

**EFFECTIVE LONG TERM ADAPTATION AND METABOLIC STATE REGULATION OF SKI-RACERS**

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**Abstract.** *Purpose:* to scientifically substantiate effective mechanisms of organism's bio-chemical adaptation of ski-racers in competition period with the help of lipid peroxidation indicators, oxidative modification of proteins and activity of hypothalamus pituitary adrenocortical system. *Material:* in the research 14 sportsmen of 18-25 years' age (combined team of university) with different level of sportsmanship participated. Assessment of free radical oxidation, anti-oxidant system, cortisol level was fulfilled with the help of indicators' quantitative analysis by bio-chemical methods applied to blood serum samples. *Results:* it was found that in the basis of bio-chemical changes under intensive physical loads is increase of catabolic processes' speed. Change of organism's metabolic orientation of ski racers at optimal level results in working muscles' energy supply improvement, increase of energy systems' power and sports efficiency. *Conclusions:* Application of interval trainings at stages of preparation to special significant competitions results in expected adaptation and increase of sports efficiency. We also showed their effective role in ensuring long term reactions, conditioning high sports efficiency.

**Key words:** lipids peroxidation, oxidative modification of proteins, sports efficiency, cortisol, effective adaptation.

**Introduction**

Since the time of Soviet Union and up to the present in ski racings, the models of excessive loads have been used, which brought high sports results. However, to day, in connection with application of new technologies in ski racers' training the role of special endurance and sports efficiency increased. According to modern tendencies special endurance of ski racers is determined by aerobic and anaerobic processes in muscles, which permit to generate high strength and power in upper and lower limbs [21, 23, and 24].

In our previous researches we determined excretion of creatine and non organic phosphorus as indicator of Judo wrestlers' metabolic state. Bio chemical basis of Judo wrestlers' special endurance is connected with high level of creatine phosphate track of bio-energetic. General endurance is connected with priority presence of lipid metabolism in energy supply of motor functioning [10]. In assessment of ski racers' metabolic state in conditions of concentrated development of local-regional muscular endurance in basic period of training we found variability of products in heptanes phase of lipid extracts. It results in increase of aerobic share of energy supply [4].

At present time physiology of sports have great scope of information on researches of cardio-pulmonary system. There is much less researches on long term bio-chemical adaptation, whose regulation and phases, nevertheless, are under attention of researchers [5, 13, 20]. With it, it is necessary to note that there is a lot of works, devoted to lipids peroxidation, stress indicators, allostasis. A little bit less there are works on protein synthesis, which is of great importance in plastic and energetic processes as well as in buffer component, which maintain the level of cations and reduce elastic viscous properties of skeletal muscles. Very important direction is connected with study of contracting muscular proteins' metabolism's molecular properties. First of all it is necessary to study the processes in cell membrane and membranes of self-plasmatic reticulum (SPR), mechanisms of receptors' functioning, which are located in membranes of glucoses transportation proteins.

As on to day, in informational field of sports physiology and motor functioning there exists a contradiction between volume characteristics of positive and negative influence of physical exercises on ski racers' psycho-physiological (in wide sense) potential. Such situation conditioned the choice of the subject of our research.

*Hypothesis:* it is assumed that sportsmen organism's integrative functioning in extreme environmental conditions is manifested in combined reflection of free radical lipids' oxidation, antioxidant activity of blood plasma and protein synthesis. All these in total determine energy supply, plastic and defensive functions of the tested sportsmen's organisms.

*The purpose of the research* is to study indicators of bio-chemical processes in ski racers with high sports efficiency.

**Material and methods**

*Participants:* the contingent to be researched consisted of ski racers (male), members of combined team of university of age 18-25 years old. The first group included sportsmen with higher sports efficiency (1<sup>st</sup> group, n=5); the second consisted of sportsmen with weaker sports efficiency (2<sup>nd</sup> group, n=9). The research was conducted in competition period of training (February).

*Organization of the research:* we fulfilled laboratory testing of free radical oxidation, antioxidant system; we estimated activity of hypothalamus pituitary adreno-cortical system (determination of cortisol level). For this purpose we used quantitative analysis of indicators with bio-chemical methods, applied to blood serum samples. The object of

laboratory testing was heparinized blood taken from cubital Vienna in the morning at empty stomach. All tested gave their consent for taking blood that does not contradict Declaration of Helsinki.

Assessment of condition of lipids' peroxidation processes included quantitative determination of primary, secondary and final peroxidation products in blood plasma with separate registration of lipid peroxides in heptanes and isopropanol phases of lipid extract [6, 11, 12, and 22].

Assessment of condition of proteins' oxidation modification included estimation of carbonyl products' content of blood plasma proteins' oxidation modification by their reaction to 2,4 – dinitrophenylhydrozine with further spectral-photometric registration of interacting products –dinitrophenylhydrozones [2, 7, and 8]. The content of carbonyl products' content of blood plasma proteins' oxidation modification was registered in 5 (five) samples of blood serum.

Spectral photometric detection of lipid peroxidation products in heptanes and isopropanol blood serum extracts as well as level of carbonyl proteins was fulfilled with the help of spectrometer «SF-56» (LOMO - Spectr, Sankt Petersburg, Russia).

Estimation of cortisol content was realized with fluorometric micromethod [3]. Cortisol content was determined in 5 (five) blood serum samples. Determination of fluorescence intensity for quantitative detection of cortisol level was carried out with the help of bio-liquids' analyzer «Fliorat – 02 ABLFT » (Lumax, Sankt-Petersburg, Russia) with wave length of fluorescence excitation of 405 nm and emission 546 nm.

*Statistical analysis:* statistical processing of the research's materials was fulfilled with the help of Statistica 10.0, SPSS 17 programs on bases of key methods. Confidence of differences between groups was determined with Manna-Whitney criterion.

### Results of the researches

It is known that processes of lipid peroxidation in blood plasma is one of criteria of sportsman's special endurance and condition of aerobic energy supply mechanisms' objective assessment (see table 1).

**Table 1.** Content of lipid peroxidation molecular products at competition stage of training in both groups (M±m)

Group	Isopropanol-solved			Heptanes-solved		
	Primary (DC) E <sub>232</sub> /E <sub>220</sub>	Secondary (KDsCt) E <sub>278</sub> /E <sub>220</sub>	Final (SB) E <sub>400</sub> /E <sub>220</sub>	Primary (DC) E <sub>232</sub> /E <sub>220</sub>	Secondary (KDsCt) E <sub>278</sub> /E <sub>220</sub>	Final (SB) E <sub>400</sub> /E <sub>220</sub>
1	0.45±0.01	0.25±0.07	0.02±0.002	0.63±0.01	0.12±0.02	0.06±0.09
2	0.43±0.02	0.18±0.05	0.02±0.002	0.48±0.02	0.19±0.03	0.17±0.04
p	> 0.05	< 0.05	> 0.05	< 0.05	< 0.05	< 0.01

Notes:

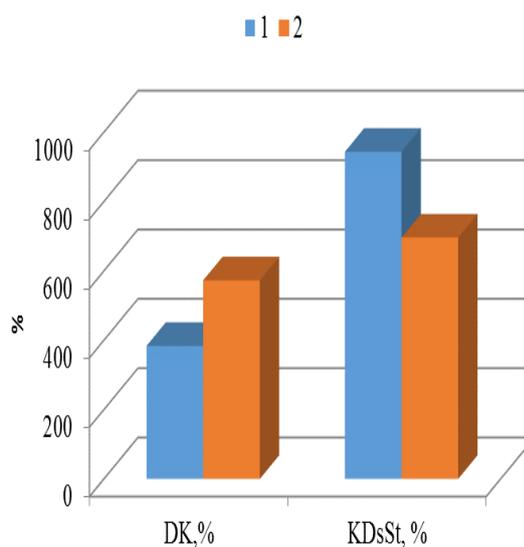
DC – diene conjugates;

KDsCt – keto-diene and coupled trienes;

SB - Schiff bases.

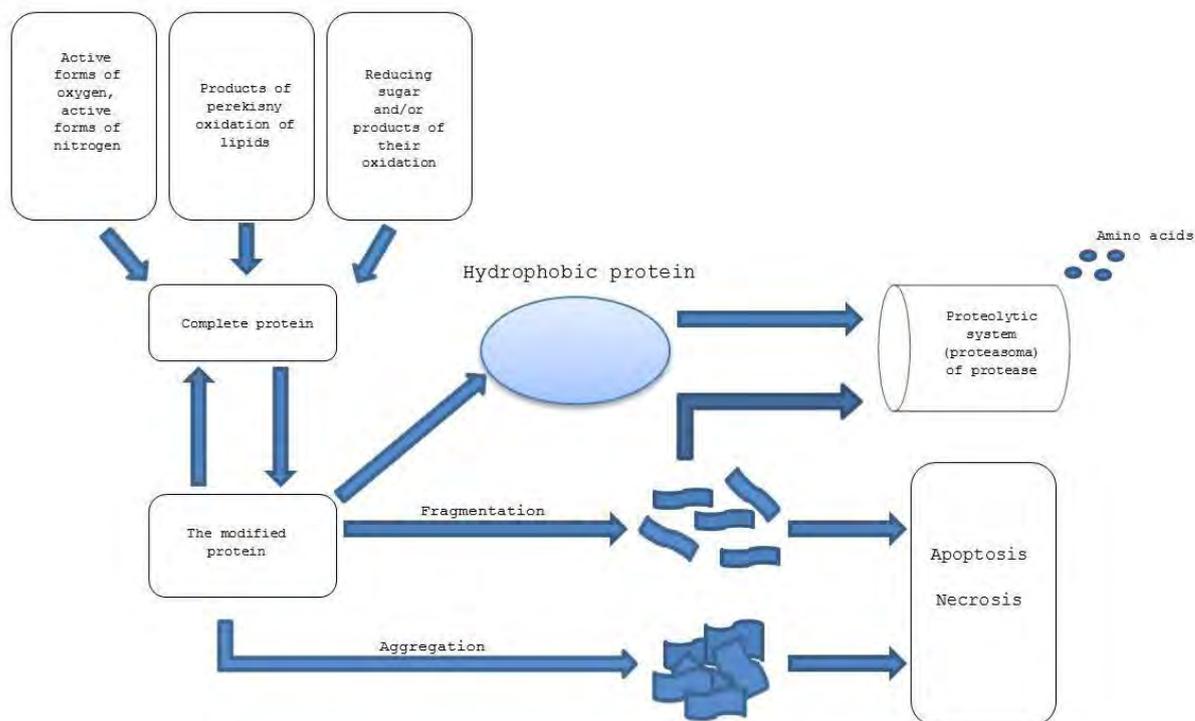
By results of the research (see table 1) it is clear that in group 1 there is increased content of LPP in heptanes (p >0.05) and in isopropanol phases (p >0.05) of lipid extract. It is known that at the account of accumulation of primary LPP diene conjugates polarity of hydrophobic carbohydrate tails of fat acids, which form a layer of cell membranes, increases. The parts with increased polarity are displaced from membranes. It makes easier self-renewal of membrane structures, increases intensity of electronic transportation in respiratory chain and facilitates steady hyper functioning of myocardium under hypoxia [9, 17]. At the same time in group of leaders we observed reduced content of secondary (p <0.05) and final (p <0.01) heptanes solved. This fact says that in competition period sportsmen-leaders have increased glucose content, which, in its turn, results in braking of fats disintegration (as less effective source of energy supply with competition speeds).

Intensification of lipids peroxidation processes in leaders' group was accompanied, at the same time, by increased level of antioxidant activity, determined by content of peroxidation secondary products, after induction by ascorbate (see fig. 1).



**Fig.1.** Indicators of induced lipids' peroxidation (DC – diene conjugates; KDsCt – keto-diene and coupled trienes in both groups (group 1 (1), group 2 (2), %

It is known that under oxidation stress cell proteins (together with lipids) undergo radical attack of activated oxygen metabolites. One of promising directions in science is practical study of proteins' oxidation modification in biological material in pathological state. Results of proteins' oxidative destruction is damage of proteins; native structure (see fig. 2).



**Fig. 2.** Ways of formation and utilization of modified proteins by Davies, K.J. [18]

Under effect of oxygen active forms two processes can take place: fragmentation of proteins, whose markers are aldehyde dinitrophenylhydrazones (ADNPH); aggregation of proteins, whose markers are ketone dinitrophenylhydrazones (KDNPH) [15].

Products of proteins' oxidation, formed spontaneously and in induced way in Fenton's reaction [1] shall be measured. It is considered that indicators of proteins' spontaneous oxidative modification characterize organism's

general physiological condition, while indicators of proteins' oxidative modification characterize reserve adaptation potentials of organism [15].

**Table 2.** Content of carbonyl proteins (CP) (level of proteins' oxidative modification) in both groups (M±m)

Group	Spontaneous			Induced		
	CP1, EDop/g of protein	CP2, mc.mole/g of protein	CP3, mc.mole/g of protein	CP1, EDop/g of protein	CP2, mc.mole/g of protein	CP3, mc.mole/g of protein
1	5.82±1.25	0.43±0.21	0.54±0.21	92.03±1.74	3.21±1.12	1.55±0.17
2	1.11±0.47	0.26±0.17	0.30±0.15	76.21±1.43	3.03±1.11	1.27±0.11
p	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05

Notes:

CP1 - a ADNPH – aliphatic aldehyde-dinitrophenylhydrozones ( $\lambda_{\max} = 270$ ).

CP2 - a KDNPH n - aliphatic ketone-dinitrophenylhydrozones of neutral character ( $\lambda_{\max} = 370$ ).

CP3 - a KDNPH main - aliphatic ketone-dinitrophenylhydrozones of main character ( $\lambda_{\max} = 430$ ).

EDop/g of protein – units of optical density per 1g of protein.

mc.mole/g of protein - mc.mole/g per 1 g of protein.

At early stages of oxidative stress aldehyde-dinitrophenylhydrozones (ADNPH) prevail and at later stages - ketone-dinitrophenylhydrozones (KDNPH).

Higher values of proteins' oxidation modification in group of leaders ( $p < 0.05$ ) point at intensification of oxidation processes. Intensity of induced oxidation of proteins' modification in group 2 is much less ( $p < 0.05$ ). It witnesses about less proteins' reserve for oxidation. At the same time, induced oxidative modification of proteins permitted to register higher resistance of system to peroxidation in leaders' group.

Therefore, intensive loads in competition period increase sportsmen organism's demand in proteins. Proteins fulfill plastic and energetic functions, which is glucose transportation in anaerobic conditions of motor functioning [26].

V.A. Rogozkin [13] found that increase of glucose supply to muscular cell takes place at the account of increase of proteins' transporters quantity and owing to increase of these proteins metabolism. Glucose transportation into muscular cell is closely connected with presence of specific proteins transporters in it and their mobilization. Reduction of glucose level helps to slow down production of amino acids in liver [5]. It stimulates glycogen and cortisol [16].

Analysis of results of general proteins and cortisol content in blood plasma of ski racers showed multidirectional dependence of these indicators on each other (see table 3). Indicators of cortisol in leaders' group were lower by 113.2 nmole/l ( $p < 0.05$ ). Content of general proteins in this group prevailed by 9.64 g/l ( $p < 0.05$ ) in contrast to ski racers with lower sports efficiency.

**Table 3.** Content of general proteins and level of cortisol in blood of both groups' ski racers (M±m)

Group	General proteins, g/l	Cortisol, nmole/l
1 (leaders)	81.61±8.47	367.3± 54.14
2	71.97±8.12	480.5±32.17
p	< 0.05	< 0.05

Cortisol is a hormone, which increase intensity of proteins' decay and amino acids' release from them. It ensures the presence of initial compounds for glucose synthesis. Thus, in this case we observe reduction of metabolism's intensity in leaders' group. It witnesses about economizing of organism's work in state of rest.

### Discussion

The main target of training process in sports is achievement of the highest cumulative adaptation effect, which shall reflect in increment of workability indicators and improvement of sports results [27].

In connection with changes in modern ski racing, new means of ski trail's preparation, introduction of sprinter disciplines in competition programs, the scientists all over the world review morphological functional characteristics of elite skiers. Besides, means of technique's and special workability assessment are perfected [21, 19, and 25]. Most of researches in conditions of mobilization stress with indicator of lipids' peroxidation and antioxidant activity were fulfilled on animals [6]. Researches in sports on studying of stress-tension indicators relate to the end of the last century and were connected with assessment of metabolic and cardio-vascular states.

The progress of sports efficiency in present researches is conditioned by application of training loads with concentrated development of local-regional muscular endurance in aerobic mode at stage of basic training. In this case

organism's vegetative systems are not limiters of workability [14]. Introduction of interval trainings at stages of preparation to special important competitions brought the expected effect of adaptation and increase of sports efficiency. We showed their effective role in ensuring of long term reactions, conditioning high sports efficiency (second place of male combined team of LURSU in ski racing at 4<sup>th</sup> All-Russian winter Universiade, 2016).

#### Conclusions

1. Higher sports efficiency in leaders' group is characterized by prevalence of values of lipids' peroxidation primary products (diene conjugates) in heptanes and isopropanol phases of extract; by less level of secondary heptanes solved products of lipids' peroxidation (ketodienes and coupled trienes).

2. In leaders' group we observed higher level of antioxidant activity: reduced – of cortisol; increased of general proteins, comparing with group of lower sports efficiency.

3. Intensification of proteins oxidation processes in leaders' group results in increase of glucose content and glycogen accumulation – main source of energy supply in anaerobic conditions of motor functioning.

5. The work of energy supply mechanism in leaders' group is characterized by more effective combination of aerobic and anaerobic abilities.

4. Increase of reserve-adaptation potential's share in leaders is characterized by increased content of aldehyde and ketone-dinitrophenylhydrozones of main character and ketone-dinitrophenylhydrozones of neutral character.

#### Conflict of interests

The authors declare that there is no conflict of interests.

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