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DEPENDENCE OF THE ENZYME-SECRETORY ACTIVITY OF DIGESTIVE GLANDS AND ENZYMATIC HOMEOSTASIS IN RATS ON ENVIRONMENTAL FACTORS

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Abstract

Any emotional, physical, or chemical stimulus may disrupt the state of dynamic equilibrium in which an organism normally exists. This initiates a complex set of adaptive reactions aimed at adjusting the organism to altered environmental conditions and preventing disturbances in the composition and properties of the internal environment. Homeostasis, developed and consolidated during evolution, enables organisms to adapt to changing environmental factors. During adaptation, physiological systems may undergo functional restructuring, with activation of some regulatory mechanisms and inhibition of others.

Among the environmental factors requiring physiological adaptation are changes in ambient temperature and solar radiation. The present study was designed to investigate the enzyme-secretory activity of digestive glands and enzymatic homeostasis in rats exposed to different ambient temperatures and solar insolation.

Materials and Methods

The experiments were conducted on 20 outbred male rats weighing 150–200 g. Studies were performed during different seasons characterized by substantial variations in environmental temperature. During winter (December), the temperature in the experimental room ranged from 10 to 15°C; during autumn (October), from 20 to 25°C; and during summer (July), from 37 to 40°C.

In summer, a separate group of rats was additionally exposed to direct solar radiation for 30 minutes at noon on the day of sacrifice. The animals were maintained in standard cages without restriction of movement. All groups received the same mixed carbohydrate-protein diet and had free access to drinking water.

Before sacrifice, animals were anesthetized and euthanized by decapitation. Following decapitation, blood samples were collected, and the parotid, submandibular, and sublingual salivary glands were excised. The glands were homogenized in physiological saline at a ratio of 1:10 relative to gland mass. The homogenates were filtered, and the filtrates as well as blood serum samples were analyzed for the activity of hydrolytic enzymes: amylase (Smith–Roy method modified by A.M. Ugolev), lipase (Tietz method), and pepsinogen (Hirschowitz method). Total protein concentration was determined using the Lowry method.

Enzyme output and total protein secretion were calculated relative to gland mass. Results obtained during autumn and summer were compared with winter values.

Results and Discussion

The findings demonstrated marked seasonal differences in the enzymatic profile of salivary glands and blood serum associated with variations in ambient temperature. Different enzymes responded differently to environmental temperature changes.

Amylolytic activity and amylase output of the salivary glands were highest during winter, when environmental temperatures were lowest. Elevated ambient temperatures exerted an inhibitory effect on amylase secretion. During autumn, when temperatures ranged between 20 and 25°C, amylolytic activity of the parotid gland decreased approximately tenfold, while amylase output decreased fifteenfold compared with winter values.

During summer, amylase activity and output remained close to autumn levels; however, under solar insolation these parameters exhibited pronounced fluctuations. Similar patterns were observed in the submandibular and sublingual salivary glands.

Serum amylase activity during winter and autumn was approximately ten times higher than during summer. These findings suggest that moderate temperature elevation suppresses exocrine amylase secretion, whereas exposure to temperatures of 37–40°C additionally inhibits endocrine release of amylase into the bloodstream. Since blood amylase originates not only from salivary glands but also from the pancreas, elevated ambient temperatures likely suppress the secretory activity of multiple digestive glands.

Lipase activity exhibited a different pattern. Lipolytic activity and lipase output in salivary glands reached maximal values during autumn. In winter and summer, these indices were approximately 8–10 times lower than those observed during autumn. The lowest lipase output in the parotid gland was recorded under combined exposure to high temperature (37–40°C) and solar radiation. These findings indicate a clear dependence of lipase secretion on ambient temperature, with optimal secretion occurring at 20–25°C. Both lower and higher temperatures exert an inhibitory effect on salivary lipase secretion.

Blood lipase activity during winter was approximately 5–6 times lower than during other seasons. Thus, elevated temperature appears to suppress salivary lipase secretion without significantly affecting endocrine release of the enzyme from gastrointestinal glands, whereas cold exposure inhibits both processes.

Pepsinogen content and output in salivary glands also reached maximal levels during autumn, exceeding values observed in other seasons by approximately 8–10 times. Similar changes were detected in blood pepsinogen concentrations. Since the principal source of circulating pepsinogen is the chief cells of the gastric glands, and salivary pepsinogen is secreted through a process of recreation from the bloodstream, alterations in ambient temperature appear to modulate gastric secretory activity and consequently affect pepsinogen release into circulation.

Total protein secretion by salivary glands also depended on environmental temperature. The highest total protein output was observed during autumn, whereas blood protein concentration reached its maximum during summer.

Conclusions

1. Amylase secretion is directly influenced by ambient temperature. Moderate temperature elevation inhibits exocrine secretion, whereas pronounced temperature increases suppress endocrine release of amylase into the bloodstream, resulting in decreased serum enzyme levels.

2. Optimal secretion of lipase, pepsinogen, and total protein by salivary glands occurs at moderate environmental temperatures (20–25°C). Both lower and higher temperatures inhibit their secretion.

3. Moderate ambient temperature (20–25°C) enhances pepsinogen release into the bloodstream, whereas both cooling and overheating suppress this process.

4. Summer heat (37–40°C) combined with solar insolation stimulates the endocrine release of lipase and total protein into the bloodstream.

Keywords

Ambient temperature; solar insolation; salivary glands; amylase; lipase; pepsinogen; enzymatic homeostasis; digestive glands; rats.

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