CHANGES IN THE RELATIONSHIP BETWEEN CORTICAL POLARIZATION IN RABBITS AND THE STATE OF SLEEP OR WAKING DURING ONTOGENESIS

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Changes in the steady cortical potential are compared with changes in cortical electrical activity dependent on the state of sleep and waking in young rabbits during ontogenesis. A correlation is found between the formation of the sleep — waking EEG in ontogenesis and changes in the steady cortical potential during modification of the current physiological state. A statistically significant positive shift of the steady potential in a state of sleep begins to be recorded in rabbits after the 8th-9th day of life, coinciding with the critical period of ontogenesis and the appearance of slow high-amplitude electrical activity in the cortex, which was absent at an earlier age.

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Previous investigations showed that in animals born immature (dogs, rabbits), the frequency-amplitude characteristics of cortical electrical activity specific for the state of sleep and waking in adults are still absent at an early age [1, 2].

The object of the present investigation was to assess changes in cortical polarization and its approximate level in rabbits of different age groups in states of sleep and waking.

EXPERIMENTAL METHOD

Changes in the cortical steady potential (SP) were investigated under chronic experimental conditions. Ordinary nonpolarizing Zn — $ZnSO_4$ electrodes made up as a semi-airtight organic glass capsule were used. The capsules were inserted into ring clips, one of which was fixed on the head at the projection of the sensorimotor cortex, the other to the patella. Because of the design of the electrodes they could be quickly removed to test the zero recording.

To record the SP a method of discrete recording of a constant voltage [5] combined with a "Kaiser" ink-writing electroencephalograph was used. The SP tracing consists of short pulses corresponding in amplitude to the voltage fed into the input of the voltage transformer. The polarity of the recording was determined in each experiment by applying a voltage of definite sign to the input of the transformer so that an upward deviation represented negativity and a downward positivity. The SP was recorded through the skin and cranial bones, so that it was impossible to obtain absolute values of the SP, but merely to determine their changes during sleep and waking.

EXPERIMENTAL RESULTS

Depending on the results obtained, the experimental animals could be divided into three age groups: group 1 from 1 to 7-8 days, group 2 from 8-9 to 20-22 days, and group 3 from 22-23 days to 1-1.5 months. It is in these age groups, according to previous observations [2], that the most important transformations take place in the sleep — waking electrical activity of the cortex.

In the older rabbits, starting from the age of 22-23 days, the change from a state of active waking (a state of alertness) to a resting state or to light barbiturate sleep (nembutal, 10-15 mg/kg body weight, subcutaneously) was accompanied by changes in the EEG rhythm typical of the adult animal. Under these circumstances the SP shifted toward positivity by 2.04 ± 0.29 mV (Table 1; Fig. 1, curve 3).

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TABLE 1. Changes in Cortical Steady Potential in Rabbits of Different Ages in States of Waking and Sleep (M ± t)

Age group	No. of animals	State	Magnitude of SP	P
1 (1 to 7-8 days)	11	Waking	−0.87 ± 0.36	> 0.1
		Sleep	−0.37 ± 0.18	
2 (8-9 to 22-23 days)	12	Waking	−2.00 ± 0.28	< 0.01
		Sleep	−0.80 ± 0.23	
3 (22-23 days to 1.5 months)	9	Waking	−1.80 ± 0.24	< 0.001
		Sleep	+0.24 ± 0.08	

Note: Age shown in parentheses.

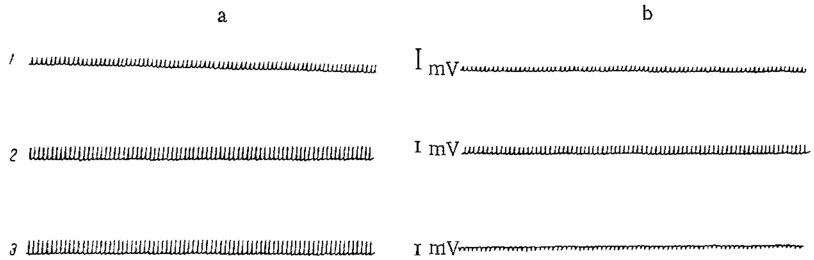

Fig. 1. Changes in steady potentials in rabbits of different ages depending on the state of waking (a) and sleep (b). 1) Rabbit aged 6 days; 2) 15 days; 3) 30 days. Upward deviation indicates negativity, downward deviation, positivity.

In the youngest rabbits (under 7-8 days old) no such changes were found. As previously shown [2], at this age differences in the sleep and waking patterns characteristic of adults are not yet present on the EEG. During waking and sleep, a low-amplitude and comparatively low-frequency activity of similar type was recorded on the EEG. Nevertheless, at this early age changes in SP depending on the state of sleep and waking were recorded (Fig. 1, curve 2). Just as in the previous investigations, a state of natural sleep was induced in these young animals by keeping them, after they had fed, at a temperature corresponding to the thermoindifferent zone [3]. Motor activity associated with application of the electrodes to the rabbit or a change in environmental temperature was taken to imply a waking state. Under these conditions, the positive shift in SP on going to sleep was 0.5 ± 0.04 mV.

After the age of 8-9 days the positive shift of SP in the rabbits during sleep (1.2 ± 0.16 mV) was more than doubled compared with its value at the earlier age (Fig. 1, curve 1). According to results obtained previously [2], the increase in positive shift coincided with the appearance of slow and spindle-shaped waves in the anterior regions of the cortex, becoming most marked after 13-15 days.

Differences in SP recorded during sleep and in a waking state were significant only in the rabbits of groups 2 and 3. In the youngest animals these differences were not significant (Table 1). This table also shows that the positive shift of SP in a state of sleep increased with age. Comparison of groups 1 and 2 shows that the increase in SP was statistically significant.

The results show that during postnatal ontogenesis, after a certain critical period of development, parameters characteristic of the anabolic sleep of adults began to be recorded: slow high-amplitude and spindle-shaped electrical activity appeared in the anterior regions of the cortex, combined with cortical hyperpolarization.

This critical period of development is marked in the rabbits of age group 2 by the commencing function of the visual and auditory receptors, formation of the posture of weight-bearing on the limbs, and the beginning of reorganization of the sleep—waking cycle to the adult type. Later, after the age of 22-23 days, in connection with the increased motor activity in the waking state (leaving the nest) the sleep—waking cycle assumed a 24-h rhythm. At this same age, according to data obtained in the writers' laboratory, the characteristically adult cortical — subcortical mechanisms of activation and inhibition begin to function. Electrical activity in all parts of the cortex, during both sleep and waking, came to resemble that of adults. Cortical hyperpolarization in a state of sleep increased still further.

The relationship discovered between the increase in cortical polarization during sleep and the level of physiological activity in the waking state agrees with the results of previous work carried out in this laboratory, and also with results obtained by Lobashev and Savvateev [4], who state that in mammals, sleep with what they term a "compensatory" character appears at those stages of phylogenesis when high functional activity is found in the waking state.

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