EFFECT OF MUSCULAR WORK ON THE MOTOR FUNCTION OF THE STOMACH AND DUODENUM

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Despite the considerable theoretical and practical significance of studies directed to the clarification of the effect exerted by muscle work upon the activities of various organs and systems in the healthy organism, the changes in the digestive tract due to muscle work have been studied but inadequately. The overwhelming majority of the studies have dealt with changes in the secretory glands under the influence of the most varied kinds of muscle work. In regard to gastrointestinal movements the studies have been few and have dealt principally with the function of stomach emptying.

Observations on the influence of static effort upon motor (peristaltic) activity of the digestive tract [2, 5] are very scant and deal only with stomach movements, particularly under conditions of physiological hunger.

The present study is devoted to an examination of the influence static muscular effort exerts upon three different types of gastric motor activity: periodic, "hunger" contractions, "acid" movements [6] and the peristaltic movements occurring when a stomach has been filled with food. It was interesting to compare simultaneously motor activity of the duodenum with changes in the motor activity of the stomach.

The results we obtained enabled us to compare the influence of static motor effort upon gastric and duodenal motility with results obtained when making analogous studies upon the influence of dynamic motor effort (running in a treadmill) in the same animals [4].

EXPERIMENTAL METHODS

The experiments were conducted using 6 dogs, each one having a fistula in the fundic portion of the stomach. Besides this, three of them had duodenal openings to the outside. The animals were used in these experiments after they had fasted 18-20 hours. The experiments were begun in the absence of a pronounced acid secretion (of the stomach contents). The usual balloons recorded gastric movements. In order to record duodenal activity, a modification of this method was used, as worked out in our laboratory by V. F. Mostun [3].

"Acid" movements of the stomach were initiated by sham feeding (feeding with the gastric fistula open); within 5-7 minutes, 150 grams of raw meat were given. Experiments made to observe gastric peristalsis during digestion were conducted in an identical manner except that the sham feeding was replaced by the real.

The static muscular effort consisted in having the dog support a large weight (sand bag) which was laid across the shoulder girdle of the animal. The intensity and duration of the load was varied in two ways: 1) relatively short but very intense effort; in this instance, the dog being made to support a weight equal to its own (sometimes more) for 10 minutes; 2) prolonged but less intense effort; the weight being in this instance about half the body weight and being supported for about an hour.

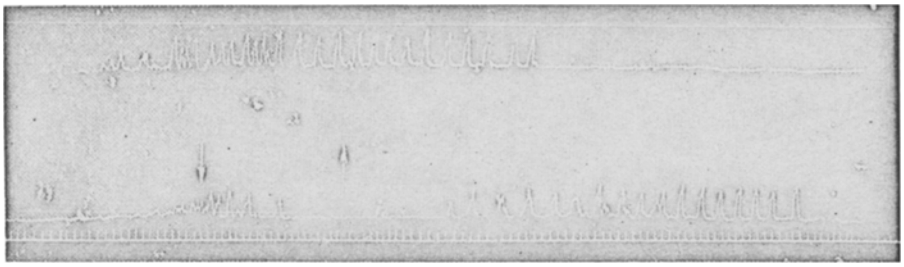

Fig. 1. Influence of intensive static effort upon "hunger" contractions of the stomach (dog Kashtan).
Read from left to right, from above down. Arrows indicate beginning and end of the static work.

Before commencing experiments pertaining to the effect of muscular loading,"background" studies were made and the influence of the new type of environment, associated with the loading studies, was extinguished.

The influence of high intensity, short duration static effort upon "hunger" contractions of the stomach was observed in two dogs – Kashtan and Tsirkach. In these experiments, the "background" period of "hunger" contractions was recorded first, after which the next period of contractions was preceded by the placing of the static load. Figure 1 represents a typical experiment (dog Kashtan).

EXPERIMENTAL RESULTS

It is evident that a static load, placed at the very beginning of a period of "hunger" contractions, depresses them in a very short interval of time. Removal of the static load allows the "hunger" contractions to resume. The same relationships were observed in analogously conducted experiments with a second dog – Tsirkach, although a somewhat larger load was required.

The influence exerted by prolonged but less intense static loads upon "hunger" contractions occurring periodically in the stomach and duodenum was studied experimentally on two dogs – Reke and Peggy. The experiments were conducted in two variations. In the first variation, after having recorded the "hunger" contractions and in the quiet interval, the static load was placed and kept to the end of the next period of contractions. When this maneuver was employed,it was evident that these latter contractions began and ended (at the termination) of an hour of static effort. The majority of these experiments indicated that the contractions of the "hunger" type in the stomach occurring during static effort were of shorter duration; the analogous duodenal motor changes were also less pronounced.

In the second variation, work of the same intensity and duration, was stopped just before an anticipated period of gastric "hunger" contractions. When this was done, the gastric and duodenal contractions were not depressed in regard to the length of time, number or intensity of the effort.

The influence of static loading was studied upon the digestive and "acid" gastric contractions of dogs Kashtan, Tsirkach, Peggy and Aster; the amount of load and length of time it was kept on was the same as in the preceding experiments.

Figure 2 is a typical sample. It can be seen that "acid" (Fig. 2,a) and digestive movements of the stomach (Fig. 2,b) are not markedly depressed by a short and intensive period of static loading. There was no depression of digestive movements of the stomach under the influence of the second type (prolonged) of static loading. However, when the load was increased in the same animals, it could be seen that a very intense static load did produce some depression of gastric motility (Fig. 2,c).

In order to compare the motor changes in the stomach with those in the duodenum, experiments were conducted on three dogs – Aster, Dik, and Peggy – intensive static loading being observed for its effects upon the periodic "hunger" contractions of both bowel segments. Figure 3 represents such an experiment on dog Aster. It can be seen that the braking effect of the static loading is clearly reflected in gastric movements but not in

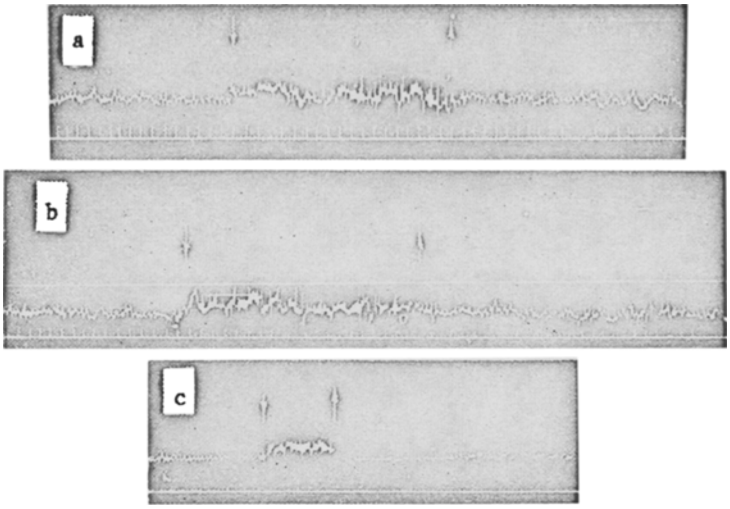

Fig. 2. Influence of intense static effort on "acid" (a) and digestive (b,c) movements of the stomach (dogs Kashtan and Aster).
Read from left to right. Arrows indicate beginning and end of static effort.

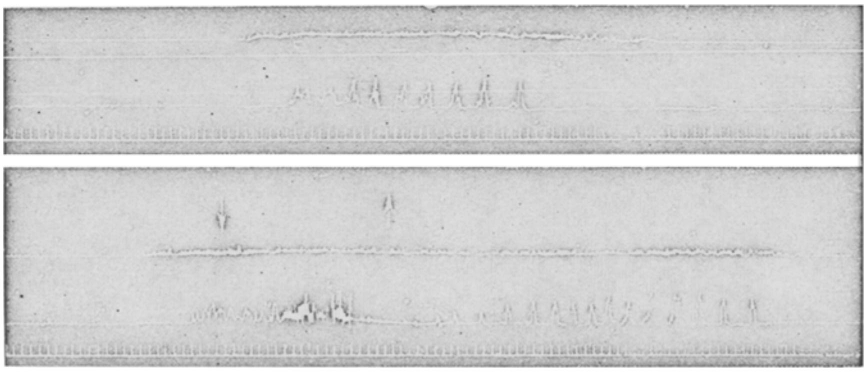

Fig. 3. Influence of intense static effort on "hunger" contractions of stomach and duodenum (dog Aster).
Read from left to right; meaning of tracings (from above downward): duodenal peristalsis; gastric movements; time marker. Arrows indicate beginning and end of static load.

those of the duodenum. The other animals studied gave about the same response, i. e., a more or less clearly seen difference between the gastric and duodenal responses to static loading. Thus, it can be said, that when static work depresses "hunger" contractions of the gastrointestinal tract the effect is more manifest in the stomach than it is in the duodenum. Static loading alters the "hunger" gastric contractions more sharply than it does the "acid" and digestive movements.

It is materially important to observe that static loads exert a depressing effect on the gastrointestinal tract only while it is being exerted, as its effect disappears almost as rapidly as the effort ceases, this being different from the effects of dynamic efforts [4] where the same animals demonstrated a braking motor effect not only during the effort but also for some time (minutes) after its cessation. Analysis of our data shows that short, intensive static loading powerfully depresses the motility of both the stomach and duodenum. The results of the second variant of our experiments when there was prolonged static loading of a lesser intensity should be compared:

in this instance the depressing effect of the static loading vanishes as quickly as the load is removed; in the period of "hunger" contractions which begin immediately after the load is removed, no braking can be observed. In both cases the rapidity and clear-cut sharpness of the effect indicate a reflex mechanism as the initiator of the changes.

Special tests established the fact that neither the new experimental conditions associated with the performance of the muscular effort nor the changes in the intra-abdominal pressure accompanying the muscular contractions can possibly be the source of the braking effect we observed during muscular work.

It can be supposed that the static work accomplishes its braking effect by means of reflex pathways originating in the moving tissues, first of all by a reflex involving the receptors of the moving muscles. As a proof of thi-, we can accept the studies of V. I. Beltukov and M. R. Mogendovich and their associates who demonstrated experimentally that adequate stimulation of muscle receptors suppresses gastric peristalsis. We can think that the stream of impulses coming from taut muscles creates a stimulatory focus in the area of the movement analysor which, in its turn, affects other nerve centers including the digestive, regulating gastrointestinal activities including the motor functions.

This question we explored in special experiments. As an indicator of changed irritability of the digestive center we used unconditioned salivary secretion and movement responses to specific stimulation by food. These studies were made on the same dogs, the static loads being of same intensity and duration. As a result we observed that, during intensive static work, the desire to eat was sharply diminished: the animal usually refused food. This effect of static loading disappeared as quickly as the load was removed, salivary secretion being noted very frequently just as the burden was taken off. Loss of appetite was observed also when static loads of lesser intensity but longer time were applied, this being manifested by the animals not making a vigorous movement to approach the food at the end of the hour of static labor, however, this reaction tended to vanish with the removal of the load.

These observations testify to the manner in which static loading affects the digestive center.

Finally, we should note the differences between the way static loading affects the periodic "hunger" contractions and "acid" movements, those arising during sham feeding in connection with varying functional states of the digestive apparatus and the condition of the central nervous system.

The entire discussion compels us to believe the changes in motor activity accomplished as a response to static effort are mediated by a basic reflex mechanism which must work in close conjunction with alterations in the functional state of the digestive center.

SUMMARY

The effect of muscle work on the gastric and duodenal motor function was studied in dogs.

It was observed that the static stress inhibited the "hunger" contractions of the stomach and duodenum; the inhibitory effect disappeared as the stress ceased. The static muscle work effect was more pronounced in "hunger" contractions of the stomach than in those of the duodenum. Under the influence of static stress, the periodic "hunger" contractions of the stomach varied more extensively than its "acid" and digestive contractions.

LITERATURE CITED

[1] V. I. Beltukov and M. R. Mogendovich, Uspekhi Sovremennoi Biol., 1952, Vol. 33, Issue 2, pp. 161-172.

[2] V. I. Dedlovskaya, Influence of Static Effort Upon the Secretory and Motor Functions of the Stomach.* Dissertation, Sverdlovsk, 1953.

[3] V. F. Mostun, Byull. Eksptl. Biol. i Med., 1950, Vol. 29, No. 6, pp. 410-414.

[4] A. N. Pomeltsov, in the book: Reports of the Conference of the Young Scientists of the Inst. of Normal and Pathologic Physiology Acad. Med. Sci. USSR,* Moscow, 1956, pp. 68-69.

[5] G. E. Skachedub, Materials on the Physiology of Internal Analyzers;* Dissertation, Molotov, 1954.

[6] I. A. Edelman, Gastric Movements and the Transfer of the Stomach Contents into the Bowel,* Diss. St. Petersburg, 1906.

* In Russian.