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Research of the characteristics of adaptation syndrome in Antarctica by means of gas discharge visualization technique

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Introduction

Adaptation, a complex socio-biological process of active adjustment of the organism to changing environmental conditions, having a phasic character, creating a possibility of living in severe climatic conditions, is the most important characteristic of biological objects.

A complex of factors, determining human organism behavior in high latitudes, consists of a whole series of elements including climato-geographical, socio-ecological, and other aspects of human activity. These are heliomagnetic effects, variation of light, periodicals static electricity, water-salt balance disorder, hypodynamia due to spending much time indoors.

A separate group of negative factors include an isolation during 10 months a year, absence of contacts with family and relatives, absence of habitual diet and natural vitamins and lack of visual irritants.

Under the effect extreme climatic, geographic and socio-psychological conditions, human organism is in the state of chronic stress of all functional systems. That can be considered as one of the main risk factors of the origination and development of pathological changes in the organism or the exacerbation of chronic diseases existing before. The central nervous system shows most sensitive reaction to the extreme environmental conditions. Almost every expedition marks cases of development of adaptation syndrome, subject to out-patient and, often, in-patient treatment, as well as the development of dystonia and neurosis, provoking individual transformation – up to the development of hypochondriac and depressive tendencies and hysterical symptoms. These forms of disadaptation of polar explorers in expeditions are mostly manifested during polar nights in Antarctica. Basing on the reports given, we made up a conclusion that it was necessary to improve the system of thorough selection of the healthiest people for expeditions, to disclose possible initial stages of diseases, as well as forms of diseases or premorbid states, which could manifest themselves during expeditions.

The purpose of the present research is the determination of actual duration of adaptation period of polar explorers – members of Russian Antarctic expedition, by means of gas discharge visualization technique.

28 polar explorers – members of 48th Russian Antarctic expedition at station “Novolazarevskaya” took part in the research.

Method of research

The investigation of period of adaptation of polar explorers was performed by way of gas discharge visualization technique (GDV) in dynamic mode [1]. Dynamic GDV images (GDV-grams) of 10 fingers were received in the form of avi-files for 20 members of the expedition, each numbered from 1 to 20. One GDV-gram contained a dynamic image of one finger, 5 seconds long, with sampling frequency of 10 frames a second. The measurements were performed once a month during 7 months (from April to October).

Dynamic images were processed with the help of GDV Video Analyzer program for further numerical estimation [2]. As a result of dynamic GDV-gram processing, time series of the following 10 GDV-gram parameters were obtained: background area, form coefficient of image, average radius of image isoline, normalized mean square deviation of average radius of isoline, length of isoline, entropy for isoline, average intensity of exposure, number of fragments in image, fractality for isoline, and fractality mean square deviation for isoline. The averaged values of time dynamics of the described parameters were investigated according to months; average values taken according to time (all points in the time series of parameter) and all 10 fingers, at that.

Maximal entropy of time series is the characteristic of time series of GDV-gram parameters. This entropy is determined for certain parameter and one GDV-gram (for one finger) as follows. Let us consider different ways of division of parameter domain with time series, containing M points, into J ($1 \le J \le M$) intervals. Maximal entropy H is calculated according to formula:

$$H_m = \max_J \left(-\sum_{j=1}^{J} P_j \ln P_j \right), \qquad (1)$$

where $P_j = N_j / N_M$, N_j — amount of points in time series, where parameter values fall into j-interval of division ($1 \le j \le J$), N_M — amount of all different values of parameter in time series of length M; the maximum in (1) is taken for the divisions of different lengths J. The maximal dynamical entropy H_m for all GDV-grams, corresponding to 10 fingers, is received by averaging H_m from (1) for all GDV-grams. This very value of dynamical H_m is considered further.

Results

The main aim of research was to reveal the characteristics of behavior of GDV-gram parameters and their dynamic characteristics for polar explorers on long time intervals (months). A characteristic feature of most of the parameters of GDV-grams is their variability, i.e. quite significant variability of their values in time. The dynamics of average values of parameters in time series of several months is quite different for different parameters. However, dynamic curves of maximal dynamical entropy H_m have the same form regardless of the GDV-gram parameter, used for the calculation of H_m. As an example, figure 1 shows all these curves for polar explorer number 18.

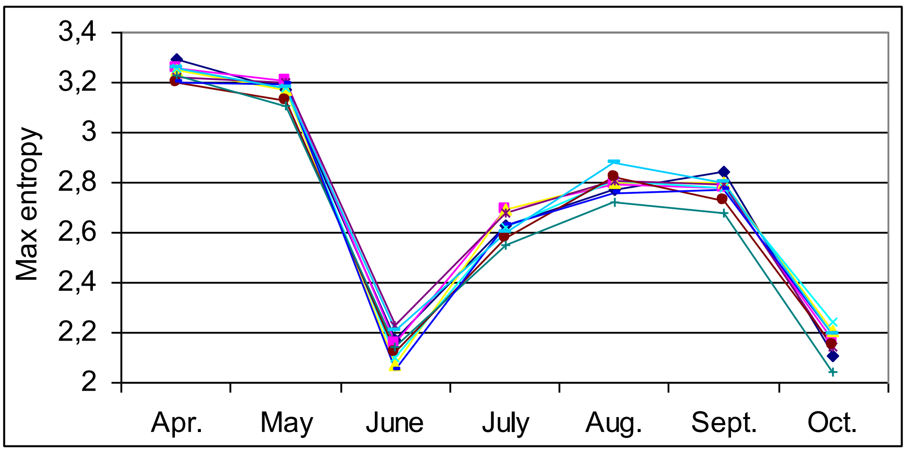

Fig. 1. Dynamic curves (from April to October) of maximal entropy H_m of time series of all GDV-gram parameters for N18.

The value of deviation of curves one from another in fig.1 is located within the limits of mean square deviation of H_m functions of particular GDV-grams from H_m average value for every parameter. This fact indicates that function H_m is a robust characteristic of the investigated GDV image, i.e. it does not depend on the parameter used for the numeralization of this image. Hence, we can consider the dynamics of H_m, not specifying the parameter according to which it was calculated; i.e. H_m entropy is invariant relative to the choice of parameter for its calculation. At the same time, the figure demonstrates that H_m value can significantly change from month to month, i.e. entropy carries some information on the changes of state of the investigated object, taking place in time intervals of several months.

The comparison of dynamic curves of maximal entropy H_m for different polar explorers enabled to reveal the following general characteristic in the dynamics of H_m. Entropy of 18 from 20 polar explorers is minimal in June, from which 12 persons have global minimum and the rest 6 – local. Fig.2 and 3 represent a typical dynamics of H_m entropy with global minimum in June (for polar explorer N 6; fig. 2) and local minimum in June (for polar explorer N3; fig. 3).

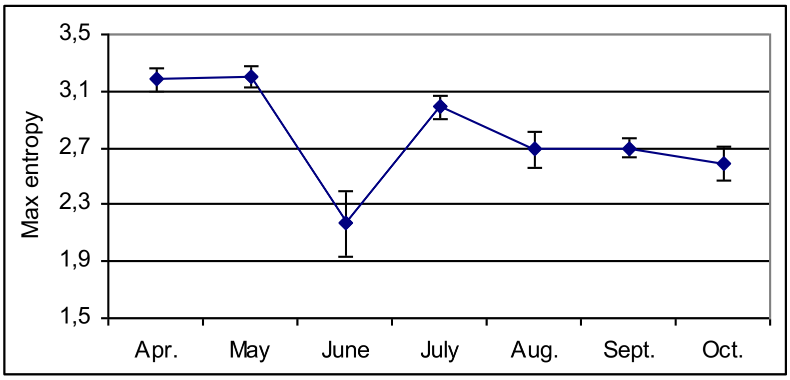

Fig. 2. The dynamics of maximal entropy H_m for N6. Values of entropy for every month are shown in the curve together with the mean square deviation. In June H_m undergoes global minimum.

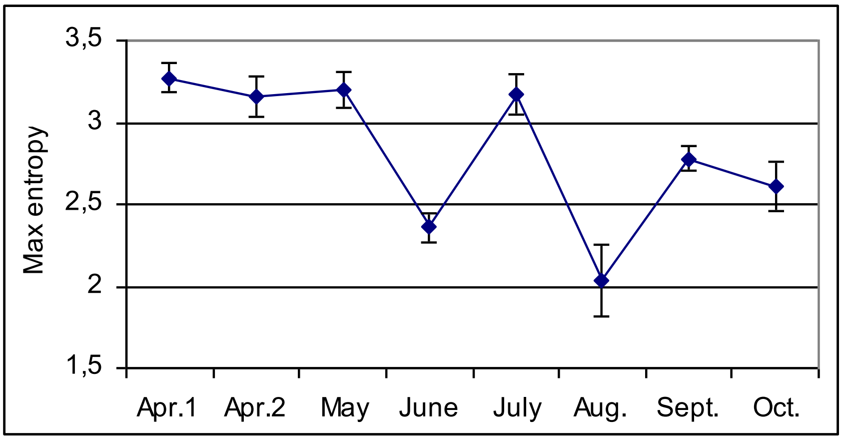

Fig. 3. The dynamics of maximal entropy H_m for N3. Values of entropy for every month are shown in the curve together with the mean square deviation. The first two values correspond to the two measurements carried out in different days in April. In June H_m undergoes global minimum.

The "law of minimum" in June for maximal entropy has exceptions for polar explorers N11 and N16. Fig. 4 and 5 demonstrate the behavior of H_m for the given participants of the expedition.

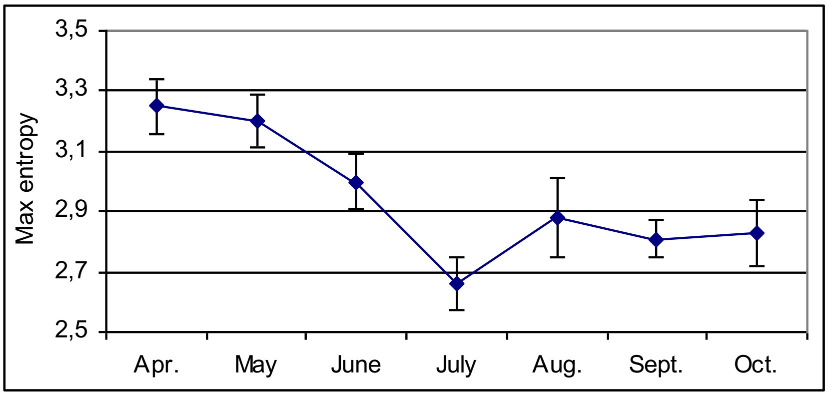

Fig. 4. The dynamics of maximal entropy H_m for N11.

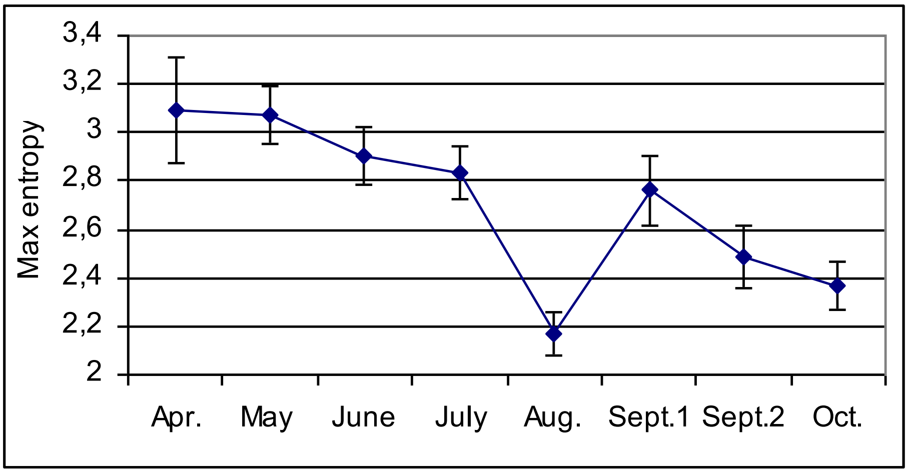

Fig. 5. The dynamics of maximal entropy H_m for N16.

These figures demonstrate that for polar explorers N 11 and N16 the entropy decreases almost monotonely in the first months of expedition, too, but it reaches its minimum later — in July for N11 and in August for N16.

Two periods of time — before June and after June — are clearly distinguished one from another in the dynamics of average values of three parameters: background area, average radius of image isoline and length of isoline. Average values of these parameters show abrupt jump in June for all polar explorers. Typical dynamics of the average value of background area is represented in fig.6. (for N6). It is apparent that maximal change of value of the parameter takes place in June.

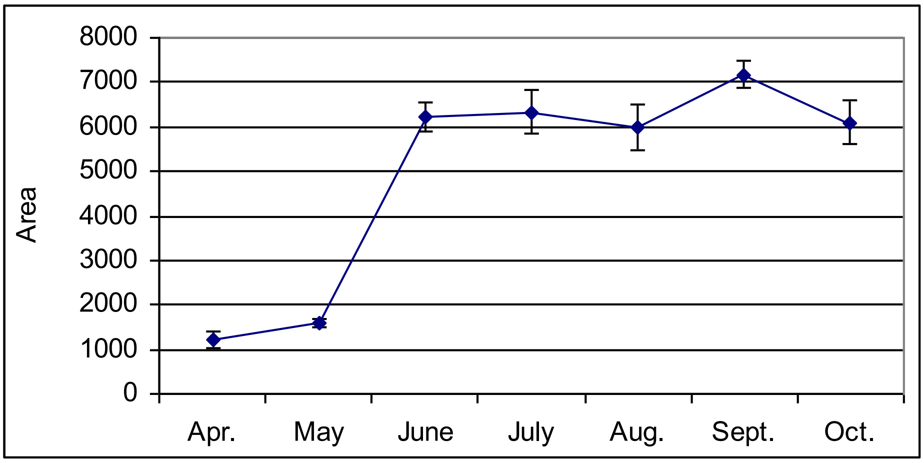

Fig. 6. The dynamics of average value of background area for N6.

Interpretation of results and conclusions

During a first few months at the arctic station the participants of the expedition passed the stage of adaptation to the conditions and environment. The given adaptation period was characterized by a decreased level of working capacity and other behavioral characteristics of polar explorers. The end of adaptation period came approximately in June and was accompanied and, to a certain extent, determined by the polar night, when persons as if isolated themselves and accepted environmental conditions. Thus, the period of adaptation was quite a long and clear time interval.

The results described above enable us to assume that there is correlation between the adaptation period of polar explorers and the characteristics of dynamics of H_m entropy and GDV-gram parameters. The validity of such a supposition in the case of entropy (1) is determined by two facts: (a) function H_m is a robust characteristic of the state of polar explorer, as it doesn't depend on the method of numeralization of GDV-images (see fig. 1); (b) function H_m is quite variable on time intervals of several months and its behavior in the first months (during adaptation period) has a common character for all polar explorers. The latter condition might mean that during the period of adaptation the entropy characterizes some factors in the dynamics of organism's state, which are common for all polar explorers. To our mind, the most probable candidate for the part of this factor is the adaptation syndrome.

The end of adaptation period in June is characterized by the minimum (local or global) of maximal entropy for 90% of polar explorers. In June polar nights begin, which, apparently, effect the common behavior of entropy this month. For other 10% the entropy decreases monotonely in the first months, reaching the minimum 1 or 2 months later. That is probably concerned with the fact that the adaptation period of these polar explorers is longer than that of the others. Taking into account the informational meaning of the notion of entropy, we can interpret the minimum of function H_m as the state of maximal stress. In this regard, it is quite logical that, as a rule, the entropy reaches its maximum in the very first month (see fig. 1–5), when the expedition only begins and the polar explorer hasn't yet "forgotten" the continent. This value almost doesn't repeat further during the expedition, i.e. stress is a constant attendant of a polar explorer in the course of expedition.

June is connected with the biggest jump of average values of the three parameters (background area, average radius of image isoline and length of isoline), and that relates to all of the considered participants of the expedition. However, one shall be careful in connecting this fact with the end of adaptation period, as the mentioned jumps take place in June for polar explorers N 11 and 16; entropy reaches its minimum for them in July and August. Owing to the described robustness, the entropy is a more reliable characteristic in the given case.

This analysis enables to maintain a possibility of interpretation of maximal entropy H_m as a criterion of adaptation of the participants of expedition. Possible application of the obtained results consists in a more precise estimation of length of the adaptation syndrome of a polar explorer. For this purpose it is sufficient to calculate the dynamics of entropy of GDV images in more detail (for a big amount of days) and find the moment when the entropy reaches the first minimum. The given moment (day, week) might be considered the end of adaptation period and, respectively, might serve as a start for the increase of loads in the work of a polar explorer. For the purpose of control and a more objective estimation of the adaptation process, calculation of jumps of average values of the described three GDV-gram parameters might also be used.

It is worth mentioning that the accepted method of determination of the current psycho-physiological state (CMS) does not allow solving the task of identifying the length of the adaptation period. The CMS research of polar explorers during seven months (from April to October) of the expedition showed that the CMS data practically didn't change during this time.

The presence of global minimums of H_m entropy for polar explorers N11 and N16 not in June, but in July and August, respectively, probably means that the period of adaptation for these participants exceeded usual 3 months. That, in its turn, indicates that the length of adaptation period is quite unique for every participant. Particularly, possible adaptation anomalies, such as prolonged adaptation syndrome, can be disclosed with the help of the described above technique of entropy control. The presence of such anomalies can refer to the problems of organism functioning, and, thus, the described entropy estimates can be used in diagnostic purposes.

In conclusion, it is worth mentioning that the described results have rather a preliminary character, and their interpretation shall be considered as a scientific hypothesis. There is no doubt that further research shall be conducted for a more detailed analysis. Specifically, detail comparison of prognosis on the basis of values of entropy (1) and parameters of GDV-grams with various biophysiological parameters might become the next logical step.

Reference

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2. Korotkov K., Krizhanovsky E., Borisova M. The technique of investigation of objects by means of dynamic GDV-graphy // Science, Information, Spirit: proceedings of V Intern. Congress, St. Petersburg, July 10-12, 2001 – SPb.: SPbSIFMO, 2001. – p. 83-84