# MORPHOLOGY AND PATHOMORPHOLOGY

## BIOLOGICAL RHYTHMS OF TISSUE BASOPHILS OF THE RAT DURA MATER DURING EXPOSURE TO NOISE AND VIBRATION

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Biological rhythms are among the most important mechanisms regulating the functions of the body. They are found at all levels of organization of living systems — from the cell to the organ [2, 8]. It is generally considered that a biological rhythm is a sufficiently stable oscillatory process, leading to the reproduction of a biological phenomenon at equal time intervals. However, there is also another point of view, according to which biorhythms are closely connected with the modifying action of external environmental factors and play an important role in processes of adaptation [1, 8].

The aim of this investigation was to study the effect of exposure to noise and vibration (ENV) on the biorhythmologic characteristics of the tissue basophils (TB) of the dura mater (DM), for these cells, which have a stable circadian rhythm of functional activity, are a convenient model with which to study biorhythmologic processes at the cellular level [4, 10].

### EXPERIMENTAL METHOD

Experiments were carried out on 108 mature noninbred albino rats weighing 170-180 g during the time of the autumnal equinox (September 22-24). Material was taken every 2 h for 3 days, the animals having previously been exposed for 15 min to ENV on the FD201A apparatus. The maximal noise level was 90 dB and vibration 50 Hz, the outline having an amplitude of 0.8 mm. A group of animals not exposed to noise and vibration served as the control. The control and experimental rats were kept under identical animal house conditions. DM was removed immediately after decapitation of the rats. TB were demonstrated with a 0.5% solution of methylene blue. Functional activity of TB was judged on the basis of their absolute number, their concentration per square millimeter in the frontal, parietal, and occipital regions of DM, and the ratio between the numbers of intact and degranulated (3 degrees of activity) TB [6, 9, 10]. The relative number of moderately degranulated cells was studied quantitatively by mathematical methods of analysis of biorhythmologic data on the SM 7209 computer, using the "Skazka-3" program [5].

### EXPERIMENTAL RESULTS

Irrespective of the region studied, TB in the rat DM lie along the course of blood vessels or without any visible connection with them, they are round, oval, or fusiform in shape, and measure from 9 to 20 $\mu$. Depending on their functional activity, four types of TB are distinguished: 1) conventionally intact, 2) weakly degranulating, 3) moderately degranulating, and 4) actively degranulating, with massive release of granules [10]. The shape of the TB is closely linked with their functional state. Round, intact TB with regular outlines lengthen if their functional activity increases, to become fusiform or to change into a cloud of granules. It is important to note that, all other conditions being the same, marked ($p < 0.05$) local differences in the number of TB in DM were observed in the mature rats (Fig. 1a). TB in the frontal region of DM were larger ($p < 0.01$) than in the parietal and occipital regions. The numerical density of TB in the parietal region did not differ significantly from that in the occipital region ($p > 0.05$). Judging by the number of degranulated cells, activity of TB in the frontal region was significantly higher ($p < 0.001$) than activity of the corresponding cells in other regions of DM, in both the control and the experimental series (Fig. 1b).

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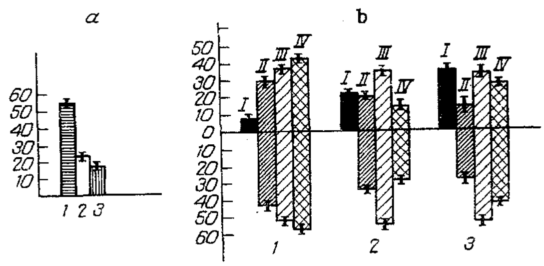


Fig. 1. Local differences in metric parameters (in per cent) of TB in rat DM: a) numerical density of TB in different regions of DM in mature rats. 1) frontal, 2) parietal, 3) occipital region; b) difference in numerical density of different types of TB in frontal (1), parietal (2), and occipital (3) regions of DM in control (above) and after ENV (below). I) intact TB, II) weakly degranulated TB, III) moderately degranulated TB, IV) actively degranulated TB. Values of parameters in frontal region of DM of rats at 6 a.m. taken as 100%.

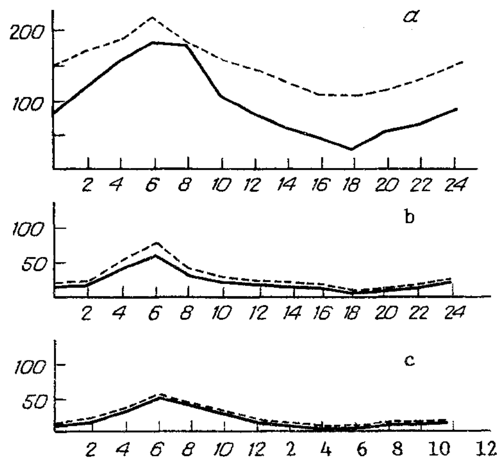


Fig. 2. Circadian rhythm of activity of degranulating TB in frontal (a), parietal (b), and occipital (c) regions of rat DM in control and after ENV. Continuous line, control; broken line, experiment (after ENV). Abscissa, clock time; ordinate, mean number of TB in DM.

The results of our investigations of the rhythm of TB in the rat DM are summarized in Fig. 2. The period of oscillations of the rhythm of TB function in the regions studied in both experimental and control animals was close to 24 h, evidence of the stability of the circadian organization of these cells. Meanwhile the absolute number of TB in the experimental rats showed significant changes in all regions of DM (Fig. 2a, b, c), and this was the case also with the chief characteristics of the biological rhythm of TB in DM: power of the harmonic, mesor, amplitude, and acrophase. Mathematical analysis of the data showed that after ENV their values rose sharply, but under these circumstances the local differences in the TB rhythm, as established for the control group, remained unchanged. The frontal region was significantly more active in this respect, for under normal conditions and also under the influence of ENV, several characteristics of the biological rhythm of TB in that region predominated over the other regions. For example, in the frontal region of DM in the control animals the mesor was 91.7, whereas in the parietal and occipital regions it was 18.7 and 19.6 respectively. In the experimental rats it increased to 151.2 in the frontal and 24.3 and 21.5 in the parietal and occipital regions of the dura respectively. The amplitude of oscillations of the rhythm of TB in DM after ENV was increased by 1.5 times in the frontal region, 1.3 times in the parietal, and 1.1 times in the occipital region. Since changes in the amplitude of the oscillations and mesor indicate flexibility of the system in response to extremal influences (the

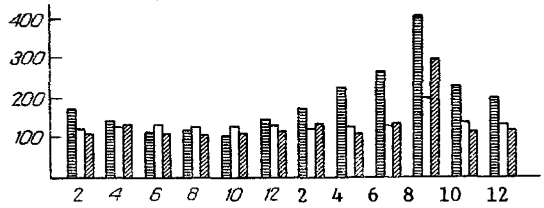


Fig. 3. Relative change in number of TB in frontal (horizontally shaded columns), parietal (unshaded columns), and occipital (vertically shaded columns) regions of DM after ENV for 24 h. Abscissa, clock time; ordinate, number of TB (in per cent). Values of parameters in corresponding regions of DM in animals of control group taken as 100%.

higher their values the greater the flexibility of the system [7]), in our experiments the system of TB of DM in the frontal region possessed the greatest flexibility.

The acrophase, i.e., the time of the peak value of the absolute number of TB during the 24-hour period, was increased after ENV by more than 10 degrees. Whereas in the regions of DM studied in the control rats it was 96.3 degrees in the experimental animals it was 85.5, corresponding to the wave at about 6 a.m. (Fig. 2). Reduction of the acrophase in this case points to an earlier time of maximal TB activity after ENV.

Stability of the rhythm characterizes its ability to preserve the circadian pattern after exposure to stress. The period of oscillation of the rhythm of TB activity in DM was found to change (but not significantly) after ENV, but whereas in the frontal and occipital regions the change amounted to 0.1 h, in the parietal region it was 0.3 h. In other words, TB was least stable in the parietal region of DM.

It is important to note that the number of TB and, consequently, their functional activity, depends on the time of exposure to noise and vibration (Fig. 3). The greatest changes in TB after ENV were observed at 6 p.m. and the least at 8 a.m. Changes in the value of the parameters were more marked in the frontal region than in the other regions of DM (Fig. 2a).

It can thus be concluded from these investigations that, first, TB have an intrinsic rhythm of functional activity in each region of DM, with the least stable rhythm in the parietal region, second, that ENV modifies the internal structure of biorhythms of TB in DM, i.e., biorhythms with endogenous nature [3], but nevertheless closely connected with external environmental factors and, in particular, with ENV, and third, the greatest deviations in the parameters studied under the influence of ENV are observed in the frontal region of DM at 6 p.m. and the least deviations at 8 a.m.

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