Role of the Epiphysis in Organization of the Infradian Rhythmicity of Physiological Systems

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In 330 control and epiphysectomized rats divided into groups (each included 15 rats), we compared the dynamics of the following indices: temperature and mass of the body, daily volume of urine, activities of succinate and \( \alpha \)-glycerophosphate dehydrogenases in lymphocytes, activity of peroxidase in blood neutrophils, and motor activity in the open field test. In control rats, a set of infradian rhythms was manifested, and their periods were about 26; 18; 13.5; 9; 7; and 3.5 days. In epiphysectomized rats the same set of the periods was observed, but the spectral density of and phase relations between the rhythms were considerably modified. We conclude that the role of the epiphysis in organization of the infradian rhythmicity of physiological processes is significant, but it plays a rhythm-organizing, but not a pacemaker, role. Epiphysectomy results in considerable desynchronization of the studied processes.

INTRODUCTION

During recent years, study of the complicated neuroendocrine organ, the epiphysis, has significantly intensified. According to the early concepts, the epiphysis, besides the metabolism of pigments, controls only the processes related to reproduction, fitting different physiological processes to a photoperiod duration. Now these concepts have been significantly modified. The epiphysis was shown to be involved in the control of a number of various physiological processes [1, 2]; this fact is to a considerable extent based on the existence of mutual connections of the epiphysis with various brain structures and endocrine glands. By exerting a complex influence on the state of the hypothalamo-hypophyseo-suprarenal system, the epiphysis interacts with different endocrine organs including the gonads, and thyroid, pancreatic, and suprarenal glands; it should be mentioned that intensification of the epiphysal functions exerts mostly restraining, inhibitory influences on these organs [3-5]. The involvement of the epiphysis in the control of behavior, emotional states, and the waking–sleep cycle was emphasized in many publications [6]. These epiphysal functions provide fitting of the processes of adaptation to changes in the environment and limiting of stress-related phenomena. Due to these properties the epiphysis is considered a component of the stress-limiting system [7], a conclusion supported by morphological data [8].

More and more information is being accumulated that shows an extremely important role of the epiphysis and its main hormone, melatonin, in the development of immune reactions [9]. Concepts supposing an oncostatic effect of this hormone also have been proposed [10-13].

Results of some studies indicate the existence of magnetoreceptive functions of the epiphysis: it responds to the influence of electromagnetic fields (EMF) by a decrease in the nocturnal peak of the melatonin level or by a shift of the acrophase of its circadian rhythm [14].

Considering the above data, new investigations on the role of the epiphysis in temporal organization of physiological functions deserve attention. The role of this structure in organization of the circadian and seasonal rhythms is well known. Now it is widely accepted that the spectrum of parameters of physiological functions within a sufficiently extensive range of the periods should be considered a most adequate characteristic of the temporal organization of these functions [15]. Infradian rhythms represent one of the most significant components of such a spectrum. The role of the epiphysis in organization of the processes with a multi-day cyclicity remains very scarcely studied. This
is why we attempted to discover the role of the epiphysis in providing the multi-day (infradian) rhyth-
mics of a few physiological systems.

METHODS

In the studies of physiology of the epiphysis several experimental approaches have been used. Among them are peripheral denervation and extirpation of the supe-
rior cervical ganglion, keeping of the animals under conditions of constant illumination, influence of EMF with various parameters, pharmacological blockade of β-adrenoreceptors, experiments with cell cultures, im-
itiation of an epiphyseal hyperfunction by injections of the extracts of the structure, etc. Yet, epiphysectomy remains the most reliable technique, because in this case the number of uncontrolled and accompanying factors considerably decreases.

Our experiments were carried out on 330 male albino rats weighing 180-220 g. For the experiments, we selected animals of a similar age, with a medium level of the motor activity and low level of emotional reactions in the open field test (OFT); this selection allowed us to form rather homogeneous animal groups.

Two equivalent groups (each including 15 animals) were formed for each separate type of the experiments: one group included control rats, while epiphysectomy was performed in the rats of another group. Both groups were kept under standard vivarium conditions, with a 12/12 h illumination/darkness cycle. In the animals of both groups everyday measurements of the following indices were performed over 35-45 days: volume of urine, temperature and mass of the body, activities of succinate and α-glycerophosphate dehydrogenases (SDH and GPDH, respectively) in lymphocytes, activity of peroxidase in neutrophils [18, 19], and indices of behavior in the OFT. Blood samples were taken from the v. caudalis. The measurements, blood sampling, and observations of the OFT activity were performed within similar time intervals (within 9.00 and 10.30 each day).

Epiphysectomy was performed with the use of a standard technique under sodium thiopental anesthesia (30 mg/kg). The experiments were begun not earlier than after a 30-day-long interval after epiphysectomy; the adequacy of the latter was verified postexperiment-
ally.

Power spectra of variations of the studied indices were evaluated with the use of Fourier’s transforma-
tions; amplitude/phase characteristics were calculated using cosinor-analysis. These approaches now are con-
sidered the most adequate for characterizing the temporal organization of the processes in the systems with different levels of complexity [15].

RESULTS

Spectral analysis allowed us to identify a certain set of infradian rhythms in the intact animals. Their periods equaled approximately 26; 18; 13.5; 9; 7; and 3.5 days. Rhythm oscillations of such durations in the activity of different physiological systems were reported earlier by other authors [15, 21]. The amplitude/phase parameters of the above oscillations demonstrated certain specificity, related to the type of a parameter, and clear mutual dependence. It is obvious that the phase characteristics of the identified rhythms are of the greatest interest because an integral organism can exist only at certain phase relations of different oscillation processes at all levels: this is a necessary condition for the maintenance of homeostasis [22]. A high level of coincidence of the phases was observed in the intact animals for the phases of rhythms of the SDH and α-GPDH activities in lymphocytes. This finding probably shows that different stages of oxidation-reduction processes are highly correlated in space and time.

Analysis of the dynamics of the mean activity of dehydrogenases, body mass, body temperature, and

Fig. 1. Power spectra of the horizontal motor activity in the open field tests of epiphysectomized (A) and control (B) rats. Abscissa) Duration of a period, days; ordinate) spectral power, arbitrary units. Limits of the mean ± 3σ range are shown.