EFFECT OF 5-HYDROXYTRYPTOPHAN ON SHIVERING THERMOGENESIS

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Active heating of susliks on emerging from hibernation is closely linked with the intensification of shivering thermogenesis. Intraperitoneal injection of 5-hydroxytryptophan (a serotonin precursor) into susliks reduces shivering thermogenesis markedly in the awakening animals and delays their rewarming.

KEY WORDS: shivering thermogenesis; 5-hydroxytryptophan; serotonin; hibernation.

The authors of the hypothesis that biogenic amines participate in the regulation of body temperature [5] considered that serotonin raises it. However, after injection of serotonin or its precursor, 5-hydroxytryptophan, a fall of body temperature was found in rats [9], mice [3], rabbits [6], sheep [4], and golden hamsters [7]. 5-Hydroxytryptophan sharply inhibits the rewarming of susliks on awakening from hibernation [1]. The mechanism of action of serotonin and its precursor on temperature regulation remains unexplained.

The object of this investigation was to study the effect of 5-hydroxytryptophan on shivering thermogenesis of susliks awakening from hibernation.

EXPERIMENTAL METHOD

Experiments were carried out on male red-cheeked susliks (Citellus major erythrogenius Brandt). In the fall the animals fell into hibernation under near-natural conditions at a temperature of 3-3.5°C. Emergence from hibernation was studied in April, when the animals were moved into a room with a temperature of 20-22°C. During awakening of the susliks the electrical activity of the cervical portion of the trapezius muscle, the longissimus dorsi, and the tibialis anterior muscles and the body temperature were recorded every 15 min. The EMG was recorded with wire electrodes which pierced the muscles to be tested. The level of the EMG was estimated by means of integrators and expressed as effective values of amplitude (μV_{eff}). The body temperature was measured by an ordinary or electric thermometer inserted into the rectum to a depth of 8 cm. The beginning of active rewarming of the suslik was determined by measuring the cadaveric temperature of a suslik killed in a state of hibernation. 5-Hydroxytryptophan was injected intraperitoneally in a dose of 50 mg/kg immediately after the initial measurements.

EXPERIMENTAL RESULTS AND DISCUSSION

The initial body temperature of the animals was about 4°C. Temperature curves of the control susliks, of animals receiving 5-hydroxytryptophan, and of the dead suslik coincided during the first 30 min after removal into the warm room. After the temperature of the living susliks had reached 11-12°C it rose more rapidly than the temperature of the dead animal. It was evidently then that the mechanisms of thermogenesis were activated and a process of active heating began. The body temperature of the control animals

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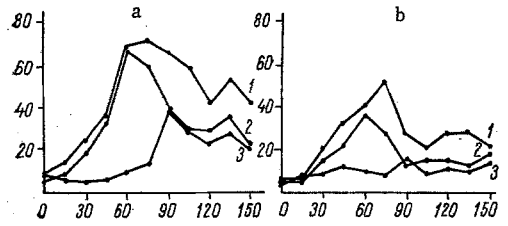

Fig. 1. Electrical activity of muscles of susliks during awakening: a) control susliks; b) susliks receiving 5-hydroxytryptophan; 1) longissimus dorsi, 2) trapezius, 3) tibialis anterior muscles. Abscissa, time after beginning of rewarming (in min); ordinate, electrical activity of muscles (in μV_{eff}).

reached 36.8 ± 0.71°C 135 min after the beginning of rewarming, and thereafter it remained unchanged.

5-Hydroxytryptophan caused definite slowing of rewarming of the awakening susliks. The inhibitory effect began to appear after 75 min, and by the end of rewarming of the control animals the body temperature of the susliks receiving 5-hydroxytryptophan had reached only 29.1 ± 0.58°C. Their subsequent rewarming ceased after 3-5 h.

By the 45th minute, i.e., the beginning of active rewarming, the integral amplitude of the EMG of the cervical and dorsal muscles had increased considerably (Fig. 1). Maximal values of the EMG of the control animals were observed between 60 and 90 min. This was also the time of the fastest increase in the body temperature.

Contractile activity of the muscles, especially of those most concerned with chemical temperature regulation (the trapezius and longissimus dorsi muscles) was reduced by the action of 5-hydroxytryptophan to two thirds of its level in the control animals ($P < 0.05$).

The results are in harmony with information showing the hypothermic action of serotonin and 5-hydroxytryptophan on nonhibernating animals [3-6] and they confirm the view that serotonin is a factor contributing to the loss of heat by the body [8]. However, serotonin evidently acts not only on the center for heat loss, as was hitherto considered, but also on heat production, for it inhibits shivering thermogenesis.

LITERATURE CITED

1. N. K. Popova, Dokl. Akad. Nauk SSSR, 210, 496 (1973).
2. A. D. Slonim, The Ecological Physiology of Animals [in Russian], Moscow (1971).
3. J. Borofsky and A. Feldstein, Experientia, 26, 990 (1970).
4. J. Bligh, J. Physiol. (London), 185, 46 (1966).
5. W. Feldberg and R. Myers, J. Physiol. (London), 173, 226 (1964).
6. J. Jacob, J. Girault, and R. Peindaries, Neuropharmacology, 11, 1 (1972).
7. L. Jansky, M. Lehouckova, S. Vybiral, et al., Physiol. Bohemoslov., 22, 115 (1973).
8. W. Reid, L. Volicer, H. Smookler, et al., Pharmacology, 1, 329 (1968).
9. J. Schmidt and C. Fähse, Acta Biol. Med. Germ., 13, 607 (1964).