EFFECT OF PROLONGED TRANSVERSE RADIAL ACCELERATION ON THE SECRETION OF INTESTINAL JUICE AND ENZYMES IN DOGS

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Only isolated references could be found in the literature [4, 7] to investigations of certain functions of the digestive system, especially of the small intestine, during exposure to longitudinal radial acceleration.

Since nowadays transversely acting overloads are the commonest to be encountered, and are better tolerated than longitudinal, the present investigation was undertaken to examine the changes in the secretion of the intestinal juice and enzymes during exposure to prolonged transverse radial acceleration.

EXPERIMENTAL METHOD

The investigation was carried out on four dogs with segments of the proximal part of the small intestine isolated by Thiry's method. In three dogs the intestinal juice was obtained during periodic secretion and secretion in response to mechanical stimulation of the animal (Pirat, Ledi, Nora) 18 h after feeding. In the fourth dog (Sivyi) the intestinal juice was obtained only in response to mechanical stimulation 1 h after eating. In the case of periodic secretion the experiments lasted for 6 h, and in the case of secretion in response to mechanical stimulation—5 h. The indices used were the volume of intestinal juice during the experiment and the activity of its enterokinase, alkaline phosphatase, amylase, and lysozyme. The activity of the first three enzymes was determined by the methods used and developed in the digestion laboratory of the Institute of Nutrition, USSR Academy of Medical Sciences [5, 6, 8]; the lysozyme activity was determined by M. I. Kozar' using O. G. Alekseeva's method [1].

After the background values of these indices had been determined, the animals were exposed to the action of single transverse (dorso-ventral) radial acceleration on a centrifuge of radius 4.2 m. The rate of increase of the overloading was 0.2 g/sec. The magnitude of the overloading applied was 8 g and the time of its action 3 min (8 g—3 min). According to data in the literature [9] an overload of this type may be encountered when a cosmic ship is being maneuvered into the second cosmic velocity.

Over 300 experiments were performed and about 1500 determinations of the activity of the enzymes were made. The numerical results obtained were analyzed by statistical methods [2].

EXPERIMENTAL RESULTS

The effect of radial acceleration on the periodic secretion (of the dog Nora) is shown in Fig. 1. Exposure to transverse radial acceleration led to a sharp fall in the secretion of intestinal juice in the first days after exposure. Later considerable fluctuations in the volume of intestinal juice developed, towards both hypo- and hypersecretion, with a long after-effect (8-9 weeks), after which the volume of juice became stabilized within the limits of the background level. The activity of the enzymes was unchanged during the first 2 days. Changes began on the 3rd day after exposure. For instance, the activity of enterokinase, amylase and, in particular, alkaline phosphatase rose considerably and remained at a higher level, with fluctuations to either side, for a period which differed for each enzyme. Whereas the after-effect in relation to amylase activity in this dog lasted 12 weeks, and in relation to enterokinase activity 14 weeks, in relation to alkaline phosphatase activity it lasted more than 16 weeks. The situation with lysozyme was completely different. From the 3rd day after exposure its activity fell sharply and stayed at this level for 5 weeks. It then returned towards its original value, but later fell again, although not to such a marked degree as in the first weeks after exposure.

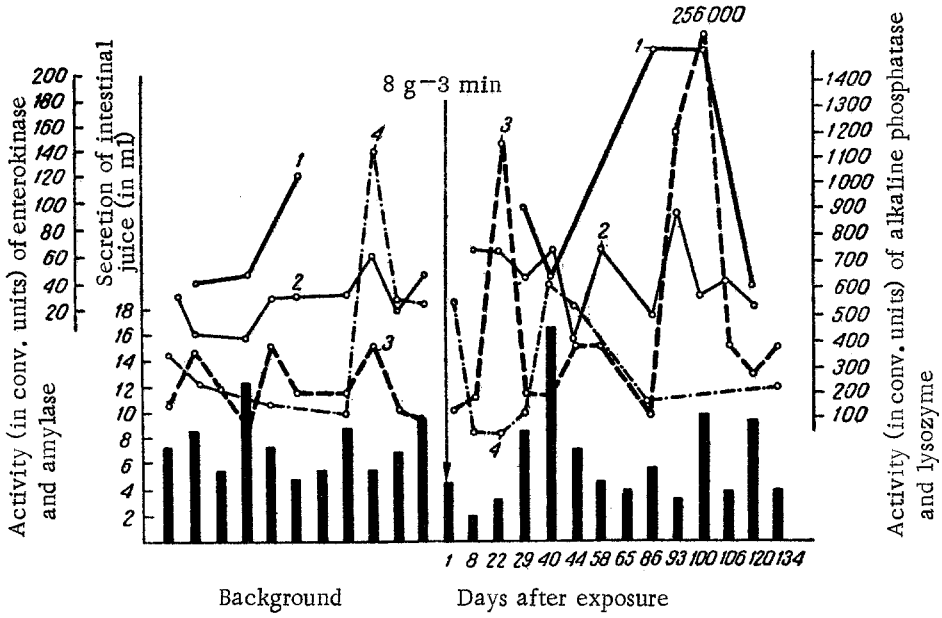

Fig. 1. Secretion of intestinal juice and enzymes by the dog Nora in a fasting state before and after exposure to acceleration. Columns) volume of intestinal juice during periodic secretion. 1) Enterokinase activity; 2) amylase; 3) alkaline phosphatase; 4) lysozyme (in conventional units per ml intestinal juice). Arrow) moment of exposure to acceleration. The alkaline phosphatase activity is reduced 100 times.

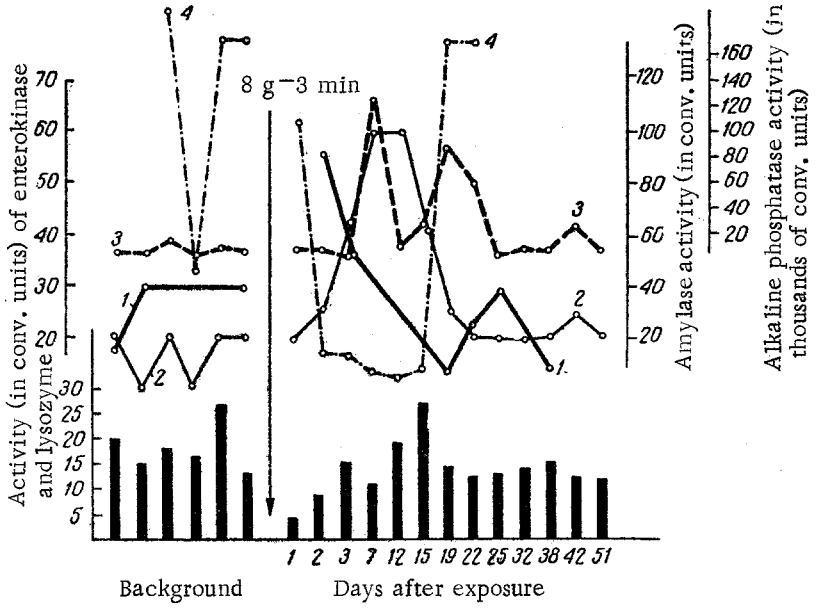

Fig. 2. Secretion of intestinal juice and enzymes by the dog Sivyi after a meal, before and after exposure to acceleration. Columns) volume of intestinal juice in response to mechanical stimulation. 1) Enterokinase activity; 2) amylase; 3) alkaline phosphatase; 4) lysozyme (in conventional units per ml intestinal juice). Arrow) moment of exposure to acceleration. The lysozyme activity is reduced 10 times.

In the dogs Pirat and Ledi similar changes were observed in the studied indices to those in the dog Nora, but the depression of secretion of intestinal juice continued for only the first 2 days after exposure. The duration of the after-effect in these dogs in relation to the secretion of both intestinal juice and enzymes also was slightly shorter.

TABLE 1. Secretion of Intestinal Juice and Enzymes Before and after Exposure to Prolonged Transverse Radial Acceleration in the Dog Pirat, with a Thiry Isolated Segment of Small Intestine, in a Fasting State (M ± m)

Index	Before exposure (7 expts.)	After exposure (7 expts.)	Increase or decrease (in %)	P
Volume of intestinal juice (in ml per experiment)	4.8 ±1.09	3.8 ±1.7	−20.8	> 0.25
Activity of intestinal enzymes (in conv. units) per ml of intestinal juice:				
enterokinase	57.6 ±16	86.0 ±25.8	+49.3	> 0.5
alkaline phosphatase	28.7 ±6.8	180 ±48	+901	> 0.01
amylase	28 ±9.3	52.3 ±7.9	+46.4	> 0.1

Note: Here and in Table 2 the alkaline phosphatase activity is reduced 1000 times.

TABLE 2. Secretion of Intestinal Juice and Enzymes before and after Exposure to Prolonged Transverse Radial Acceleration in the Dog Sivyi, with a Thiry Isolated Segment of Small Intestine, 1 h After a Meal (M ± m)

Index	Before exposure (6 expts.)	After exposure (11 expts.)	Increase or decrease (in %)	P
Volume of intestinal juice (in ml per experiment)	17.4 ±2.08	13.5 ±1.7	−24.4	> 0.1
Activity of intestinal enzymes (in conv. units) per ml of intestinal juice:				
enterokinase	16.3 ±3.6	17.9 ±6.7	+9.8	> 0.5
alkaline phosphatase	7.6 ±2	32 ±12	+320	> 0.05
amylase	14.3 ±3.6	35.7 ±9.7	+149	> 0.05
lysozyme	691 ±120	247 ±104	−64.2	< 0.02

Since there is an essential difference between the mechanisms of secretion of intestinal juice in the cases of periodic secretion and of secretion in response to mechanical stimulation, the influence of radial acceleration of the same magnitude on the latter was studied. The dynamics of the values obtained when these experiments were carried out on the same animals as before were identical with the changes during the periodic secretion of intestinal juice and of enzymes. The difference between these two types of secretion, as before exposure to acceleration, was that in response to mechanical stimulation much more intestinal juice and much less of the enzymes were secreted, but the direction of the changes after exposure was the same as in the case of periodic secretion. Rather different results were obtained during secretion in response to a mechanical stimulus 1 h after a meal. As Fig. 2 shows, during the 1st week the secretion of intestinal juice was depressed. Later it increased, and then fell again, becoming stabilized at a level slightly below the background value. Observations continued for 50 days after exposure to acceleration.

The activity of the enzymes in the intestinal juice obtained in these experiments varied in the same way as the activity of the enzymes in the juice obtained in the experiments described above, i.e., in the first days after exposure it remained substantially unchanged, and later it varied considerably. For instance, from the 3rd day after exposure the amylase activity rose and remained high for 2 weeks. For the next 5 weeks it remained within the limits of the background figures. The alkaline phosphatase activity was unchanged for the first 3 days, but later it fluctuated sharply, rising from the background level (3370-17,000) to 85,000-127,000 conv. units. However, towards the beginning of the 6th week of the period of the after-effect its activity returned to the background level. The enterokinase activity did not change so sharply, but nevertheless it rose slightly during the first days of the period. The lysozyme activity fell for 2 weeks after the 2nd day after exposure to acceleration. In subsequent experiments it rose to its initial values and remained within the limits of the background variations.

Hence, the changes in the values of the secretion of juice in response to mechanical stimulation after a meal were similar to the changes in the indices during periodic secretion and during secretion in response to mechanical stimulation in a fasting state, but the duration of the after-effect was different. For example, using different criteria of the secretion of intestinal juice and enzymes, the after-effect lasted for between 5 (lysozyme) and 16 (alkaline phosphatase) weeks in a fasting state, compared with between 2 (lysozyme) and 6 (alkaline phosphatase) weeks in the case of secretion after a meal. The duration of the after-effect in the other dogs, as shown by the indices of secretion of intestinal juice and enzymes, occupied an intermediate position. For this reason a statistical analysis was made of the experimental results only in the period of the after-effect and not throughout the period of observation.

As an illustration the results of the statistical analysis of the indices of periodic fasting secretion in the dog Pirat (Table 1) and of secretion in response to mechanical stimulation after a meal in the dog Sivyi (Table 2) are given below.

The results obtained suggest that the form of stimulation investigated may have a pathological action, but evidently this is not so. I. P. Razenkov [3], who attached fundamental importance to the functional state of organs and tissues, showed that a change in the functional state of an organ in some cases may modify its functional manifestations in such a way that they resemble those observed in a pathological state, although in fact no pathological lesion is present.

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