Original Article

Hormonal activity and performance of ski-racers

ANASTASIA S. BAKHAREVA¹, ALEXANDER P. ISAEV², ALBERT S. AMINOV³, OLGA V. MELNIKOVA⁴

^{1,2,3,4}South Ural State University (National Research University), Chelyabinsk, RUSSIA,

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Abstract.

The purpose of the article is to study the dynamics of hormonal activity in ski-racers in the preparatory and competitive period and to establish significant changes that demonstrate the effectiveness of competitive activity. Changes in testosterone, urine estrogens, T4 tyrosine and cortisol were compared in racers under training conditions of alternating middle altitude hypoxia and normoxia (group 1) and only normoxia (group 2).

Materials and methods. 17 male ski-racers aged 18–23 years were involved in the study. The first group (1) consisted of cross-country skiers with a training process in the conditions of alternating middle altitude hypoxia (May-August-October) and normoxia (n = 7); the second group - ski-racers with the training process only in conditions of normoxia (n = 10). The study was conducted in the preparatory and competitive period (July and December). The cortisol content was determined using fluorometry with the help of Fluorat-02 ABLFT biofluid analyzer (Lumex, St. Petersburg, Russia) at a fluorescence excitation wavelength of 405 nm and an emission of 546 nm. At the same time, the object of laboratory research was heparinized blood taken from a cubital vein in the morning, on an empty stomach. The levels of total testosterone, urine estrogens, and T4 tyrosine were obtained with the help of a non-invasive AMP blood analyzer (Ukraine). Discriminant analysis was applied for statistical data processing as well as rank correlation analysis and nonparametric analysis of variance (William R. Kleck (1986).

Results. It was found that in the 1st group of athletes there was an increase in total testosterone by 11.05% (p > 0.05), a decrease in urine estrogen and cortisol by 17.55% (p < 0.05) and 29.91% (p < 0.05), respectively. In the 2nd group, by the competitive period, we detected a decrease in testosterone by 6.41% (p > 0.05), urine estrogen by 3.49% (p > 0.05), tyrosine T4 by 0.18% (p > 0.05) against the background of an increase in the concentration of cortisol by 25.85% (p < 0.05). Conclusion. The study showed that people with a combined training process have a more successful competitive activity. The nature of the responses in the process of adaptation is determined by a decrease in catabolic and an increase in anabolic processes.

Key words: cross-country skiers, testosterone, cortisol, estrogens, T4 tyrosine, hypoxia, normoxia.

Introduction.

Analysis of Russian and foreign literature about the mechanisms of long-term adaptation of elite ski-racers shows the urgency of the problem. Until now, reactive transitional states that define the boundaries of homeostasis disturbance remain the least studied, when physiological and biochemical prerequisites for adaptive structural changes in the body are created as result of progressive physical exertion. It has been studied and shown that under conditions of increased activation of the regulatory mechanisms of homeostasis, there is a general mobilization of the energy, plastic and information reserves of the body. Metabolic stress causes the activation of growth factors, hormones, activator proteins, enzymes. The growth of the contractile part, enzymes and energy reserves of the cell, as well as an increase in the amount of water inside the cell are stimulated (Isaev A.P., Erlikh V.V., Romanov Y.N., Bakhareva A.S., 2016, . Isaev A.P., Erlikh V.V., Bakhareva A.S., Saraykin D.A., Pavlova V.I., Maleev D.O., 2018). The physiological changes in ski-racers that occur as result of training loads with various modes of muscle contraction are primarily determined by the provision of the neuromotor apparatus, launching a multi-level system-forming complex of adaptive-compensatory and regulatory mechanisms. However, many researchers are narrowly focused and reveal individual aspects, but not an integral status of the body of athletes. The optimal relationship between catabolic and anabolic processes includes molecular-cellular mechanisms of neuronal, neuromotor, gas exchange, neuroendocrine, cardiopulmonary units, enzymatic complexes and their regulation in the integrative activity of the body. As a result of muscle loads, the hormonal-humoral mechanism in the adaptation process is activated (Megerian, S.D., Maslennikova, O.M., 2015). Studies have shown that various training stimuli and training periods cause the secretion of various hormones (Samsonova A.V., Kos'mina E.A., 2012, Wernbom M., Järrebring R., Andreasson M.A., Augustsson J., 2009). In the article edited by D.V. Popov [2006] it is showed that the excretion of hormones of anabolic action was mainly activated by a metabolic, rather than mechanical stimulus from a contracting muscle (Popov, D.V. Tsvirkun, D.V., Netreba A.I., Tarasova O.S. et al., 2006). At the same time, anabolic hormones have a greater effect on glycolytic muscle fibers (type II), accelerating the synthesis of fast myosin. While steroid

hormones (glucocorticoids), the excretion of which is especially pronounced at the end of long muscle work, are more responsible for the expression of slow myosin genes in type I muscle fibers (Shenkman B. S., 2016). Long high-intensity endurance workouts when working for more than 1 hour with a power not lower than the threshold of anaerobic metabolism cause an increase in basal morning cortisol levels and a decrease in testosterone, as well as a change in growth hormone concentration (Gibney J, Healy M.L., Sonksen P.H., 2007). The effect on the functional activity of the pituitary-adrenal system is exerted by peroxidase, which is formed under the action of hypoxic factors (Khaitsev, N.V., Vasiliev, A.G., Trashkov, A.P., Kravtsova, A.A., 2015).

Materials and methods.

To conduct the study, 17 male ski-racers aged 18–23 years were involved. The first group (1) consisted of cross-country skiers with a training process in the conditions of alternating middle altitude hypoxia (May-August-October) and normoxia ($n = 7$); the second group - ski-racers with the training process only in conditions of normoxia ($n = 10$). The study was conducted in the preparatory and competitive period (July and December).

The cortisol content was determined using fluorometry with the help of Fluorat-02 ABLFT biofluid analyzer (Lumex, St. Petersburg, Russia) at a fluorescence excitation wavelength of 405 nm and an emission of 546 nm. At the same time, the object of laboratory research was heparinized blood taken from a cubital vein in the morning, on an empty stomach. The levels of total testosterone, urine estrogens, and T4 tyrosine were obtained with the help of a non-invasive AMP blood analyzer (Ukraine). Discriminant analysis was applied for statistical data processing as well as rank correlation analysis and nonparametric analysis of variance (William R. Kleck, 1986).

Results.

An analysis of the table allows us to state that in the preparatory period, the level of total testosterone was 2.25% lower ($p > 0.05$) in ski-racers of the 1st group compared to the 2nd group, urine estrogen was higher by 24.22% ($p < 0.05$), the tyrosine hormone T4 was lower by 12.83% ($p > 0.05$), the concentration of cortisol was higher by 32.79% ($p < 0.05$) (Table 1).

Table 1. Dynamics of hormonal activity in ski-racers in the training period ($M \pm m$)

Group	Total testosterone (nmol/l)	Urine estrogen (nmol/24 hours)	Tyrosine T4 (nmol/l)	Cortisol (nmol/l)
preparatory period				
1	16.47 ± 1.92	29.11 ± 3.40	75.37 ± 4.53	479.00 ± 15.54
2	16.84 ± 0.95	22.06 ± 2.39	85.04 ± 3.01	321.90 ± 5.85
p	> 0.05	> 0.05	> 0.05	< 0.05
competitive period				
1	18.29 ± 0.80	24.00 ± 1.89	80.42 ± 2.76	335.71 ± 14.14
2	15.76 ± 1.05	21.29 ± 1.89	84.89 ± 2.90	405.10 ± 6.67
p	> 0.05	> 0.05	> 0.05	< 0.05
differences (p) between periods				
1	> 0.05	< 0.05	> 0.05	< 0.05
2	> 0.05	> 0.05	> 0.05	< 0.05

In the competitive period, in the 1st group of athletes, priority indicators were such as testosterone and urine estrogens, whose levels became higher by 13.83% ($p > 0.05$) and 11.29% ($p > 0.05$), respectively. At the same time, the concentrations of the tyrosine hormones T4 and cortisol were lower by 5.56% ($p > 0.05$) and by 20.67% ($p < 0.05$), respectively.

Fig. 1. Dynamics (%) of hormonal activity in ski-racers in the periods of preparation

Assessing the dynamics (Fig. 1) of hormonal activity from the preparatory to the competitive period, we recorded that in the 1st group of athletes there was an increase in total testosterone by 11.05% ($p > 0.05$) and tyrosine T4 by 6.70% ($p > 0.05$). At the same time, a decrease in urine estrogen and cortisol levels by 17.55% ($p < 0.05$) and 29.91% ($p < 0.05$), respectively, was established. In the 2nd group of ski-racers, by the competitive period, we revealed a decrease in testosterone by 6.41% ($p > 0.05$), urine estrogen by 3.49% ($p > 0.05$), tyrosine T4 by 0.18% ($p > 0.05$) against an increase in the concentration of cortisol by 25.85% ($p < 0.05$).

Discussion.

Modern skiing is associated with an active metabolism of skeletal muscle, which is mostly influenced by the hormonal status of the athlete's body (Goldspink G., 2005). At the same time, the hormonal status allows us to assess the functional status of the respiratory, cardiovascular system, the work of skeletal muscles and the efficiency of the organism as a whole. The results of the studies demonstrated that the combined regime of hypoxia and normoxia showed a higher concentration of cortisol in the preparatory period. An increase in the level of cortisol causes a cumulative stress syndrome, which encompasses the neuroendocrine system, neuromotor function, connective tissue processes, autonomic reactions, activation of physiological barriers and granulocytopoiesis (De Arruda A.F.S., Aoki M.S., Paludo A.C., Drago G., Moreira A., 2018). It has been studied that glucocorticoid receptors are important transcriptional elements. Against the activation of the sympathoadrenal system with the participation of postsynaptic β -adrenergic receptors, the processes of glycolysis, glycogenolysis, gluconeogenesis and lipolysis are activated. Simultaneously with the release of catecholamines under conditions of hypoxic stress, the hypothalamic-pituitary-adrenal system is activated through the secretion of glucocorticoids. The excess of cortisol, which is a catabolic hormone, leads to a decrease in muscle protein, while testosterone stimulates protein synthesis. Therefore, the ratio of cortisol and testosterone has a direct effect on muscle strength during adaptation to physical activity [6]. It has been shown earlier that increased levels of cortisol and low testosterone correlate with a decrease in blood viscosity, hematocrit and plasma viscosity (Melnikov, A.A., Vikulov, A.D., 2004). An increase in testosterone provides an increase in the hemodynamic productivity of the heart and maintenance of strength characteristics (Borzykh, A.A., Kuzmin, I.V., Martyanov, A.A., Borovik, A.S., Sharova A.P. et al., 2012). In literature, it has been demonstrated that in the male body testosterone has two mechanisms of action: it activates androgen receptors and turns into estradiol, and also activates estrogen receptors. In endothelial and smooth muscle cells of the walls of blood vessels, as well as in coronary cells, testosterone under the action of aromatase is converted into estradiol and reduces the rate of atherogenesis. However, the effect of estrogen reduces the rigidity of peripheral arteries (Kerimova, K.N., Bakhshaliev, A.B., Gadzhiev, R.F., Hamidova, E.S., 2012). In addition, a high level of performance is associated with a decreased level of estradiol (Nikitina, L.Yu., Soodaeva, S.K., Shashkova, T.V., Petrovskaya, Yu.A. et al., 2013). Thyroid hormones, by increasing tissue sensitivity to catecholamines, increase heart rate, and also directly affect heart contractility. So, with a decrease in thyroxine concentration, myocardial contractility decreases, and vice versa (Cunha G. V. Tibana R. A., Ernesto C. et al., 2017). The positive inotropic effect of thyroid hormones is explained not only by their direct effect on the heart (participation in the synthesis and modulation of the activity of contractile proteins and calcium transport), but also by the regulation of systemic vascular resistance. Other literature has shown that with a decrease in thyroid hormones, there is a decrease in aortic elasticity and vascular endothelial dysfunction (Mazur, E.S., Kileinikov, D.V., Semenychev, D.G. et al., 2013).

Conclusion.

A dynamic study of the hormonal level in high performance sports indicates the effectiveness of the training process and adaptation of the body. Sports activities are provided by complex, interdependent reactions aimed at meeting the basic adaptive needs of the body. Systematic physical activity contributes to the systematic development of long-term adaptation, the effectiveness of which is exerted by the work of the endocrine system. A comparative analysis of hormonal status in ski-racers in different conditions of the training process showed that the dynamics of hormone concentration is associated with multidirectional metabolic changes in the body. The combined training regime (middle altitude hypoxia and normoxia) in cross-country skiers of the 1st group affected the efficiency of catabolic and anabolic hormones, which determined their success in competitions.

To effectively manage the training process, it is necessary to analyze the results of a biochemical examination, as well as other physiological parameters for determining the athlete's performance in the training system.

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