrates during exercise could delay the muscle protein breakdown and a subsequent effect of BCAAs on fatigue since the brain's uptake of tryptophan will be reduced [14].

The effect of dietary carbohydrate consumption on the free testosterone to cortisol ratio during a short-term intense micro-cycle of exercise training was examined by Lane et al. [15]. The performance of intensive training (70-75% maximal oxygen consumption, 60 min per day) at three consecutive days by male subjects subjected to a low-carbohydrate diet (about 30% of daily intake) lead to significant decrease (with 43%) of this ratio in comparison to pre-study resting measurements [15]. In our study we observed a reduction in testosterone/cortisol ratio in T3 (Fig. 2C), mainly because of the reduced testosterone concentration (Fig. 2A) and to a lesser extent because of slight insignificant rise of cortisol concentration (Fig. 2B). There was no correlation between cortisol and testosterone level ($r = 0.09$; $p = 0.784$). This observation suggests existence of an independent of cortisol mechanism for testosterone lowering as that proposed by Biswas et al [16]. Therefore brain serotonin likely exerts an inhibitory effect on testicular steroidogenesis by modulating the gonadotropin-releasing-factor release and thence pituitary gonadotropins [16].

It has been suggested that overtraining impairs the adaptation processes including the shift in the balance of oxidized substrates and this provoke hypoglycemia occurrence [17]. Therefore this effect could be prevented by adequate pre-exercise feeding with carbohydrates, but consumption ofcarbohydrate meal with high glycemic index could also favorite hypoglycemia [17].

Conclusions

The observed increase in recovery processes in the period before the competition according to the results obtained by the RESTQ-Sport test probably is due to the reduction of training loads in this period.

The decrease in the concentration of testosterone and testosterone/cortisol ratio in the same period is due to large loads in the previous training period and thus reflects the state of short-term overtraining.

In power sports with weight categories the reduction of mostly the carbohydrates intake probably has a negative impact on the recovery process and partly explains the slight increase in cortisol in T3.

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DE GRUYTER OPEN
ASN, Vol 4, No 1, Pages 76-83, 2017

To reduce the negative effects of reduced carbohydrate intake in the pre-competition period the time for a carbohydrate food consummation should be taken in consideration. A good carbohydrate feeding 1-2 hours before exercise, amounting to expected carbohydrate expenditure is a good prevention of hypoglycemia during exercise and could reduce the depletion of glycogen stores.

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