UDC 577.3:612.017.2(211)

BIORHYTHMIC ASPECTS OF INTERCONTINENTAL ANTARCTIC ADAPTATION

Frunze IZVESTIYA AKADEMII NAUK KIRGIZSKOY SSR in Russian No 2, Mar-Apr 86 (manuscript received 14 Nov 85) pp 35-39

[Article by A.L. Maksimov and T.B. Chernook: "Biorhythmic Aspects of Intercontinental Antarctic Adaptation"]

[Text] Biorhythmic research today has been making increasing use of adaptation to a new environmental habitat to study ecological-physiological mechanisms [1, 2].

Many works have been devoted to the study of the functioning of various physiological systems under Antarctic conditions, including attempts made to study the effect of the polar day and night on the biorhythms of polar research workers at both coastal and intercontinental stations [3,4].

The biorhythmic examinations made of polar research workers at the high-altitude Antarctic Vostok station (3488 M) are of great interest from the standpoint of evaluating adaptation conditions. We know that adaptation to a height in the range of 3500 M under the conditions of Pamir and Tyan-Shan occurs in several stages, and moreover, the stable phase of the adaptation is mainly formed by the 45th day [5]. Considering the high extremality of the conditions of the intercontinental Vostok station (hypoxia, geomagnetic fluctuations, the polar night, extreme dryness of the air, etc.), it may be assumed that polar research workers, in order to achieve a relatively stable adaptability, require a considerably longer time than 1 1/2 months. By the middle of the winter period, stabilization of the physiological function response may be expected, making it possible for the organism to live and work without stressing the adaptational mechanisms. Important information on the adaptation potentials of an organism can be obtained by studying the cyclic recurrence of the physiological processes [6, 7], which exist at all organizational levels of living organisms and make it possible to seek ways to predict and correct the disturbances arising with the effect of unfavorable factors on the organism [8]. At the same time, the most significant point in the biorhythmic investigation is the fact that the disturbance in the circadian rhythm of the organism can be adequately judged from the change in the physiological parameters of the organism without additional functional loads. This makes the study most valuable under extremal environmental conditions, when the organism is already experiencing a highly stressful effect and each additional functional load can induce dysadaptation phenomena against the background of exhaustion of physiological reserves.

In order to clarify the question of whether a stable adaptation phase occurs in polar research workers after 6 months of wintering at a polar station under conditions of Antarctic high altitude, as well as to evaluate the rearrangement in the structure of the biorhythmic status, we carried out a comparative study of the circadian rhythm of a number of functional indicators in a person before the Antarctic wintering period and after half of the sojourn under the conditions of the high-altitude Vostok station.

The work was carried out at the Vostok station during the 27th SAE [Soviet Antarctic Expedition]. Seventeen polar research winterers were studied. Background studies had been made of the same persons at the start of the Black Sea voyage (14 persons) and there was no background examination of the three persons who had arrived in Antarctica by air. The indicators were recorded at 0700, 1100, 1500, 2300 and 0300 local time. Each one tested in the 24-hour check took part one time. The body temperature was recorded sublingually by means of an electric TPM thermometer, the pulse rate was counted by a cardiogram and a saliva sample was collected, in which the sodium and potassium content was determined by the flame photometry method, using a Tseysov photometer [9]. The check time in each temporal period was not over 5 minutes. The data was processed by a Kosinor* analysis [10].

In the morning background studies, the pulse rate (PR) was 68±2 beats/min, and then a marked rise toward 1500 hrs (79±2 beats/min) was observed, with a subsequent reduction by nighttime. The group was characterized by quite uniform indicators. The Kosinor analysis revealed a 24-hour rhythm with the following parameters: oscillation amplitude equal to 5.94 beats/min and an acrophase occurring at 1500 hours (Fig. 1). The same trend in shifts was retained in the background studies related to temperature. The nighttime reduction in it was replaced by a daytime rise. Its maximum temperature was reached at 1900 hours (Fig. 2). The 24-hour temperature range reached 0.8°C (35.9-36.7). A 24-hour rhythm with an oscillation amplitude equal to 0.2°C and an acrophase occurring at 1624 hours were revealed.

A study of the biorhythms of the salival content of sodium and potassium, the indicators of vegetative homeostasis [11] established the fact that in the background studies the highest values were noted in the evening and at night. A 24-hour and 12-hour rhythm for sodium, with amplitudes of 5.22 and 5.4 m-equiv/l were revealed, as well as acrophases occuring at 0410 and 0418 hours respectively, and a 24-hour rhythm of potassium removal with an amplitude of 3.16 m-equiv/l and an acrophase equal to 5 hrs 24 min (see table).

In the middle of the winter period, occurring during the polar night, another picture was revealed with respect to biorhythms for all the indicators studied, which lay in a displacement of the circadian rhythm in the direction of ultradianal components. For example, the greatest PR value occurred at 0300 (81±3 beats/min), and at the same time there was no uniform reduction (in the evening and at night) or uniform rise (daytime) of the indicator, as was

*Kosinor: Editor--cosine analysis?

characteristic for the background studies. In addition, the dispersion range of the indicator increased (43÷280), which points to a great nonuniformity in the response in the group examined in the course of the 24-hour period. The 24-hour rhythm proved to be statistically negligible and at the same time its acrophase was shifted in the nighttime (0030 hours) and a considerable damping of the amplitude was noted (2.39 beats/min). If one takes into consideration the fact that the amplitude of the oscillations serves as a "measure of the resistance of the oscillator to external effects" [1], the decrease in the amplitude of the oscillations and such a sharp shift in the acrophase in the earlier period indicates the considerable stress experienced by the polar research workers' organisms in this period. An autospectral analysis showed that a considerable part of the general dispersion of the process is concentrated at the ultradianal frequencies, and given the statistically known 12-hour rhythm, the value of the average level of pulse rate changes (it increases to 75 as opposed to 63 beats/min), as do the oscillation phases, which fall during the nighttime hours (0142 hours). The shift of the 24-hour rhythm to 12-hour ones and the displacement of the acrophase from daytime to nighttime (Fig. 1) indicate a considerable discrepancy in the levels of the heart activity and the activity of the organism.

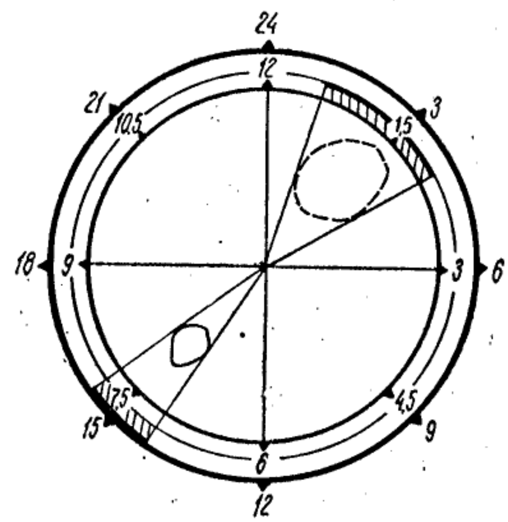

Fig. 1. Kosinors of the diurnal pulse rhythms.

The solid line indicates the ellipse of error for background studies (24-hour rhythm); the dotted line is for study in the polar night (12-hour rhythm).

The 24-hour physiological rhythms were usually synchronized by geophysical and social transducers which have a 24-hour period and a stationary phase-amplitude structure. Free-flow rhythms are ordinarily observed in those examined under conditions of insulation from the external time transducers. Catching the endogenous oscillator rhythm, particularly with a social transducer, often leads to inner desynchronization of the rhythms, when the circadian rhythms of different functions have a varying width of the catching window, for example, the temperature rhythm at first goes out from control of the "inducer" [1]. In this case the 24-hour rhythm of the physiological functions undergoes profound rearrangement, leading to the person's chronophysiological adaptation to the new environment and a change in the phase-amplitude structure of the circadian rhythms. In our opinion, this is precisely what happens in the middle of the winter period which falls within polar night in the Antarctic. This assumption was confirmed in studying the biorhythms for all the indicators studied by us. As can be seen from Fig. 2, the 24-hour temperature range in the period studied was much less (0.3°C) and there were no statistically significant 12- and 24-hour rhythms. In the opinion of N.I. Moiseyeva [8], in basically healthy persons, well adapted to the change in environmental conditions, a great range of values is noted in the constant in the course of the 24-hour period, as is a relative stability in the structure of the curves. In persons who have adapted poorly, the curves reflecting the dynamics of the same function differ considerably. There is less variation in the values in the course of the 24-hour period for them. On the prognostic plane, the appearance of a "plateau" (blood thickening) and a shift in the maximum and minimum of the indicators is evidence of an unfavorable trend in the adaptation process. Consequently, the temperature indicator in our studies attests to considerable stress on the adaptation mechanisms in polar research workers in mid-winter.

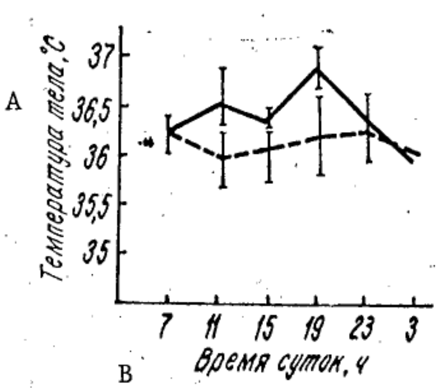

Fig. 2. Diurnal Rhythm of Body Temperature

The solid line indicates the diurnal rhythm of the body temperature in background studies; the dotted line--in the middle of the polar night. The confidence interval is indicated for $p < 0.05$.

A--body temperature, in °C
B--time of day, in hours

A study of the biorhythms of the sodium excretion from the saliva in the polar night showed an increase in the spread of the indicators and their nonuniformity, as compared with the background studies. At the same time, the rhythm was noted as a 12-hour one. The acrophase occurred at 2 hrs 36 min (Table 1), which was 1 hour and 42 minutes less than in the control studies, i.e., again, as for the other indicators, in mid-winter there was a stimulation of the ultradianal rhythm, and even in the absence of statistically significant rhythms, a spectral analysis showed the presence of well marked peaks from the ultradianal rates.

The coinciding of the sodium minimum in the saliva with the maximum cardial activity attests to the activation of the sympathoadrenal system occurring during the time awake, despite the absence of a natural daylight factor [11, 12]. In our studies the background indicators of sodium in the saliva also have the highest value at night, but during the polar winter the minimal values of sodium in the saliva, combined with a high level of cardial activity, occur in the period of nighttime rest. This change in the interrelation of the indicators is the result of a considerable rearrangement on the part of the vegetative functions of the organism.

Table

Results of the Kosinor Analysis of Diurnal Rhythms in the Sodium and Potassium Excretion From Saliva in Polar Researchers at the Vostok Station, 27 SAE

Parameters	Sodium in saliva, m-equiv/1		Potassium in saliva, m-equiv/1	
	24 hr	12 hr	24 hr	12 hr
		Background Studies		
Level	15.59	15.59	23.61	--
Amplitude	4.02≤5.22≤6.42	1.91≤4.15≤6.39	0.10≤3.61≤7.12	
Acrophase	3.8≤5.4≤7.2	3.0≤4.3≤5.3	3.0≤5.4≤8.3	
		Studies in Polar Night		
Level	--	14.7	--	23.07
Amplitude		0.15≤3.61≤6.08		1.40≤5.57≤9.74
Acrophase		1.2≤2.6≤4.0		1.7≤2.5≤3.6

Excretion of potassium from the saliva, in contrast to all the other indicators, in the period analyzed differed in the large spread of values in the course of the 24-hour period (dispersion 34÷142). In contrast to the background of the mid-winter 24-hour rhythm, it is transformed to a 12-hour one, with an oscillation amplitude equal to 5.57 m-equiv/1 and an acrophase--2 hrs 30 min. The marked rise in oscillation amplitude (5.57 as against 3.61) also reflects the presence of a stress reaction [7]. The mechanism of increasing the amplitude of the initial oscillations of S.I. Stepanova[2] is applicable due to the activation of the discharge and reestablishment of the energy and plastic resources of the redirection of the organism's functional systems.

Thus, in mid-winter, the amplitude of the curves of the pulse, temperature and sodium is markedly concentrated, in contrast to the potassium, where there is reverse tendency. Evidently, we observe here a double-unit phenomenon reflecting the stressed state of the organism. Only with the marked increase in amplitude does the process go along the path of stress of the physiological functions operating at a higher level, and with a decrease--along the path of exhausting the functional reserves. In the first instance the phenomenon is more favorable for the organism, since with a sufficient breadth of physiological reserves there is a compensation of the process, except at a new regulation level. In the second instance the process is connected with inadequate expenditure and reduction of the energy and plastic resources, which also characterizes the phenomenon of exhaustion reflected in the damping of the amplitudes.

The studies made make it possible to draw the following conclusions:

In mid-winter, falling during the polar night, considerable changes were noted in the biorhythmic indicators with respect to the periodic organization and pulse-amplitude characterisitics;

In this period there was an inversion in the rhythm of the pulse rate, ultradianal phenomena consisting of a circadian rhythm appeared, and at the same time a maximum in the rate of the cardiac contractions occurring at nighttime coincided with a minimum retention of sodium in the saliva, which attested to the activation of the sympathoadrenal system during nighttime rest;

No statistically significant 24- and 12-hour rhythms were revealed with respect to the temperature indicator and, at the same time, a considerable flattening of the diurnal curve of the body temperature occurred;

The potassium and sodium excretion from the saliva was characterized by a great value spread during the 24-hour period and the appearance of ultradianal rhythm with the 12-hour period;

The above statements make it possible to conclude that after a 6-month stay at the Vostok station, no stable adaptation phase was found in the polar research workers of the 27th SAE, which was evidently the result of the extreme wintering conditions.

BIBLIOGRAPHY

1. Ashoff, Yu. and Viver, R., "The Human Circadian System," in the book: "Biologicheskiye ritmy" [Biological Rhythms], Moscow, Mir, 1984, p 362.

2. Stepanova, S.I., "Stress and Biological Rhythms," KOSM. BIOLOGIYA I AVIAKOSM. MEDITSINA, No 1, 1982, pp 16-20.

3. Deryapa, N.R., Moshkin, M.P. and Posnyy V.S., "Problemy meditsinskoy bioritmologii" [Problems of Medical Biorhythmology], Moscow, Meditsina, 1985, 206 pages.

4. Panin, L. Ye. and Sokolov, V.P., "Psikhosomaticheskiye vzaimootnosheniya pri khronicheskom emotsionalnom napryazhenii" [Psychomatic Interrelations Under Chronic Emotional Stress], Moscow, Nauka, 1981, p 167.

5. Mirrakhimov, M.M., Aydaraliyev, A.A. and Maksimov, A.L., "Prognosticheskiye aspekti trudovoy deyatelnosti v usloviyakh vysokogorya" [Prognostic Aspects of Work Activity Under High-Altitude Conditions], Frunze, Ilim, 1983, 161 pages.

6. Katinas, G.S., "Biologicheskiye ritmy i ikh znacheniye dlya cheloveka" [Biological Rhythms and Their Significance for Man], Leningrad, Znaniye, 1978, 15 pages.

7. Sorokin, A.A., "Ultradiannyye sostavlyayushchiye pri izuchenii sutochnogo ritma" [Ultradianal Components in Studying Diurnal Rhythm], Frunze, Ilim, 1981, p 52.

8. Moiseyeva, N.I. and Sysuyev, V.M., "Vremennaya sreda i biologicheskiye ritmy" [A Temporary Environment and Biological Rhythms], Leningrad, Nauka, 1985, 125 pages.

9. Rummel, A.G. and Bazhenova, A.F., "A Method of Determining Sodium, Potassium and Chlorine in Biological Fluids and Tissues," in the book: "Kortikosteroidnaya regulyatsiya vodno-solevogo gomeostaza" [Corticosteroid Regulation of Water-Saline Homeostasis], Novosibirsk, Nauka, 1967, pp 234-243.

10. Yeroshenko, V.Sh. and Sorokin, A.A., "A Package of Applied Programs for Kosinor-Analysis and Methodological Instructions For Its Use. Algorithms and Programs. Informational Bulletin, " GFAP SSSR, No 5, (37), 70, 1980, p 38.

11. Bayevskiy, R.M., "The Problem of Predicting Man's Situation Under the Conditions of Space Flight," FIZIOL ZHURN. SSSR IM. I.M. SECHENOV, Vol 56, No 6, 1972, p 819.

12. Krivoshchekov, S.G., "The Rhythmic Conjunction of Sodium Excretion from the Saliva and the Cardiac Contraction Rate in Human Acclimatization," in the book, "Tsirkadnyye ritmy cheloveka i zhivotnykh" [The Circadian Rhythms of Man and Animals] Frunze, Ilim, 1975, pp 176-181.

12151
CSO: 1840/1282