Bulletin of Experimental Biology and Medicine, Vol. 146, No. 3, 2008 ATHLETIC MEDICINE

Free Testosterone as Marker of Adaptation to Medium-Intensive Exercise

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Translated from *Byulleten' Eksperimental'noi Biologii i Meditsiny,* Vol. 146, No. 9, pp. 330-332, September, 2008
Original article submitted July 4, 2008

A 4-week study of adaptation reserves of the body was carried out during medium intensive exercise (medium intensive training: 60-80% threshold anaerobic metabolism). Two groups of athletes were singled out by the results of pulsometry analysis: with less than 20% work duration at the level above the 80% threshold anaerobic metabolism and with more than 20% work duration at the level above 80% threshold anaerobic metabolism. No appreciable differences between the concentrations of total testosterone, growth hormone, and cortisol before and after exercise in the groups with different percentage of anaerobic work duration were detected. In group 1 the concentrations of free testosterone did not change throughout the period of observation in comparison with the levels before training. In group 2, the level of free testosterone increased in comparison with the basal level: from 0.61±0.12 nmol/liter at the end of week 1 to 0.98±0.11 nmol/liter at the end of week 4 ($p<0.01$). The results indicate that the level of free testosterone can be used for evaluating the degree of athlete's adaptation to medium intensive exercise.

Key Words: *free testosterone; cortisol; medium intensive exercise*

Many approaches to evaluation of an athlete's adaptation to physical stress are used in modern athletic medicine and physiology; among these approaches are physiological and biochemical values and subjective sensations of the athlete [1,4-6,8,11]. However, no markers predicting imminent exhaustion of adaptation reserve were found yet. Hormones play the key role in adaptation processes and modify the rate of recovery by regulating the anabolic and catabolic processes [10]. Long-term highly intensive training of athlete endurance (longer than 60-min work at a power no lower than the threshold anaerobic metabolism; TANO) increases basal morning level of cortisol, reduces testosterone level, and changes growth hormone concentration [1,3,7,13]. Though the greater part of the training time is spent for medium intensive exercise (longer than 60 min at a power of 60-80% TANO), their effects on the athletes is underrated and virtually not studied.

We searched for hormone markers for evaluating the adaptation reserve in medium intensive exercise.

MATERIALS AND METHODS

The study was carried out in 11 young men specialized in academic rowing for more than 4 years, who signed informed consent to participation in the study. The protocol of experiment was approved by Ethic Committee of the Institute. The mean characteristics of participants in the study: age 17.2±0.9 years, body weight 92.4±11.7 kg, body length 191.4±4.5 cm, maximum oxygen consumption 48.4±4.3 ml/min/kg.

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0007-4888/08/1463-0354

The study was carried out for 30 days (1 mesocycle, including 4 microcycles, 7 days long each). Two days before the mesocycle beginning, all volunteers were tested on a Concept II rowing ergometer with stepwise increasing power (100 W initial power; 50 W step, 3 min duration of a step). Exercise was performed until the moment when it became impossible to endure working at the preset power any longer. Lactate concentration in the peripheral blood was measured during the test at the end of every 3rd min. Heart rate was recorded in a permanent mode by the Polar S610 heart monitor. The TANO value was estimated by lactate concentration (4 mmol/liter). Individual pulse zones were calculated for each athlete by the results of this test: zone 1, 60-80% TANO (aerobic); zone 2, 80-100 TANO (mixed aerobic/anaerobic); and zone 3, 100-130% TANO (anaerobic/glycolytic zone).

The training plan and exercise were the same for all athletes. Training activity of the volunteers was monitored by permanent pulsometry (Suunto Team System).

Venous blood was collected after overnight fasting before training and 1 h after it before the study (T_0) and at the end of microcycles 1, 2, and 4 (T_1, T_2, T_4). Serum hormones were measured using commercial kits according to the instructions: growth hormone (EIA-1787, DRG Instruments GmbH), total testosterone (EIA-1559, DRG Instruments GmbH), free testosterone (EIA-2924, DRG Instruments GmbH), and cortisol (EIA-1887, DRG Instruments GmbH).

The difference between the parameters was evaluated using Mann—Whitney *U* test and was considered significant at $p<0.05$.

RESULTS

The boys were divided into 2 groups by the results of pulsometry. Group 1 included rowers with less than 20% work duration in zones 2 and 3 (n=5) and group 2 consisted of boys with higher percentage of anaerobic work (n=6).

The initial level of total testosterone did not differ in the two groups: 19.9±8.3 nmol/liter in group 1 and 21.7±9.2 nmol/liter in group 2. Basal testosterone concentration virtually did not change throughout the study and by the end of week 4 was 18.0±4.9 nmol/liter in group 1 and 18.9±7.5 nmol/liter in group 2. The concentration of total testosterone reduced by 10-40% in response to exercise, depending on its volume, but no appreciable differences between the groups were noted (Table 1).

The level of free testosterone decreased by 20% in both groups by the end of T_1. Starting from T_2, basal concentration of free testosterone in group 1 changed negligibly and did not reach the initial level by the end of the study. In group 2, the concentration of free testosterone gradually increased and by the end of the study was 60% higher in comparison with T_1 (T_1: 0.61±0.11 nmol/liter; T_4: 0.98±0.10 nmol/liter) and reached the T_0 values (Fig. 2, *a*). The concentration of free testosterone decreased by 20% 1 h after training (Fig. 2, *b*).

No significant differences between the initial concentrations of the morning cortisol in the two groups were detected (group 1: 137±14 ng/ml; group 2: 162±36 ng/ml), though a trend to reduction of cortisol level by the end of the study was noted (group 1: 123±19 ng/ml; group 2: 125±39 ng/ml).

TABLE 1. Testosterone and Cortisol Levels before and after Exercise (*M*±*m*)

Group, microcycle	TT, nmol/liter		FT, nmol/liter		C, ng/ml		GH, ng/ml	
	before	after	before	after	before	after	before	after
1 (n=5)								
T_0	19.9±8.3	14.3±6.0	0.58±0.28	0.40±0.11	136.9±14.1	97.0±22.8	0.48±0.32	0.35±0.43
T_1	15.3±5.1	16,8±6,8	0.39±0.20	0.32±0.10	141.9±26.0	66.7±22.7	0.08±0.07	0.25±0.24
T_2	17.5±6.8	15.0±3.5	0.41±0.14	0.31±0.09	159.2±8.2	81.87±23.7	0.05±0.02	0.28±0.28
T_4	14.8±2.8	13.9±3.1	0.42±0.11	0.57±0.15	122.7±19.2	52.5±40.5	0.32±0.37	0.18±0.09
2 (n=6)								
T_0	21.7±9.2	13.8±6.5	0.88±0.25	0.58±0.25	162.2±35.7	78.0±35.5	0.37±0.50	0.10±0.09
T_1	18.0±7.2	18.3±7.1	0.61±0.12	0.72±0.33	141.9±34.0	58.6±31.9	0.20±0.29	0.34±0.23
T_2	18.0±7.9	19.2±10.3	0.82±0.22	0.58±0.28	154.5±35.1	71.4±32.0	0.01±0.02	0.15±0.06
T_4	18.9±7.5	14.7±6.0	0.98±0.11	0.63±0.33	124.7±38.6	61.42±20.8	0.06±0.09	0.29±0.50

Note. TT: total testosterone; FT: free testosterone; C: cortisol; GH: growth hormone; before: before training; after: after training.

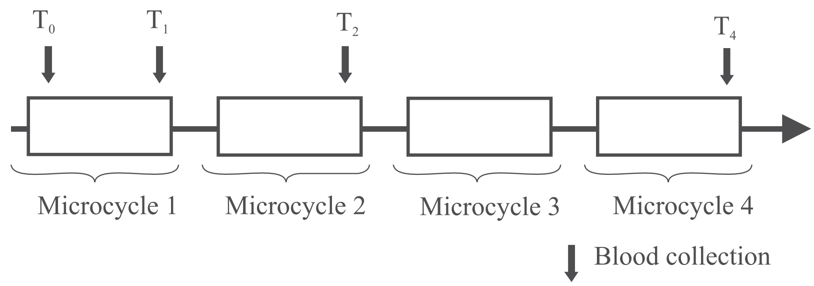

Fig. 1. Scheme of experiment.

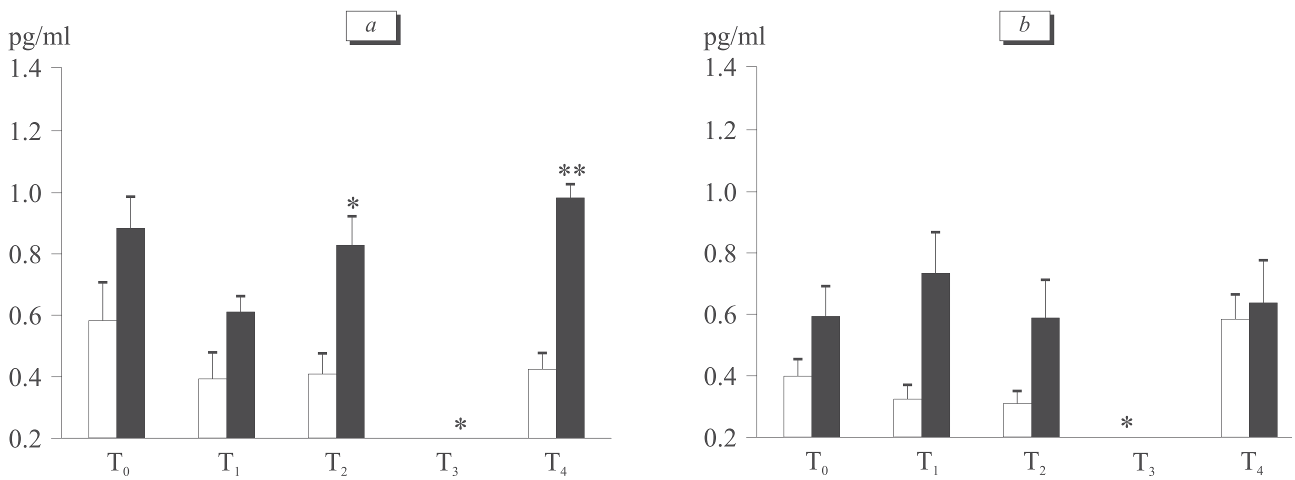

Fig. 2. Free testosterone concentrations before (*a*) and after exercise (*b*). Light bars: group 1; dark bars: group 2. **p*<0.05, ***p*<0.01 compared to T_1.

The level of cortisol decreased in response to exercise similarly in both groups (40%). No differences between the groups in the growth hormone concentrations before and after training was noted (Table 1).

Analysis of pulsometry data during training with preset power of 60-80% TANO showed a significant percentage of anaerobic work in some athletes (more than 20% total duration), which is a sign of stable activation of adaptation systems. No appreciable changes in the levels of cortisol and total testosterone before and after training in groups with different percentage of anaerobic work were noted during 4 weeks of training according to the same protocol. It is known that highly intensive exercise led to a decrease in free testosterone level [4]. The level of free testosterone increased during work in the mixed and anaerobic zones, which was due to specific features of energy substrate metabolism (exhaustion of glucose and glycogen reserves and involvement of free fatty acids (FFA) in metabolism) [12]. Free fatty acids are competitive inhibitors of testosterone and tryptophane binding by transporter proteins [9], and hence, increase of the blood FFA concentration leads to an increase of testosterone concentration.

Hence, free testosterone is a perspective marker for evaluation of adaptation degree in medium intensive exercise. Importantly that hormone concentration can depend on individual genetic features of the detoxication systems [2] and testosterone elimination from the body.

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