EFFECT OF HEAT AND COLD FACTORS ON AMYLOLYTIC AND INVERTASE ACTIVITY OF THE SMALL INTESTINE IN GROWING RATS

K. R. Rakhimov and B. A. Sadykov

UDC 612.65'332.2.014.43

Acute experiments on young rats showed that exposure to heat (40-41°C) and cold (5-6°C) and injections of ACTH (4 units/100 g body weight per injection) during the first week of life led to a sharp decrease in total amylolytic and invertase activity of homogenates and everted segments of the small intestine of the animals. The inhibition of intestinal function continued throughout the next 2 weeks of life.

KEY WORDS: intestine; enzyme spectrum; exposure to heat; hydrolytic function; stress.

Exposure of breast-fed animals to heat sharply modifies the enzyme activity of their intestinal mucosa, and this could be one cause of the increased frequency of noninfectious diseases of the gastrointestinal tract during the hot summer [1-4]. It appeared interesting to study whether these changes are specific purely for heat and how long they last after removal of the causative factor.

To study these problems the total amylolytic (due to pancreatic α-amylase and intestinal γ-amylase) and invertase activity of homogenates and everted segments of the small intestine was determined simultaneously in rats from the seventh to the 90th day of life under normal conditions and after exposure to heat, to cold, and to injections of ACTH during the first half of the breast-feeding period.

EXPERIMENTAL METHOD

Experiments were carried out on 210 young rats of both sexes (eight young to each lactating female during the first 21-23 days of life), which were subsequently fed on an ordinary mixed diet. The young rats of the

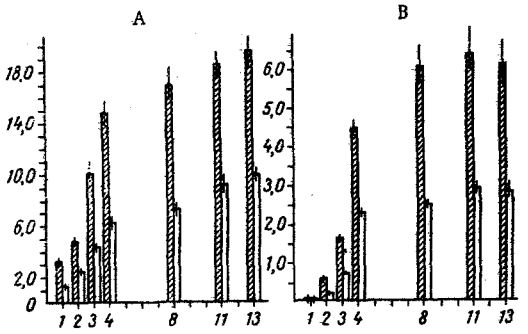

Fig. 1. Amylolytic (A) and invertase (B) activity of homogenized (shaded columns) and everted (unshaded columns) segments of small intestine of growing rats. Abscissa, age of animals (in weeks; M ± m); ordinate, activity of enzymes (in μ-moles reducing substances/g/min).

Laboratory of the Physiology of Digestion, Institute of Physiology, Academy of Sciences of the Uzbek SSR, Tashkent. (Presented by Academician V. N. Chernigovskii.) Translated from Byulleten' Éksperimental'noi Biologii i Meditsiny, Vol. 82, No. 10, pp. 1213-1215, October, 1976. Original article submitted January 12, 1976.

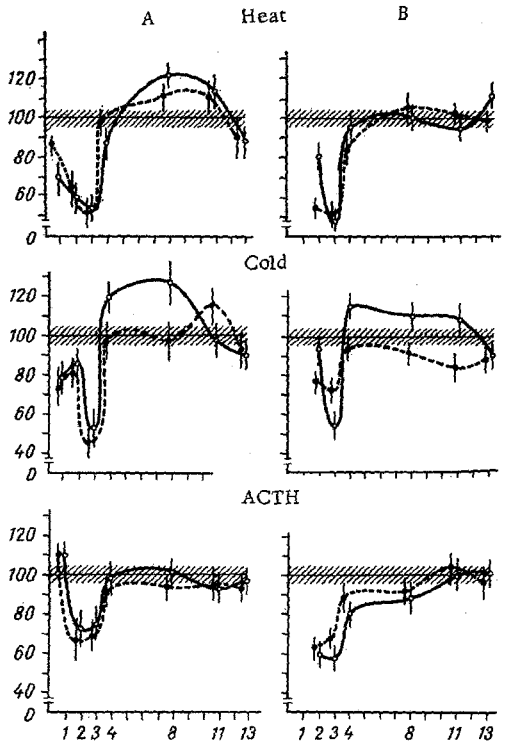

Fig. 2. Amylolytic (A) and invertase (B) activity of homogenized (broken line) and everted (continuous line) segments of small intestine of rats exposed daily during first week of life to heat, cold, or ACTH injection. Ordinate, activity of enzymes (in % of control). Remainder of legend as in Fig. 1.

three experimental groups were exposed daily from the first to the seventh day of life for 2 h to the action either of heat (ambient temperature 40-41°C) or cold (5-6°C) or they were given ACTH injections (4 units/100 g body weight per injection). The young rats of the fourth (control) group were taken from their mothers for 2 h daily and kept for that period at a temperature close to that in the cage with the lactating female (32-34°C). The young rats of group 5 received injections of physiological saline equal in volume to those of ACTH. On the seventh day of the experiment the procedures were stopped and the animals of all groups were kept under identical conditions. After 1, 2, 3, 4, 8, 11, and 13 weeks of life six young rats from each group were killed and the amylolytic and invertase activity of homogenates and everted segments of the proximal, middle, and distal portions of their small intestine were determined by photometric methods [6]. Enzyme activity was expressed in micromoles reducing substances formed per gram wet weight of tissue. The enzymic activity of the homogenates was used as an indicator of the total reserves of enzymes in the enterocytes or of protein synthesis, whereas the activity of the everted segment was used as an indicator of the digestive function of the contact systems of the small intestine [5]. Averaged results for all three portions of the intestine are given.

EXPERIMENTAL RESULTS

In the control animals of all age groups both the amylolytic and the invertase activity were greater in the homogenates of the intestine than in its everted segments. After the age of 3 weeks, i.e., when the young rats changed to definite feeding, the activity of these enzymes rose sharply to reach a maximum by the 13th week of life (Fig. 1).

In the animals exposed to heat (Fig. 2) the amylolytic activity of both intestinal preparations was much lower than in the control; this difference increased progressively until the end of the third week of life, despite termination of the exposures to heat. By the fourth week the enzymic activity had increased almost to the control level, but later some increase in the amylolytic activity of the everted segments took place although the content of the enzyme in the homogenates was comparatively constant. Normal enzyme activity was restored by the end of the experiment. Approximately the same picture was observed for invertase.

Exposures to cold (Fig. 2) led to similar changes in amylolytic and invertase activity of the preparations of small intestine, the only difference being that the increase in enzymic activity of the everted segments in the middle of the experiment was less marked than in the animals exposed to heat.

In the animals exposed both to heat and to cold a marked decrease was thus observed in the rates of protein synthesis of enzymes (homogenates) and of their translocation to the outer surface of the cell membranes (everted segments). This decrease occurred not only immediately after the end of exposure, but also for some considerable time thereafter. The nonspecific character of these changes suggests that they are manifestations of the general adaptation syndrome and that they arise through the intermediary of the pituitary–adrenal system. This hypothesis is confirmed by the similarity between the effect of ACTH and that of heat or cold (Fig. 2). Such differences as were found were evidently not differences in principle.

The results agree with observations of other workers who found that exposure to stress factors during the early period of postnatal development leaves a lasting impression on the rates of functional development of the individual organs and of the organism as a whole [7, 8].

LITERATURE CITED

1. K. R. Rakhimov, B. Zaripov, D. V. Inogamova, et al., in: Contact Digestion. Theoretical and Applied Aspects (proceedings of a symposium) [in Russian], Riga (1973), pp. 91-94.
2. K. R. Rakhimov and B. A. Sadykov, in: Enzyme Secretory Activity of the Digestive Gland and Its Regulation (proceedings of an all-union conference) [in Russian], Tashkent (1974), pp. 230-232.
3. K. R. Rakhimov and B. A. Sadykov, Dokl. Akad. Nauk Uzbek. SSR, No. 3, 62 (1974).
4. K. R. Rakhimov and B. A. Sadykov, Zh. Evol. Biokhim. Fiziol., No. 3, 313 (1975).
5. A. M. Ugolev, Contact Digestion. Polysubstrate Processes, Organization and Regulation [in Russian], Leningrad (1972).
6. A. M. Ugolev, N. N. Iezuitova, et al., Investigation of the Digestive Apparatus in Man [in Russian], Leningrad (1969), pp. 192-196.
7. N. E. Chittoni, J. Neurochem., 21, 983 (1973).
8. S. Samuels, Proc. Soc. Exp. Biol. (New York), 143, 1215 (1973).