Time Course of Lipid Peroxidation during Adaptation of Men to Novel Ecological Conditions

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Translated from *Byulleten' Eksperimental'noi Biologii i Meditsiny*, Vol. 124, No. 12, pp. 678-682, December, 1997
Original article submitted June 24, 1996

Changes in the intensity of lipid peroxidation and serum activities of superoxide dismutase and catalase were similar after 18-month adaptation to new ecological conditions of soldiers serving in two different regions. All values increased and reached the maximum by the 6th month, after which they stabilized; catalase activity decreased after 6 months.

Key Words: *adaptation; lipid peroxidation*

Living in a new ecological setting involves strain of many functional systems responsible for the formation of adaptive reactions of the organism [5,6]. Overstrain and depletion of adaptation reserve can be regarded as a predisease characterized by disordered integration of functional systems at different levels and alteration of many regulatory and homeostatic mechanisms.

At present it is believed that activation of free-radical lipid peroxidation (LPO), which can be regarded as an element of nonspecific tissue injury observed in many diseases, is a universal reaction of the organism to extreme environmental factors [2,11].

Our purpose was to investigate the time course of LPO and activities of antioxidant enzymes in blood serum in soldiers after an 18-month adaptation to new ecological conditions.

MATERIALS AND METHODS

Healthy young men aged 18-24 years were examined. They served in Western Siberia (Tomsk) and in the mountains and deserts of Central Asia (Mongolia).

The former region is characterized by continental climate, severe in comparison with the geographical regions of European Russia, situated at the same latitudes. A total of 187 subjects were examined here.

The latter region is characterized by similar features; the difference of annual temperatures reaches 90°C. The Central Asiatic region is characterized by high hypsometric position (2000 m above the sea level), low partial oxygen pressure, intensive solar radiation, and arid climate. In this region, 137 subjects were examined.

The examinees were grouped in accordance with B. P. Alisov's classification [1]: by the climatic and geographic zones from which they arrived. The time courses of adaptation processes in different groups were compared. Control groups consisted of soldiers whose service did not involve essential alteration of climatic and geographic conditions: residents of St. Petersburg serving in its environs, with professional loading similar to that in the two main groups.

Blood was collected at the moment of arrival to the place of service (initial status), and then after 1, 3, 6, 12, and 18 months of adaptation to the new region. All examinees lived in similar communal conditions and were exposed to similar exercise. For biochemical analysis, blood was collected from the ulnar vein after an overnight fast and centrifuged at 900*g* for 20 min. Serum was frozen in liquid nitrogen and stored until use. For assessing the intensity of LPO, hydroperoxides [3] and 2-thiobarbituric acid reactive substances (TBARS) [12] were measured.

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0007-4888/97/0012-1225$18.00

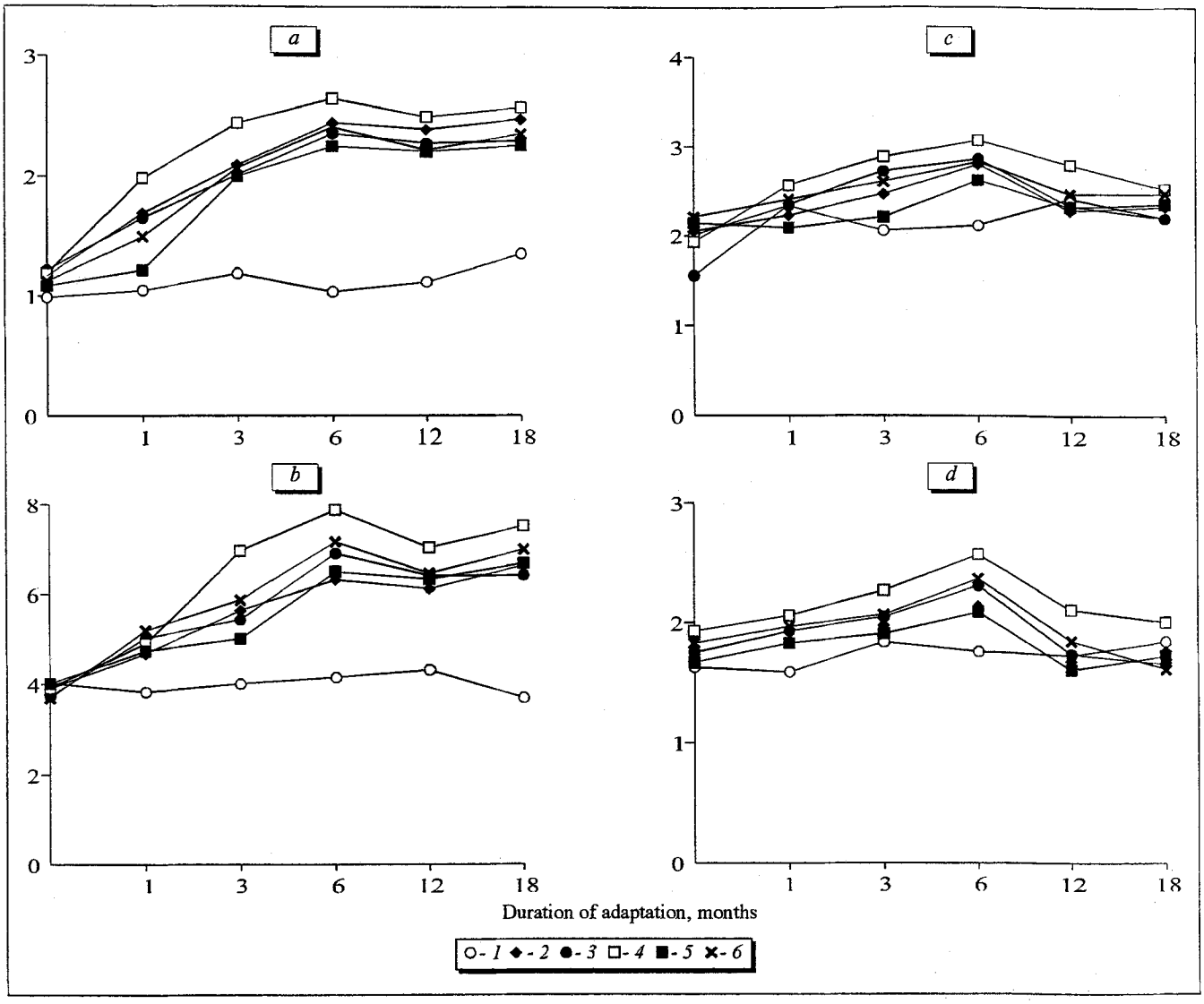

Fig. 1. Time course of lipid peroxidation and activities of antioxidant enzymes in the blood plasma of young men after a 18-month adaptation to ecological conditions of Western Siberia. Control: native residents of St. Petersburg living in this city over the entire period of observation and exposed to the same physical and psychoemotional strain as the rest examinees (*1*); subjects from the Eastern European region (*2*); from the Ural region (*3*); from Central Asia (*4*); from Southern Siberia (*5*); from the Far East (*6*). Here and in Fig. 2: ordinate: *a*) hydroperoxides, optical units/ml; *b*) substances reacting with 2-thiobarbituric acid, nmol/ml; *c*) superoxide dismutase activity, arb. units/ml×min; *d*) catalase activity, μmol H_2O_2/ml×min.

Superoxide dismutase (SOD) [7] and catalase [10] were measured.

The results were processed using standard IBM PC/AT software. Student's coefficient was used to evaluate the significance of differences.

RESULTS

Figure 1 presents the time course of LPO and activities of antioxidative enzymes in the blood of young men serving in Western Siberia. In the controls, there was a tendency toward an increase in the content of lipid hydroperoxides, which became significant by the 18th month (the difference was 36%, $p<0.05$). The concentration of final LPO products (TBARS), SOD and catalase activities virtually did not change. A general tendency toward LPO intensification was observed for both parameters in all experimental groups. The level of hydroperoxides during the first month of adaptation was significantly increased *vs.* the baseline and control levels in all test groups. These increases varied in different groups from 20 to 100%, $p<0.05$ in all cases. Later this tendency became even more obvious, and by the 6th month the concentration of LPO products reached the maximum in all groups ($p<0.01$), surpassing the initial and control levels by 1.85 and 2.7 times, respectively. The time course of hydroperoxide levels differed in

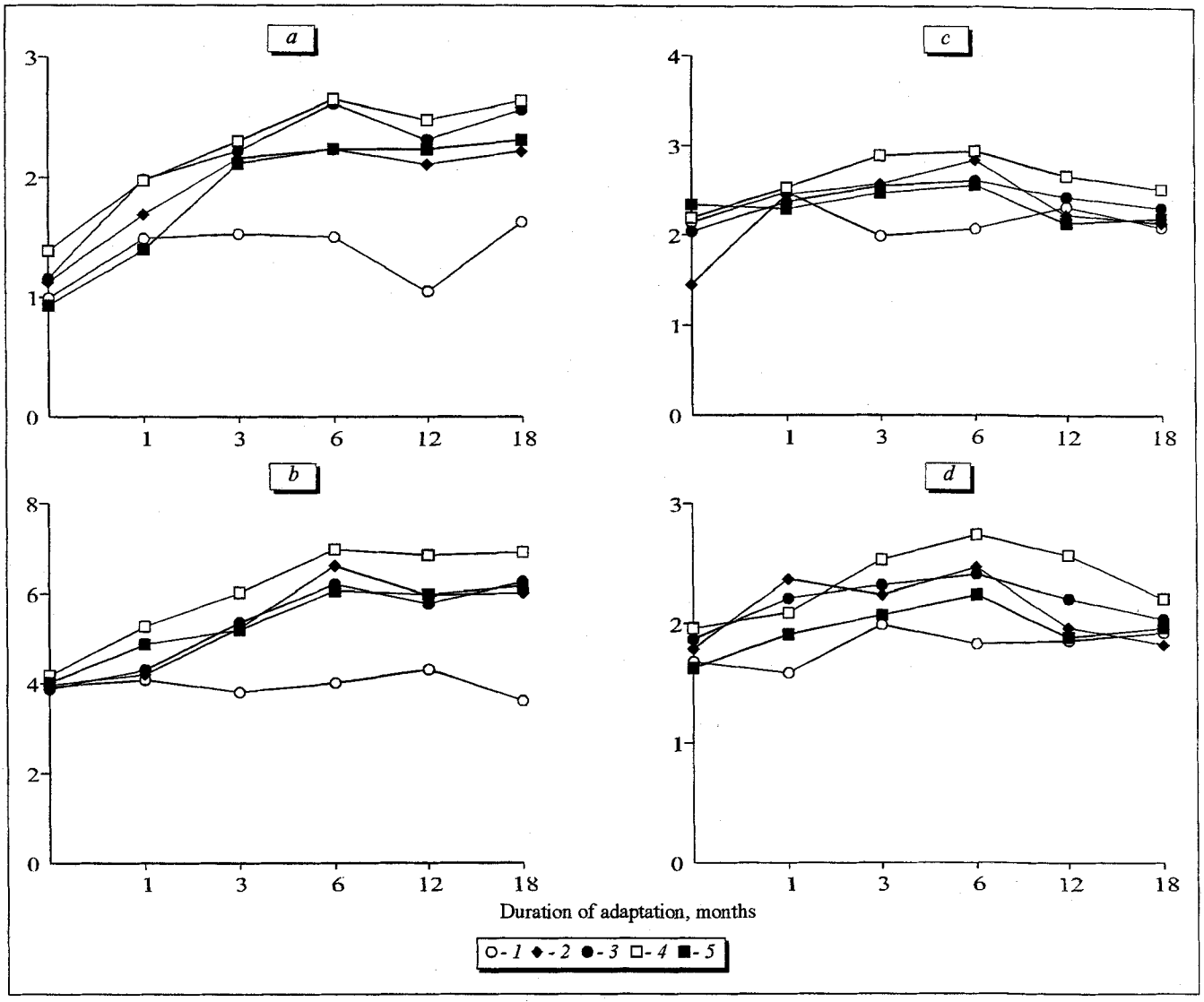

Fig. 2. Time course of lipid peroxidation and activities of antioxidant enzymes in the blood plasma of young men after a 18-month adaptation to ecological conditions of Central Asia. Control: native residents of St. Petersburg (*1*); subjects from temperate Atlantic continental European region (*2*); from continental Eastern European region (*3*); from Central Asia (*4*); from continental Eastern Siberian region (*5*).

later periods, but there were no notable fluctuations, and therefore we can speak about a stable high level of free-radical oxidation from 6th to 18th months. In addition, an increase in TBARS content was observed in the test groups; this increase somewhat lagged behind the growing levels of hydroperoxides and SOD and catalase activities. All these values reached the maximum by the 6th month (when the differences were as high as 60-100%, $p<0.01$; 24-83%, $p<0.01$, and 14-33%, $p<0.05$, respectively). Later, TBARS level stabilized, while SOD and catalase activities gradually decreased; catalase activity decreased to the initial level.

The time course of all parameters was virtually the same in the examinees serving in Central Asia (Fig. 2). The tendency toward an increase in the level of hydroperoxides, which was observed in the control group, was supplemented in the test groups by an increased content of TBARS, SOD and catalase activities (which were maximal during the 6th month); later the former two parameters stabilized, while SOD and catalase activities gradually decreased. The maximum values were higher than initial: by 98-126% for hydroperoxides, $p<0.01$; 50-67% for TBARS, $p<0.01$; 11-95% for SOD activity, $p<0.05$; and by 33-45% for catalase activity, $p<0.05$. The only characteristic feature of soldiers serving in the Central Asiatic region was somewhat increased (*vs.* the initial value) catalase level.

Besides the detected differences, there were common tendencies, absent in the control. The time course of adaptation process was liable to seasonal

fluctuations (LPO intensification during the 6th and 18th months and relative attenuation during the 12th month). The impact of contrast alteration of ecological conditions was noted. The reaction was least of all expressed, like that in the controls, in the subjects who arrived from geographical regions with similar climate, and most pronounced (for all parameters) in residents of the South for whom the ecological conditions were absolutely new. These regularities of the adaptation process are in line with tendencies observed in the time course of phagocytic activity [4]. It is probable that the detected time course of LPO is a component of the general adaptation reaction of the organism to prolonged exposure to a complex of extreme factors in case of drastic alteration of ecological conditions of residence. Changed activity of macrophages supplying potent prooxidant factors to tissues and changed activity of antioxidant system can be the mechanisms responsible for LPO changes.

At present it is assumed that if tissue concentration of LPO products is beyond the norm for a long time and the activity of the antioxidant system is intensified and gradually depleted, the lipid peroxidation syndrome develops, manifesting by universal damage to the structure and function of cell membranes. These processes, in turn, are realized as pathological shifts forming the chronic ecological professional overstrain syndrome [8,9]. On the other hand, our data indicate that the intensity of LPO is no longer increasing and is stabilized due to adaptation.

Exposure to hypoxia, including the mountain conditions, is associated with specific adaptation processes in the LPO system [6]. It is believed that under conditions of chronic hypoxia, increased phagocyte migration into tissues stimulates the production of free radicals, lipid peroxidation, and accumulation of fatty acids in the cells, damaging the membranes [11]. The fact that these features are almost undetectable when we compare the Central Asiatic arid mountain region with the "normal" conditions (Western Siberia in our experiment) implies that the effects of these important ecological factors are masked by more potent common adaptation mechanisms.

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