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Failure of medial forebrain bundle or raphe ablation to alter the daily temperature rhythm of the rat

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Summary. The data presented in the present study suggest that neither the ascending noradrenergic fibres confined to the MFB nor the serotonergic fibres originating in or passing through the mesencephalic raphe are essential for periodicity in body temperature. Both control and experimental groups, i.e., rats subjected to medial forebrain bundle or raphe ablation presented circadian periodicity in body temperature and neither the phase, amplitude or overall mean of experimentals differed significantly from controls.

During the last several years considerable attention has been focused on identifying the central neural sites and/or systems involved in rhythmic neuroendocrine function and associated activity. Frequently implicated areas have been the suprachiasmatic nuclei and the ascending monaminergic systems. Circadian rhythmicity in locomotor activity[1], drinking[1], pineal N-acetyltransferase activity[2] and adrenal corticosterone content[2] have been reported to be abolished after ablation of the rodent suprachiasmatic nuclei. Similarly, the ascending serotonergic fibres have been implicated in a variety of rhythmic neuroendocrine activities. Serotonergic neurons have been reported to participate in the regulation of sleep[3,4] motor activity[5] eating[6] pituitary-adrenal activity[7,8] and LH secretion[9].

Recently we confirmed the earlier report of Moore and Eichler[2] that the 24-h periodicity in pituitary-adrenal function is lost after suprachiasmatic nuclei ablation but we were unable to corroborate a previous report that circadian periodicity in body temperature is dependent upon intact suprachiasmatic nuclei[10]. Rather we observed a 24-h periodicity in body temperature which was not different from that of controls[11].

The above observation, taken with the several reports of monaminergic involvement in biorhythmic phenomena resulted in our focusing on the ascending monaminergic fibres as possible neural systems involved in maintenance of the daily rhythm in body temperature. The present report describes the effect of medial forebrain bundle (MFB) or mesencephalic raphe nuclei (RN) ablation on body temperature. These areas were chosen since they encompass the majority of the ascending noradrenergic fibres or represent the primary origin of the ascending serotonergic system.

Materials and methods. Adult female Sprague-Dawley rats (Charles River, CD) weighing approximately 185 g at surgery were used in this study. Prior to surgery, rats housed 2 per cage, were acclimated for 10 days to conditions of controlled lighting (fluorescent illumination from 04.00 h to 18.00 h) and temperature (26±1 °C). Food and water were available ad libitum.

MFB and RN ablation, carried out under pentobarbital anesthesia, was accomplished using a Kopf Radio Frequency Lesion Generator and accompanying probe positioned according to the stereotoxic coordinates of de Groot[12]. After surgery rats were housed in individual cages. Intact rats served as controls. To familiarize rats to handling and to assess reproductive cyclicity vaginal smears were taken 5 days a week beginning 20 days prior to temperature determination.

80 days after central neural ablation, body temperature was measured every 4 h over a 48-h period using a YSI Tele-Thermometer equipped with a rectal probe. To standardize the protocol the probe was inserted 15–17 mm through the rectum, and recordings were made 20 sec after insertion of the probe.

At autopsy brains of lesioned rats were removed, fixed in formalin and subsequently prepared for histological evaluation of the ablated area. Only rats presenting complete ablation of the MFB and RN are included in this report. Statistics were derived from analysis of variance.

Results. As evidenced in figures 1 and 2, circadian periodicity in body temperature occurred in MFB ($F=5.21$,

df = 12/104, $p < 0.01$) and RN ($F = 3.58$, df = 12/65, $p < 0.01$) animals as well as controls ($F = 3.25$, df = 12/91, $p < 0.01$). Body temperature was highest in all groups during the dark phase of the light-dark schedule and lowest during the early part of the light phase; the difference between peak and trough temperatures was significant ($p < 0.01$) in all cases. The overall mean temperature of MFB (36.0±0.1 °C) and RN (35.7±0.1 °C) groups did not differ ($p > 0.05$) from intact control (35.9±0.1 °C) animals.

At autopsy experimental rats presented gross appearances markedly different from controls as well as from each other. MFB rats were well-groomed but frankly obese ($p < 0.01$ compared to controls) whereas RN rats weighed less than MFB ($p < 0.01$) but not controls and appeared poorly groomed. RN as well as MFB rats showed evidence of vaginal cyclicity. However, the cycles of RN rats tended to be irregular and longer than those of MFB and control animals particularly during the first 30–50 days post-surgery.

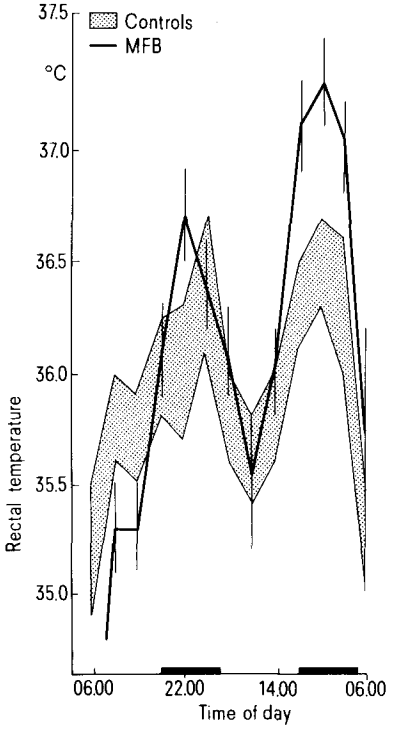

Fig. 1. Comparison of the circadian patterns of daily body temperature of intact control and medial forebrain bundle (MFB) ablated female rats. The stippled area illustrates the range encompassed by the SE of controls. The continuous line indicates the mean temperature of MFB ablated rats, vertical lines indicate SE. The horizontal black bars indicate periods of darkness.

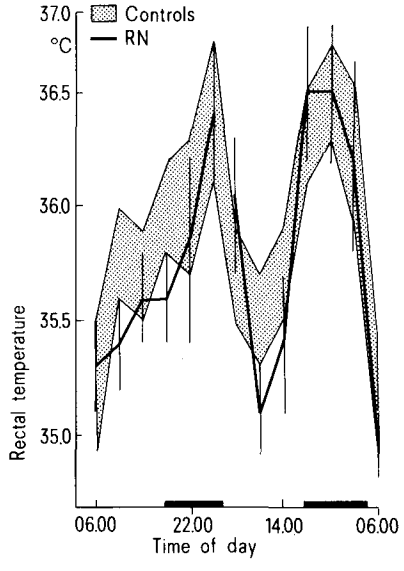

Fig. 2. Comparison of the circadian patterns of daily body temperature of intact control and raphe nuclei (RN) ablated female rats.

Discussion. The rhythmic parameters - phase, amplitude and 24-h mean - observed for controls are consistent with those previously reported from this[11] as well as other laboratories[13,14]. Highest temperatures occurred during the lights-off phase of the light-dark cycle, i.e., during the period of greatest activity.

Similar parameters were observed for experimentals. That is, the phase, amplitude and 24-h mean of MFB and RN rats were not different from those of controls. MFB rats showed a higher peak than either controls or RN rats during the 2nd 24-h period of the study, but the overall experimental mean was not different from controls.

Inasmuch as all animals included in this study presented complete ablation of the MFB or RN, spared tissue could not account for the presence of periodicity in body temperature. Rather, the data indicate that neither the ascending noradrenergic fibres confined to the MFB nor the serotonergic fibres originating in or passing through the mesencephalic raphe are essential for periodicity in body temperature.

We previously reported that ablation of the suprachiasmatic nuclei was compatible with circadian periodicity in body temperature[11] but that such lesions abolished circadian variation in serum corticosterone levels[15]. Although not reported in this study, serum blood samples from MFB but not RN animals showed 24-h periodicity in serum corticosterone levels (unpublished observation); raphe ablation disrupted the 24-h rhythm in serum corticosterone. Thus, these 2 well-established rhythms, body temperature and blood corticosteroids are not coupled in an obligatory way and can be disassociated. Additionally, it appears that the 24-h periodicity in body temperature is not dependent upon circadian periodicity in the sleep-awake cycle or the resultant activity cycle. Although not monitored in the present study, evidence exists which indicates that raphe lesions disrupt the sleep-awake cycle[16].

Collectively, these observations are of considerable interest since body temperature generally is thought to reflect variations in skeletal muscle activity, assimulation of food and indirectly endocrine activity. However, as indicated by the observations above, circadian periodicity in body temperature is not dependent upon periodicity in activity, assimulation of food or pituitary-adrenal function.

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