THE EFFECT OF STIMULATION OF THE MECHANO–AND CHEMORECEPTORS OF THE ORAL CAVITY ON CARBOHYDRATE METABOLISM

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In previous communications devoted to the study of the effect of stimulation of the receptors of the oral cavity on metabolism, the effect of the duration of stimulation on the taste receptors of the mucosa of the oral cavity on the regulation of carbohydrate metabolism was established. It was shown that prolonged sucking (for one hour) of 15 g of candy drops causes an intensive increase in the blood sugar and in the oxygen demand, which continues for many hours. If the same quantity of candy drops were eaten quickly, only a transient rise in the carbohydrate metabolism was produced [1, 2].

It is well known that in the higher animals and in man the mucous membrane of the oral cavity not only possesses taste receptors but also contains a very complex arrangement of mechanical, chemical and temperature receptors.

The present investigation was devoted to the further study of the influence of stimulation of the receptors of the oral cavity on the level of the blood sugar and on the gas exchange. It appeared necessary, in the first place, to study the influence of sucking substances of no food value on the regulation of carbohydrate metabolism and thereby to ascertain the role of the mechanoreceptors of the oral cavity in metabolism, and in the second place to define the conditions in which subthreshold concentrations of chemical (taste) stimuli become threshold stimuli, perceptible to the taste and having an effect on the regulation of carbohydrate metabolism.

EXPERIMENTAL METHOD

Observations were made on 6 healthy human subjects, ages from 18 to 49 years. As a chemical (taste) stimulus glucose was used, a 4% solution having hardly any sweet taste. The mechanical stimulus was sucking a round glass disk, which resembled a candy drop, being 3 mm in thickness and 2 cm in diameter. The disk was kept in the subject's mouth for 1 hour without causing any sensation of taste. For greater convenience the glucose was poured into a burette, from which it passed through a rubber tube and a mouthpiece, to emerge into the subject's mouth in drops, where it was gradually swallowed.

We performed several series of experiments in order to study:

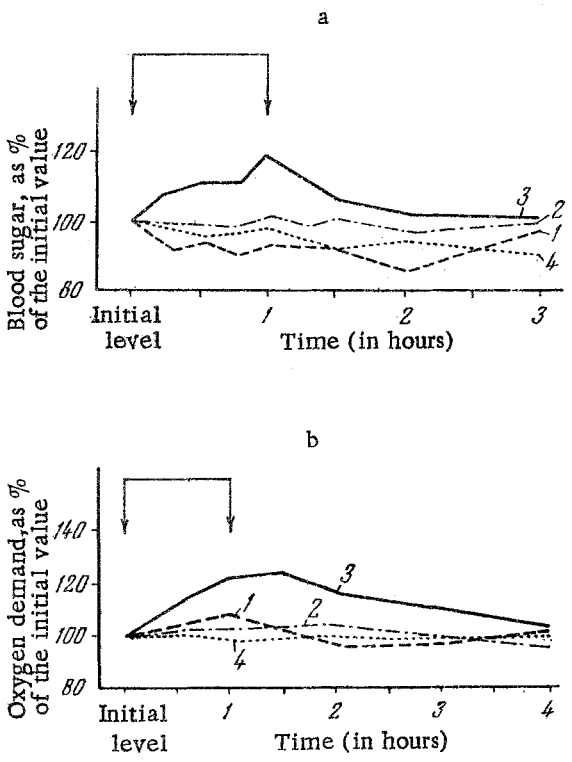
1) the effect of sucking the glass disk for 1 hour on the level of the blood sugar and the gas exchange;

2) the effect of introducing 100 ml of 4% glucose solution, in drops in the course of 1 hour, into the subject's mouth, on the level of carbohydrate metabolism;

3) the effect of administration of 100 ml of 4% glucose solution in the course of 1 hour to the subject by mouth, with simultaneous sucking of the glass disk, on the blood sugar level and the gas exchange.

We also carried out preliminary control experiments for a period of 3 hours to investigate the blood sugar level and the gas exchange. Altogether 24 experiments were performed, and the results of each series were in agreement. All experiments were carried out in the morning, on fasting subjects, within a period of 3 hours.

The blood sugar concentration was estimated by the Hagedorn-Jensen method, before the application of any form of stimulus, and then every 15 minutes during the hour that the stimuli were in action, and subsequently after 30, 60 and 120 minutes. The gas exchange was measured by the Zuntz-Haldane method, before application of the stimuli, and then over periods of 10 minutes every 30 minutes throughout the period of the observations.



The effect of stimulation of the receptors of the oral cavity on the level of the blood sugar (a) and the value of the oxygen demand (b).
1) Sucking a glass disk; 2) ingestion of 100 ml of 4% glucose solution in the course of 1 hour; 3) simultaneous ingestion of 100 ml of 4% glucose solution and sucking a glass disk; 4) control (mean values of all experiments). Duration of action of the stimulus one hour.

EXPERIMENTAL RESULTS

The results of the control experiments, carried out in the absence of any form of stimulus, showed (see Figure) that both the blood sugar and the gas exchange remained practically unchanged during the 3 hours of the experiment.

The study of the effect of sucking the glass disk on the blood sugar level and the gas exchange showed that if the disk was sucked for a long time it caused a gradual fall in the blood sugar level, which varied only very slightly from the fluctuations of the blood sugar level in the control experiments (see Figure, a). At the same

time there was a very insignificant rise in the gas exchange (by 4-8 %), and this was observed only in the course of the process of sucking itself, after which the level of gas exchange returned to its initial value as estimated before sucking the disk (see Figure, b).

These findings fully justified the view that sucking a glass disk – an object possessing no gustatory qualities – caused no perceptible change in the level of the blood sugar and gas exchange by comparison with the control results. It could therefore be postulated that mechanical stimulation of the receptors of the oral cavity during the act of sucking had no essential effect on the carbohydrate metabolism.

The results of the investigation of the effect of administration of 100 ml of 4% glucose solution on the carbohydrate metabolism are also shown in the Figure. In these experiments we studied the role of the taste receptors in the regulation of the carbohydrate metabolism, since the glucose solution entered the subject's mouth in drops and was gradually swallowed, so that mechanical stimulation of the receptors of the oral cavity by this means was avoided.

The observations showed that during the slow introduction of glucose solution into the mouth the blood sugar level and the oxygen demand did not differ essentially from their level in the control experiments. It had to be assumed that a 4% solution of glucose is a subthreshold stimulus and does not cause changes in the carbohydrate metabolism.

In the next series of observations the combined action of stimulation of the taste (chemo-) receptors and the mechanoreceptors on carbohydrate metabolism was studied. For a period of 1 hour the subjects sucked the glass disk, and at the same time received 100 ml of 4% glucose solution by mouth, in drops, through the mouthpiece. It was found (see Figure) that the simultaneous sucking of a glass disk and ingestion of glucose solution caused a marked rise in the blood sugar concentration, which was still above the initial level at the end of the 3 hours' observation.

The blood sugar level rose only 15 minutes after the beginning of the experiment, and after 1 hour it reached its highest value by comparison with the initial level (116.8%). In the next 2 hours the blood sugar level gradually fell, but nevertheless remained slightly above the initial value. Under these experimental conditions the gas exchange was also significantly increased throughout the period of observation. Thus by the combined action of glucose solution and sucking a glass disk the blood sugar and gas exchange exceeded the initial level throughout.

We may reach the following conclusion from our results: whereas stimulation of the chemo- or mechanoreceptors of the oral cavity, in isolation from each other, have no perceptible effect on the blood sugar level and the oxygen demand by comparison with the control findings, the simultaneous application of these stimuli leads to a prolonged increase of the blood sugar concentration and of the gas exchange. It must be pointed out that the subjects noticed the sweet taste of the glucose only when it was given in conjunction with the glass disk to suck, in the form of a 4% solution. It may, therefore, be considered that subthreshold stimuli of the gustatory nerves, giving rise to no sensation of taste and having no objective effect on the level of the carbohydrate metabolism, when applied at the same time as mechanical stimulation of the oral mucosa, do produce a sensation of taste and cause changes in the regulation of the carbohydrate metabolism. On the other hand, stimulation of the mechanoreceptors of the oral cavity does affect the regulation of carbohydrate metabolism, but only in the presence of a gustatory stimulus, albeit a subthreshold stimulus.

The results of our investigations confirm those of other authors. S. A. Kharitonov [5], for instance, found an increased sensation of sweetness during stimulation of the mechanoreceptors of the oral cavity. O. A. Naumova [3] demonstrated that chewing inedible material had no effect on the reaction of the vessels, whereas chewing tasty material led to changes in the vascular reactions depending on the character of the taste. During a study of conditioned vascular reflexes, A. T. Pshonik [4] experimentally converted a conditioned presensory exteroceptive vascular reflex into a conditioned reflex sensory vascular reaction, and by this means investigated the process of conversion of an imperceptible into a perceptible impulse.

On the basis of the findings in our experimental conditions it may evidently be stated that it is not only stimulation of the chemoreceptors but also stimulation of the mechanoreceptors in the mucous membrane of the mouth that is of importance in the act of sucking.

Thus the action of sucking, which is a complex combination of various influences of the food on the peripheral endings of the gustatory nerves, motivates the process of nervous regulation of carbohydrate metabolism in the intact animal.

SUMMARY

Experiments on 6 healthy young persons observed for 3 hours established that administration of 100 ml of a 4% glucose solution per os for one hour (chemical stimulation) caused no change in the levels of blood sugar and oxygen intake, as compared with controls. Neither did these indices change substantially after glass disks were sucked by the subjects for one hour (mechanical stimulation). However, when the two stimuli were applied simultaneously, the levels of the blood sugar and oxygen intake rose considerabley during the following three hours of observation. There appeared a sensation of sweetness which had been absent during drop administration of 4% glucose per os.

On the basis of this conclusion it was shown that stimulation, both of chemoreceptors and of mechanoreceptors in the oral cavity, plays a significant part in the act of sucking.

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