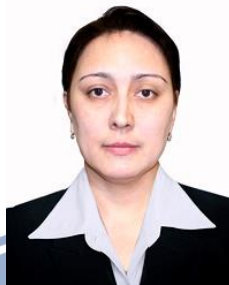




THE EFFECT OF HYPOKINESIA ON PANCREATIC ENZYME SECRETION AND
ENZYMATIC HOMEOSTASIS UNDER CONDITIONS OF ENVIRONMENTAL
TEMPERATURE CHANGES.



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ANNOTATION

Insufficient physical activity negatively affects the functioning of the pancreas and its ability to maintain normal enzyme levels. A decrease in physical activity causes a reduction in the production of the most important pancreatic enzymes - amylase, lipase and proteases, which are responsible for the breakdown of carbohydrates, fats and proteins. This may result in difficulties with digestion, impaired absorption of nutrients and other dyspeptic disorders.

Keywords: *hypokinesia, pancreas, rats, adaptation. comfortable temperature.*

Intense solar radiation and elevated temperatures are considered key environmental factors. In small amounts, they have a beneficial, adaptive effect, stimulating the activity of nerve endings, melanocytes, and other skin structures. However, when excessive, these factors can become harmful and trigger various changes in organs and tissues.

Hypokinesia, or reduced physical activity, is another significant factor influencing physiological processes in the body [5,6]. Research shows that hypokinesia negatively affects the secretory function of the pancreas and enzymatic homeostasis. Reduced physical activity leads to a decrease in the production of pancreatic enzymes such as amylase, lipase, and proteases, which are essential for the digestion of carbohydrates, fats, and proteins. This can result in digestive disorders, malabsorption, and other gastrointestinal issues. Considering the critical role of pancreatic enzymes in food breakdown, the objective of this study was formulated accordingly.

The aim of the study was to examine - the effects of hypokinesia on pancreatic enzyme secretion and enzymatic homeostasis under conditions of environmental temperature changes.

Methodology and techniques for conducting experiments and observations.

The experiments were conducted on white, non-pedigree laboratory male rats weighing 180–200 g. Intact animals (control group), which were not subjected to any external influences, were kept at an optimal ambient temperature (20–25°C) and were sacrificed in parallel with the experimental animals. Before sacrificing, the rats were anesthetized with ether and decapitated. The pancreas was then removed and homogenized with the addition of saline solution at a ratio of 1:10 relative to its weight. The homogenate was filtered, and the activity of hydrolytic enzymes was determined in the

filtrate. Enzyme output was calculated as the ratio of enzymatic activity to 1 gram of pancreatic tissue. The experimental animals were exposed to acute solar radiation on an open sunlit platform. The effect of a single 30-minute exposure to sunlight (from 12:00 to 12:30 PM) during the summer (July) was studied, with a radiation intensity of 10 watts and ambient air temperatures ranging from 37°C to 40°C.

Results and Discussion: The secretory function of the rats' pancreas under hypokinesia was evaluated by measuring the levels of amylase, lipase, and total proteolytic activity in pancreatic tissue homogenates. At the same time, the activity of amylase and lipase was also determined in the blood of these experimental animals.

Figure 1 shows the dynamics of changes in amylolytic activity in pancreatic tissue and blood in rats subjected to reduced motor activity.

Hypokinesia lasting 1 and 3 hours did not change the amylase activity in pancreatic tissue. Hypokinesia for 7 hours increased the amylase activity in the pancreatic tissue.

Hypokinesia lasting 24 hours, and for 3, 10, 15, 20, and 25 days resulted in nearly identical levels of amylase activity in pancreatic tissue.

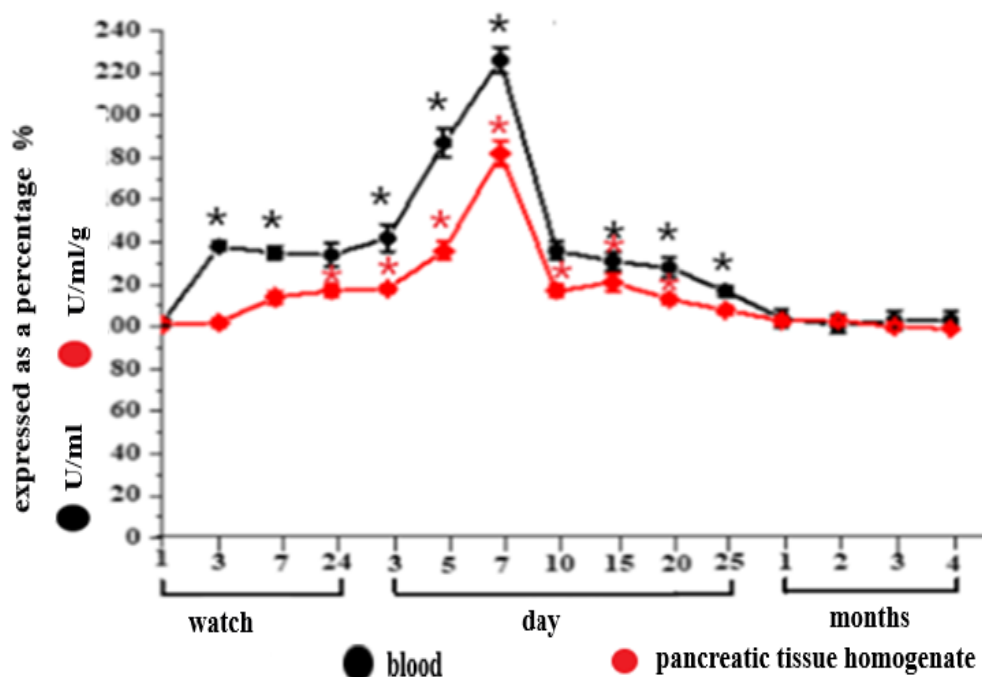


Figure 1. Amylolytic activity in the blood and pancreatic tissue homogenate under hypokinesia ($M \pm m$).

Statistically significant differences: (* $P < 0.05$; ** $P < 0.001$; $n = 10$).

An increase in amylase activity in the pancreatic tissue reached its peak on the 5th and 7th days of the experiment. During the first month of the experiment, the amylase activity in the pancreatic tissue decreased to baseline values, and this level remained stable during the 2nd, 3rd, and 4th months of reduced physical activity.

In experimental rats, changes in amylase activity in the blood and pancreatic tissue during hypokinesia showed a unidirectional pattern. Throughout all periods of hypokinesia, a very high positive correlation was observed between amylase activity in the pancreatic tissue and that in the blood (see Table 1).



Table 1

Correlation between enzyme content in pancreatic tissue homogenate and their blood levels during hypokinesia ($r \pm mr$)

Duration of Hypokinesia	Amylase	Lipase	Total Protein
1 hour	0,68±0,06	0,42±0,04	0,45±0,04
3 hours	0,58±0,06	0,69±0,06	0,44±0,04
7 hours	0,70±0,07	0,87±0,08	0,44±0,03
24 hours	0,53±0,04	0,47±0,03	0,55±0,05
3 days	0,48±0,04	0,44±0,03	0,83±0,07
5 days	0,54±0,04	0,49±0,04	0,54±0,05
7 days	0,54±0,04	0,53±0,04	0,63±0,06
10 days	0,54±0,04	0,47±0,04	0,54±0,05
15 days	0,50±0,05	0,57±0,05	0,58±0,05
20 days	0,58±0,05	0,58±0,05	0,56±0,05
25 days	0,57±0,05	0,59±0,05	0,55±0,05
1 month	0,54±0,05	0,56±0,05	0,83±0,08
2 months	0,68±0,06	0,42±0,04	0,45±0,04
3 months	0,58±0,06	0,69±0,06	0,44±0,04
4 months	0,70±0,07	0,87±0,08	0,44±0,03

The increase in amylase activity during hypokinesia occurred earlier in the blood than in the pancreatic tissue. Amylase activity in the blood began to rise from the 3rd hour of hypokinesia, while activity in the pancreatic tissue increased starting from the 7th hour. This elevated level of blood amylase activity persisted through 24 hours, and days 3, 10, 15, 20, and 25 of hypokinesia.

The peak increase in blood amylase activity coincided with a similar increase in pancreatic tissue, observed on days 5 and 7 of hypokinesia. The percentage increase in blood amylase activity relative to the control was consistently higher than that in the pancreatic tissue. Since both the pancreas and salivary glands are major sources of blood amylase, this may be due to increased secretion by both under hypokinetic conditions [1,2,3,4].

According to data from the S. Rothman laboratory [7], the pancreas is the main source of blood amylase. Pancreatic enzymes absorbed from the blood are transported back into the pancreas and secreted into the duodenal lumen as part of digestive fluids, where they participate in the hydrolysis of nutrients.

The results showed that lipase activity in both the blood and pancreatic tissue remained unchanged during the first month of hypokinesia (Figure 2). On day 30 of the experiment, lipase activity in pancreatic tissue significantly decreased, while its activity in the blood increased. As the duration of physical inactivity increased (at 2, 3, and 4 months), the changes in lipase activity became more pronounced—that is, blood lipase activity continued to increase, while its activity in pancreatic tissue markedly declined.

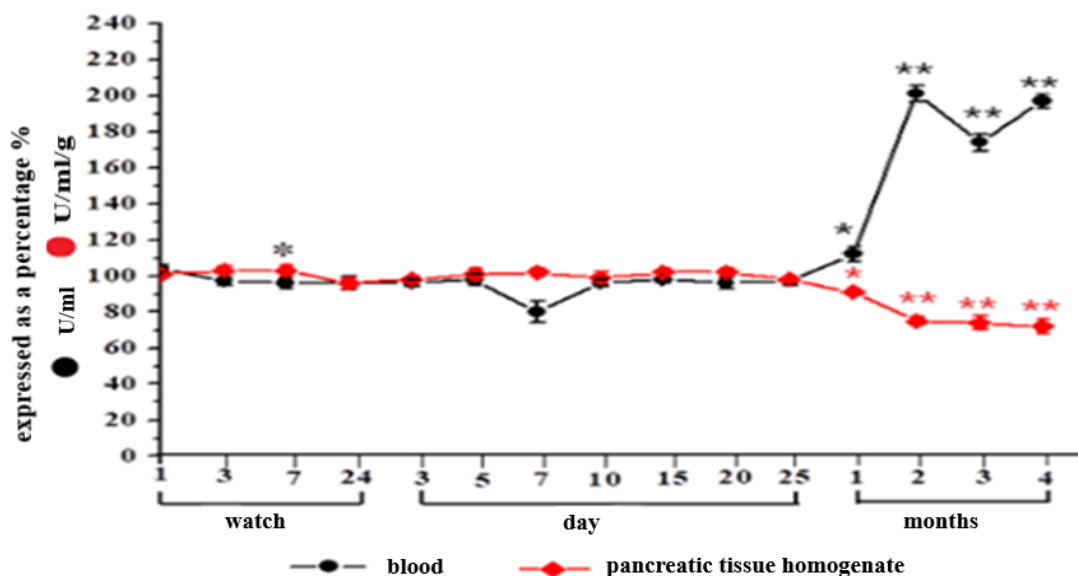


Figure 2. Lipolytic activity in blood and pancreatic tissue homogenate during hypokinesia ($M \pm m$).
Statistically significant differences: (* $P < 0.05$; ** $P < 0.001$; $n = 10$).

The origin of lipase in the blood is primarily pancreatic [4], which is confirmed by our correlation values for lipase activity (see Table 1) between blood and pancreatic tissue. Regardless of the duration of hypokinesia, consistently high positive correlation coefficients were observed for lipase activity in blood and pancreatic tissue.

Therefore, it can be concluded that the increased “leakage” of lipase from the pancreas into the bloodstream during prolonged hypokinesia is associated with morphological changes. In animals exposed to 60 days of reduced physical activity, signs of focal chronic pancreatitis and necrobiotic changes in pancreatic acinar cells were observed [5,6]. These changes may lead to a reduction in the histohematological barrier and enhance the “leakage” of lipase from acinar cells into the bloodstream.

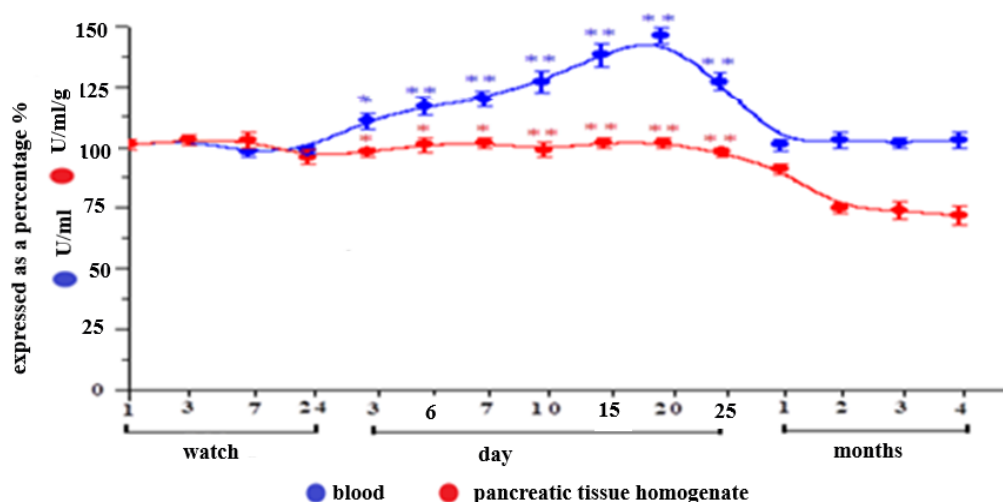


Figure 3. Total protein content in blood and pancreatic tissue homogenate during hypokinesia ($M \pm m$).
Statistically significant differences: (* $P < 0.05$; ** $P < 0.001$; $n = 10$).



During hypokinesia, the total protein content in the blood changes depending on its duration (Figure 3):

At 1, 3, 7, and 24 hours, as well as after 1, 2, 3, and 4 months of hypokinesia, the total protein content in the blood did not change. However, on days 3, 5, 7, 10, 15, 20, and 25 of reduced physical activity, the total protein content in the blood increased. In other words, limited physical activity for 3 to 25 days in rats had a significant impact on protein synthesis and secretion by protein-producing organs.

The total protein content in pancreatic tissue homogenate showed similar changes depending on the duration of hypokinesia.

It remained at baseline levels at 1, 3, 7, and 24 hours, as well as at 30, 60, 90, and 120 days of reduced physical activity. From days 3 to 25 of the hypokinetic period, the total protein content in the pancreatic tissue increased significantly.

The maximum increase in total protein in both blood and pancreatic tissue occurred at the same time point—on day 20 of hypokinesia.

Protein synthesis is primarily carried out by the acinar cells of the pancreas. This requires a large amount of initial plastic material. Transport of these materials—similar to that in other glandular cells—occurs from blood capillaries through the pericapillary space and cytoplasmic basolateral membrane into the cell [3,4].

Naturally, this process requires increased capillary blood flow and enhanced permeability of both endothelial and cytoplasmic membranes. Hypokinesia, as a stress factor, can either increase or decrease pancreatic blood flow and vascular permeability depending on the stage of the adaptation syndrome, via the hypothalamic-pituitary-adrenal axis.

This likely explains the observed increases or decreases in total protein content in pancreatic tissue.

Moreover, as previously noted, about 90% of the secreted proteins are enzyme proteins, so changes in enzyme synthesis rates under hypokinesia may be responsible for the observed alterations in total protein levels in pancreatic tissue.

The total proteolytic activity of the pancreatic tissue homogenate significantly increased on day 20 of hypokinesia and remained at that level on day 25 and after one month (Figure 4). During all other periods of hypokinesia, the total proteolytic activity of the pancreatic tissue homogenate remained unchanged.

The bicarbonate content in pancreatic tissue homogenate significantly increased during days 3, 5, 10, 15, and 20 of physical activity restriction (Figure 4). During all other periods of reduced physical activity, the bicarbonate content in pancreatic tissue homogenate remained at control levels.

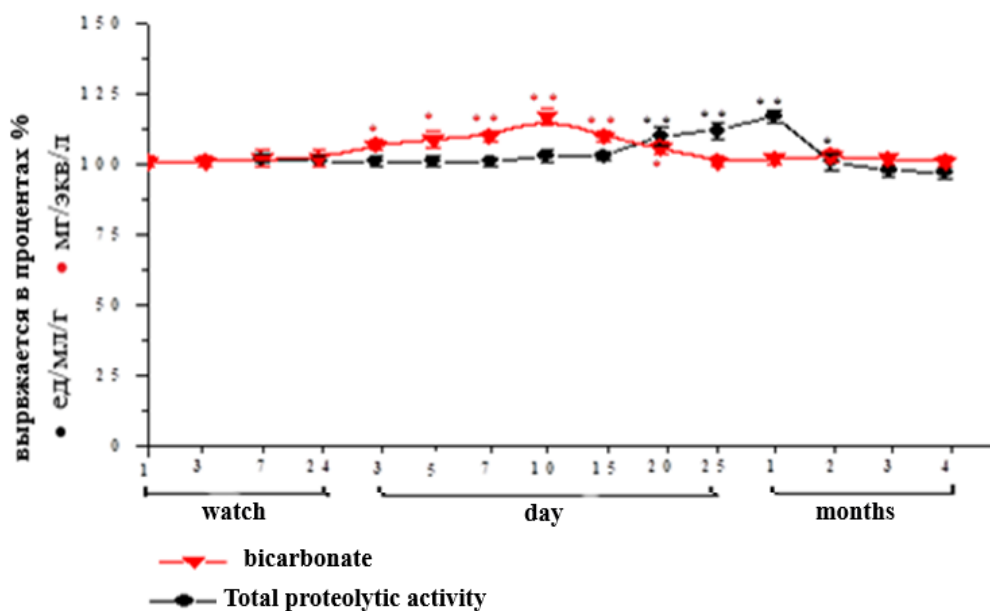


Figure 4. Total proteolytic activity and bicarbonate content in the pancreatic homogenate during hypokinesia.

Statistically significant differences: ($P < 0.05$; $ P < 0.001$; $n = 10$).**

Summarizing the study, it can be stated that hypokinesia occurs under the influence of certain stress factors:

1. During hypokinesia, the content of amylase, total protein, and total proteolytic activity in the pancreatic tissue and blood increases, while lipolytic activity decreases.
2. Changes in enzyme activity and total protein content in the pancreatic tissue and blood depend on the duration of the rats' hypokinesia state.
3. A direct correlation is observed during hypokinesia between enzyme activities (amylase, lipase) and total protein content in both pancreatic tissue and blood.

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