EFFECT OF REORGANIZATION OF THE DAILY PROGRAM ON THE DIURNAL RHYTHM OF GLYCOGEN IN HUMAN BLOOD NEUTROPHILS

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On investigation of the diurnal rhythm of the glycogen content in circulating blood neutrophils of eight healthy men, a minimum was found at 7:30 A.M. and at 7:30 P.M. and a maximum at 1:30 P.M. and 11:30 P.M. Changes in the customary daily routine consequent upon a sudden change of geographic zone (during a flight from Moscow to Khabarovsk and back) led to distortion of the diurnal rhythm of intracellular glycogen metabolism and to a shift of the rhythm in time. The diurnal rhythm of the glycogen content in the circulating blood neutrophils returned to normal within a few days.

Periodic activity of about 40 functions is exhibited in the human body [3, 11-13]. The existence of a rhythm of carbohydrate metabolism (blood sugar, liver glycogen) has been demonstrated by several workers in animals and man during the 24-h period and it has been shown to be dependent upon periodicity in the function of the autonomic nervous system and endocrine glands – pituitary and adrenal cortex [4, 8].

With developments in aviation and space research an urgent need has developed for an examination of the problem of reorganization of the diurnal rhythms of physiological functions in association with sudden changes of geographic zone. Reorganization of daily routines, programs of work and rest, and so on, are used in research to study the reactivity of the body and its compensatory and adaptive mechanisms [2, 5-7].

The object of this investigation was to study the diurnal rhythm of glycogen metabolism in the blood neutrophils allowing for changes in the rhythm of the glycogen content associated with changes in climatic and temporal parameters. It has been shown that the glycogen content in the blood neutrophils reflects the state of carbohydrate metabolism in the body and is under the control of the vago-insular system and the sympathico-adrenal system.

EXPERIMENTAL METHOD

Glycogen was investigated in circulating blood films by Shabadash's method [9, 10] in eight healthy men aged 24-30 years performing physical work. The investigation was carried out for 3 days from 7:30 A.M. until 11:30 P.M. at intervals of 3 h. All the subjects took their meals at the normal times. At each test 200 cells were counted twice in each of the three preparations (400 cells). Depending on their degree of staining the cells were divided into four conventional groups: 1) neutrophils with a high glycogen content, stained pinkish-violet (+++), 2) cells with an average glycogen content, stained bright pink (++), 3) cells with a low glycogen content, stained pale pink (+), and 4) neutrophils not containing glycogen (0). In each group the percentage of cells was calculated. The results were subjected to statistical analysis and the level of significance was P = 0.99.

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TABLE 1. Average Number of Neutrophils with Different Glycogen Contents (wt. %) per Day

Time of day (in hours and minutes)	Conventional groups of neutrophils (acc. to color)			
	0	+	++	+++
7.30	1,0±0,57	11,8±2,2	67,4±1,5	19,8±1,7
10.30	0,7±0,52	7,0±2,0	66,5±1,7	25,8±1,8
13.30	0,3±0,25	3,7±1,3	64,0±2,2	32,0±2,1
16.30	0,8±0,5	6,2±1,5	63,5±1,6	29,5±1,8
19.30	1,8±1,0	11,4±2,1	64,0±2,2	22,8±1,6
23.30	0,4±0,34	6,2±1,6	63,0±1,8	30,4±2,0

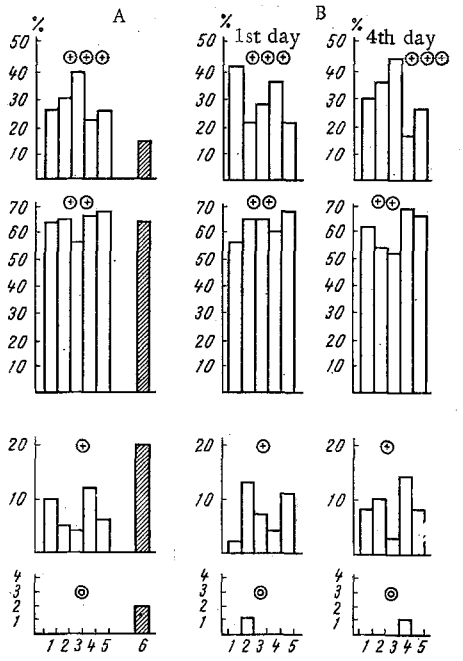

Fig. 1. Histograms of changes in diurnal rhythm of glycogen concentration in circulating blood neutrophils of subject K during a flight from Moscow to Khabarovsk and back. A) Initial period; B) recovery period. Abscissa: 1, 2, 3, 4, 5) Nos. of blood samples taken every 4 h from 7 A.M.; 6) blood test immediately after return from Khabarovsk; ordinate – number of neutrophils (in percent) with different glycogen content. (For explanation of legend, see text).

EXPERIMENTAL RESULTS

The mean data for the diurnal rhythm in the number of neutrophils with different glycogen contents in the eight subjects for a period of 3 days are given in Table 1. They show that during the 24-h period the rhythm of the glycogen content corresponds to a curve with two maxima (at 2 P.M. and midnight) and with minima at 7:30 A.M. and 7:30 P.M. These results are in agreement with data in the literature for the diurnal rhythms of functions of the autonomic nervous system.

The process of reorganization of the diurnal rhythm of the glycogen content was investigated in nine persons aged 24–43 years. Changes in the mode of life were produced in some subjects by a flight from Moscow to Khabarovsk and back, and in other subjects by artificially reversing the times of sleeping and waking (sleeping during the day and waking at night). Blood was investigated in the preliminary period (before reorganization), and also on the 1st and 4th days of the recovery period. At the time of their return from Khabarovsk a decrease in the glycogen content in the neutrophils was found in all four subjects. In two subjects there was an almost sevenfold decrease in the number of cells rich in glycogen (+++), while there were ten times more cells poor in glycogen (+) than at the same time of day in the period before the flights; in the other two subjects the corresponding differences were a fourfold decrease in the number of cells rich in glycogen and a sevenfold increase in the number of cells poor in glycogen.

On the 1st day of the recovery period the diurnal rhythm was opposite in character to that in the original period before the investigation began, while the curve of the diurnal rhythm was shifted in time. In the writer's opinion this shift corresponded to the diurnal rhythm which had existed in Khabarovsk and it was not restored to normal during the 1st day after the subjects' return even though their life was geared to Moscow conditions. By the 4th day of the recovery period the diurnal rhythm of glycogen in the neutrophils of all the subjects was similar in character to that in the preliminary period, with differences only in the absolute values. After 4 days complete recovery of the initial rhythm of intracellular metabolism was still not observed. Graphs of the reorganization of subject K's diurnal rhythm are shown in Figs. 1 and 2. No complete analogy was found between the processes of adaptation of intracellular metabolism in the subjects undertaking the flight or in the group with reversal of sleep and waking, probably because of differences in the experimental conditions.

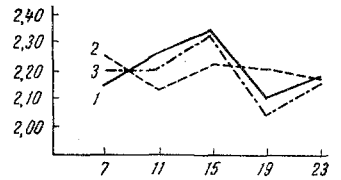

Fig. 2. Dynamics of histochemical coefficient of glycogen content in blood neutrophils (after Astaldi) in subject K during a flight from Moscow to Khabarovsk and back. Ordinate, glycogen content in neutrophils; abscissa, time of day (in hours); 1) preliminary investigation; 2) 1st day after flight; 3) 4th day after flight.

The results showing changes in the diurnal rhythm of the glycogen content in the blood neutrophils in response to reorganization of the normal daily routine of the subjects can thus be explained by the activity of homeostatic regulatory mechanisms. Because of the high sensitivity of the index used, it is suitable for investigation of reactivity of the body and of compensatory and adaptive reactions.

LITERATURE CITED

1. É. S. Alekseentseva, Fluctuations in the Blood-Sugar Level under Normal Conditions and during Exposure to Various Factors, Doctoral Dissertation, Khar'kov (1946).
2. R. M. Baevskii, G. A. Nikulina, et al., in: Proceedings of a Symposium on Biological Rhythms and Problems in the Development of Work and Rest Programs [in Russian], Moscow (1967), p. 14.
3. K. M. Bykov and A. D. Slonim, in: The Study of Regulation of Physiological Functions under Natural Conditions of Existence of Organisms [in Russian], Leningrad (1949), p. 5.
4. V. V. Koval'skii and I. A. Pleteneva, Dokl. Akad. Nauk SSSR, Nov. Seriya, 56, No. 8, 835 (1947).
5. M. I. Kuksova, Zh. Obshch. Biol., 20, No. 1, 73 (1959).
6. M. A. Matova, in: Proceedings of a Symposium on Biological Rhythms and the Development of Work and Rest Programs [in Russian], Moscow (1967), p. 20.
7. G. K. Mikushkin, Kosmich. Biol. i Med., No. 1, 32 (1969).
8. M. I. Mishnaevskii, in: Collected Scientific Transactions of Rostov-on-Don Medical Institute, Book 14 [in Russian], Rostov-on-Don (1960), p. 323.
9. L. L. Shabadash, Dokl. Akad. Nauk SSSR, 68, No. 2, 389 (1949).
10. L. L. Shabadash, The Histochemical Investigation of Glycogen in the Normal Nervous System [in Russian], Moscow (1949), p. 19.
11. O. P. Shcherbakova, The Study of the Regulation of Physiological Functions [in Russian], Leningrad (1949), p. 16.
12. I. Aschoff, in: Verhandlungen der 4-ter Konferenz der Internationalen Gesellschaft für Biologische Rhythmus-Forschung, Stockholm (1955), p. 50.
13. E. Bünning, Physiological Clock, Academic Press (1964).