

EFFECT OF FASTING ON THE INTESTINAL ABSORPTION OF D-GLUCOSE AND D-XYLOSE IN RATS *IN VIVO*

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Abstract : The present study was planned to elucidate the role of fasting on the intestinal absorption of monosaccharides particularly - glucose and xylose in inbred female albino rats. Rats (weighing 250-300 grams) were divided into three groups. One group of rats served as control while the other two were experimental. One of the experimental groups was starved for 48 hours while the other for a period of 72 hours. It was found that fasting for 72 hours causes an overall increase in absorption of glucose from small intestine. Fortyeight hours of fasting caused a significant increase in glucose absorption from distal ileum only. Increase in the glucose absorption in fasting from small intestine can well be explained on the basis of a reduction in glucose metabolism in general as an adaptation to starvation so as to leave more glucose for cerebral metabolism. No significant changes, whatsoever, were encountered with xylose absorption in fasting animals.

Key words : fasting intestinal absorption glucose and xylose

INTRODUCTION

Fasting has been practiced in our country since time immemorial. Fasting exerts physiologic as well as metabolic stress on the body. The refeeding after a fast has its own implications and the effects have been studied in detail (1, 2). Fasting causes physiological disturbances, thus the animal if mature, uses its lipid stores first (3). Therefore, fats are the major source of energy during fasting (4). There is a marked decrease in the activity of HMG-CoA reductase in fasting animals, which explains

the reduced synthesis of cholesterol during fasting. The carbohydrate metabolism product (glucose) undergoes glycolysis to produce energy and pentose phosphate pathway (PPP) also known as Hexose Mono Phosphate shunt (HMP) - which is responsible for generation of NADPH and synthesizing ribose sugars for nucleic acid biosynthesis. During fasting the first enzyme of PPP, glucose-6-phosphate dehydrogenase is inhibited that is responsible for converting glucose-6-phosphate to 6-phosphogluconate. Also, the gut undergoes proteolysis causing a loss of

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absorptive surface; as there is no mitosis going on to regenerate the intestinal mucosa (5). Hence a decrease in the absorptive surface area deprives the animal from routine absorption of nutrients viz. carbohydrates, proteins and fats. During fasting body metabolism changes for the effective adaptation to capture energy. In the initial stages of fasting energy is obtained from fats but as the time passes both the fat and protein stores are depleted and the load may come on to carbohydrate absorption during refeeding. All these observations made it logical to study specifically that whether refeeding phase shows either increased or decreased monosaccharides, glucose and xylose, absorption.

METHODS

Inbred strains of female albino rats fed on standard laboratory diet were used throughout the experiments. Rats (weighing 250–300 grams) were divided into three groups. One group of rats served as control while the other two were experimental. One of the experimental groups was starved for 48 hours while the other for a period of 72 hours. All the animals were supplied with sufficient water during the period of starvation.

Experiment: The animals were anaesthetized with sodium pentothal i.p. (40 mg/kg body weight) and abdomen was opened by a midline incision and whole of the small intestine was washed with warm saline. Five to six loops of roughly equal size were prepared from the intestine lying between proximal jejunum and distal ileum following the procedure of Crampton et al (6). Loops

were numbered as 1, 2, 3 starting from oral direction. A known volume of 300 mM sugar in normal saline was injected through a fine needle attached to a 1 ml syringe (tuberculin type). The animal was bled to death by incising the aorta after an absorptive period of about 10 minutes. The procedure up to this stage, that is the loading and absorption of glucose, remains *in vivo* because the intestinal loops remain intact within the living body of the animals. Total time taken to conduct the experiment in anaesthetized animals was about 20 to 25 minutes. Now, the loops were excised and weighed on torsion balance before and after draining, to know the final volume and then finally washed with distilled water. After constant dilution the resultant fluid was analyzed for sugar concentration. The absorption rate was calculated from the difference between the total amount of sugar injected initially and that recovered after the end of experiment. The results were expressed in terms of $\mu\text{moles/gm dry wt/hr}$. The dry weight was measured after dehydrating loops in ethyl alcohol for 24 hrs and then drying in hot air oven at $110^{\circ}\text{--}120^{\circ}\text{C}$ for 2 hours. Estimation of glucose was done by the method of Robbo and Terkildson, the reagents used were peroxidase-glucose oxidase solution and 0-dianisidine dihydrochloride coloring reagent (7) while xylose was determined using Mejbaum's method the reagents being 0.1% FeCl_3 and 1% orcinol in $\text{FeCl}_3\text{-HCl}$ mixture (8).

RESULTS

Table I summarizes the results of 48 and 72 hours fasting on glucose transport

TABLE I: Effect of fasting on intestinal absorption of D-glucose (μ moles/gm dry wt/hr) in adult rats *in vivo*.

	Sac I (Proximal jejunum)	Sac II (Distal jejunum)	Sac III (Proximal Ileum)	Sac IV (Distal Ileum)	Total absorption from all the rats
Controls Mean \pm S.E.	3015 \pm 84	3767 \pm 133	3388 \pm 77	2980 \pm 132	3310 \pm 79
48 hrs fasting Mean \pm S.E.	3849 \pm 312*	4594 \pm 389*	4044 \pm 269*	4001 \pm 364**	4122 \pm 297**
72 hrs fasting Mean \pm S.E.	4354 \pm 105***	5053 \pm 149***	4149 \pm 140****	5016 \pm 161***	4643 \pm 59***

*P=N.S.; **P<0.05; ***P<0.001; ****P<0.01.

in vivo. The conclusions were drawn as to the rate of disappearance of glucose injected into isolated loops of jejunal and ileal portions of the small intestine. The results, therefore, indicate the uptake/absorption by mucosal layer in the different portions of the intestinal segments.

In 48 hours fasting, only sac IV (distal ileum) showed a significant increase (2980 to 4001 μ moles/gm dry wt/hr) in disappearance of glucose (uptake/absorption). Whereas, there was no significant increase in the rate of absorption of glucose in other segments of the intestine. Because of this change the total absorption, when calculated, showed significant increase (3310 to 4122 μ moles/gm dry wt/hr) from that of its respective control.

However, 72 hours fasting showed that disappearance of glucose from all the sacs, significantly increased when compared to their respective controls (3015 to 4354 in sac I, 3767 to 5053 in sac II, 3388 to 4149 in sac III and 2980 to 5016 μ moles/gm dry wt/hr in sac IV). The total absorption of glucose from intestinal segments therefore, showed positive significance (P<0.001).

Another set of experiments *in vivo* was done in present study using D-xylose in which the fasted state lasted only for 72 hr. The results of this are shown in Table II. It



Fig. 1: Normal intestinal histology in albino rats.

TABLE II: Effect of fasting on intestinal absorption of D-xylose (μ moles/gm dry wt/hr) in adult rats *in vivo*.

	Sac I (Proximal jejunum)	Sac II (Distal jejunum)	Sac III (Proximal Ileum)	Sac IV (Distal Ileum)	Total absorption from all the rats
Controls Mean \pm S.E.	2611 \pm 206	2983 \pm 324	2664 \pm 164	2541 \pm 117	2690 \pm 109
72 hrs fasting Mean \pm S.E.	2682 \pm 159*	2211 \pm 34*	2469 \pm 31*	2232 \pm 116*	2407 \pm 64.02*

*P=N.S.



Fig. 2: Intestinal histology after 72 hrs of fasting.

was found that there is no significant change of D-xylose from all the segments studied. In histological studies of controlled rats, the mucosal villi appear to be elongated structures with narrow apex (Fig. 1) whereas studies made in the experiment, rats showed the short and blunt mucosa with vacuolated cells after 72 hours fasting (Fig. 2).

DISCUSSION

The experiments showed that 48 hours fasting causes significant increase only in distal ileum as compared to other segments. This increased absorption in distal ileum can be attributed to utilization of other substrates such as fats from which energy is derived for transport of glucose in ileum, whereas in jejunum glucose as such is a

substrate for its own transport (9). Sanford and Smyth (10), also demonstrated that distal ileum has a greater capacity to transport glucose and galactose under the stress of fasting in rats. The effect was specific as neither amino acids transport nor the permeability of the luminal membrane of the absorbing epithelium was altered by fasting, whereas this increase transport was accompanied by a reduced accumulation of hexose in the gut wall. In another related work, it was shown that fasting leads to increased synthesis and assimilation of glycogen (11). The duration of fasting is equally important. Arterial glucose has been reported to rise up to 70% during glucose infusion after 18 hours fast in dogs. This indicates that longer is the duration of fast, higher is the hike in glucose absorption (12). In other studies also, it has been reported that after 12, 20 and 40 hrs of fast, the recycling of glucose molecules through Cori cycle is about 18, 35 and 36% respectively (13). The experiment therefore tries to correlate the duration of fasting and any related structural and/or alterations in small intestine.

After 72 hours fasting, there is significant increase in glucose absorption in all the segments. It appears that increased absorption of glucose *in vivo* may be an adaptive mechanism to starvation enabling the tissues to derive maximum removal of glucose from intestinal tract and to supply glucose needed for vital organs of body like brain. Further starvation endows the absorptive cell membrane with an affinity

for glucose binding far in excess of the membrane of the normal mucosa.

Regarding histological studies, our findings are similar to the observations found in the previous studies. Brown, Levin and Lipkin reported that on 4th day of starvation, the villous cells were cuboidal rather than columnar and contained vacuolated cytoplasm (14). Similarly Rudo, Rosenberg and Wissler demonstrated shortening of villous length after starvation (15).

CONCLUSION

In our study, it was found that fasting for 72 hours causes an overall increase in absorption of glucose from small intestine. No significant changes, whatsoever, were encountered with xylose absorption in fasting animals. Increase in the glucose absorption in fasting from small intestine can well be explained on the basis of a reduction in glucose metabolism in general as an adaptation to starvation so as to leave more glucose for cerebral metabolism and ensure an adequate utilization of the intestinal contents.

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