

## EFFECT OF PROTEIN MALNUTRITION ON THE INTESTINAL ABSORPTION OF MONOSACCHARIDES IN RATS *IN VIVO*

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**Abstract :** The present study was planned to elucidate the role of protein malnutrition on the intestinal absorption of monosaccharides particularly – glucose and xylose, in inbred female albino rats. The experimental rats were fed with protein deficient diet containing 3% protein, whereas the control rats were given a diet containing 18% protein. The study on intestinal absorption of monosaccharides was conducted on both the groups of rats after the 7th and 15th day of receiving respective diets. The results indicated no significant impairment of glucose absorption of experimental rats fed 3% diet for 7 days as compared to the controls. However a 42% decrease in glucose absorption was observed when the animals were fed with the same diet for 15 days. The impairment was significant in all segments of intestine suggesting diminution in the absorption capacity of small intestine in malnutrition perhaps as a result of some permanent injury to mucosal cells of small intestine. Regarding xylose absorption, in experimental rats an increase of intestinal uptake was noticed in most of the segments of small intestine as compared to control rats.

**Key words :** monosaccharides protein malnutrition intestinal absorption

### INTRODUCTION

Protein malnutrition, the most important dietary deficiency in the world, has been identified as a major health problem in India. Failure of the young child to grow because of an insufficient protein intake is a classical sign of Protein calorie malnutrition (PCM). Adult PCM is seen even in industrialized countries among alcoholics and long term-hospitalized patients. PCM has been found to affect the normal histology of the small bowel (1). Extensive

research on PCM has been undertaken involving malnourished children as well as experimental animals (2). The reports have highlighted not only the digestive (3), absorptive (4) and morphological (5) alterations of small intestine in PCM but have also identified the accompanying enzymatic changes (6). Recently, Mata L demonstrated that diarrheal disease might be a cause of malnutrition (7). Unfortunately, most of the studies so far have been inconclusive. Therefore, in order to bridge the existing gaps in our understanding of

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PCM, the present study was conducted with the aim to determine the effect of protein malnutrition on the intestinal uptake of D-glucose and xylose in female albino rats.

## METHODS

Inbred strains of weanling female albino rats (40–70 gm) fed on standard laboratory diet (Table I) were used throughout the experiments. The animals were randomly divided into two groups – control and experimental in 2 sets. The numbers of animals to be used in the study were decided statistically depending on the previous studies and calculating  $\alpha$  and  $\beta$  values for the same to avoid type I and type II errors (statistical errors). In the first set, the control group (22 rats) received a synthetic diet containing 18% protein, whereas experimental group (22 rats) was given 3% protein diet for 7 days. Similarly in the second set, the control group (20 rats) and experimental group (20 rats) received the same diet as first set but for 15 days.

The intestinal uptake of monosaccharides was studied in both groups of rats after 7th and then 15th consecutive day of receiving respective diets. The animals were fasted for 12–16 hours, prior the absorption studies.

**Experiment:** The rats were anaesthetized with sodium pentothal (40 mg/kg body weight i.p.) and their abdomen was opened by a midline incision. Whole of the small intestine was washed with warm saline and 5–6 loops of intestine, approximately of equal size lying between proximal jejunum and distal ileum were prepared (8). The

loops were numbered as 1, 2, 3 starting from oral direction. These loops were then injected with a known volume of 300 mM sugar in normal saline using the tuberculin type syringe. The animal was bled to death by incising the aorta after an absorptive period of 10 minutes. Excised loops were 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 at the end of experiment. The results were expressed in terms of  $\mu$  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 110–120°C for 2 hours. Estimation of glucose was done by the method of Robbo and Terkildson (9) while xylose was determined using Mejbaum's method (10).

## RESULTS

The extent of intestinal absorption of D-glucose in the control and experimental rats is depicted in Table II. The intestinal

TABLE I: Composition of synthetic diet to be fed to the experimental animals.

<i>Constituents</i>	<i>Control percentage</i>	<i>Experimental percentage</i>
Casein (protein)	18	3
Fat	5	5
Yeast	5	5
Salt mixture	4	4
Fat soluble vitamins	1	1
Starch	67	82
Total	100	100

TABLE II: Intestinal absorption of D-glucose and D-xylose ( $\mu$ moles/gm dry wt./hr.) in weanling rats *in vivo*.

		<i>Sac 1</i> (Proximal jejunum)	<i>Sac 2</i> (Distal jejunum)	<i>Sac 3</i> (Proximal ileum)	<i>Sac 4</i> (Distal ileum)	<i>Total</i> <i>absorption</i> <i>from all</i> <i>the rats</i>
Controls (18% protein diet fed for 7 days)	D-glucose	2447 $\pm$ 216	4252 $\pm$ 343	3664 $\pm$ 269	3173 $\pm$ 227	3674 $\pm$ 148
	D-xylose	2695 $\pm$ 154	2925 $\pm$ 193	2290 $\pm$ 59	2531 $\pm$ 69	2610 $\pm$ 80
Experimental (3% protein fed for 7 days)	D-glucose	3976 $\pm$ 245 ( $>0.1$ )	4048 $\pm$ 343 ( $>0.5$ )	3899 $\pm$ 339 ( $>0.5$ )	3567 $\pm$ 253 ( $>0.2$ )	3897 $\pm$ 220 ( $>0.3$ )
	D-xylose	3150 $\pm$ 191 ( $>0.5$ )	2171 $\pm$ 78 ( $>0.2$ )	2108 $\pm$ 66 ( $>0.5$ )	2424 $\pm$ 111 ( $>0.3$ )	2426 $\pm$ 66 ( $>0.9$ )
Controls (18% protein diet fed for 15 days)	D-glucose	2832 $\pm$ 324	3495 $\pm$ 155	2433 $\pm$ 115	2762 $\pm$ 60	2878 $\pm$ 135
	D-xylose	2916 $\pm$ 90	1806 $\pm$ 170	1822 $\pm$ 195	1721 $\pm$ 51	2056 $\pm$ 168
Experimental (3% protein fed for 15 days)	D-glucose	1454 $\pm$ 66 ( $>0.01$ )	2005 $\pm$ 57 ( $>0.001$ )	1534 $\pm$ 71 ( $>0.001$ )	1271 $\pm$ 68 ( $>0.001$ )	1566 $\pm$ 32 ( $>0.011$ )
	D-xylose	3686 $\pm$ 434 ( $>0.05$ )	2795 $\pm$ 231 ( $>0.05$ )	2594 $\pm$ 141 ( $>0.02$ )	1673 $\pm$ 128 ( $>0.6$ )	2790 $\pm$ 338 ( $>0.05$ )

absorption of D-xylose in control and experimental rats is presented in Table II. It can be seen clearly from Table II that the experimental rats fed 3% protein diet for 15 days showed statistical significant decrement of intestinal uptake of D-glucose as compared to the control rats given 18% protein diet for 15 days. However the rats 3% protein diet for 7 days showed no significant impairment as compared to control rats. Regarding xylose absorption, in experimental rats an increase of intestinal uptake was noticed in most of the segments of small intestine as compared to control rats.

**Statistical analysis:** The results are presented as mean  $\pm$  S.D. The data were analyzed using paired 't' test. P values  $<0.05$  were considered significant.

## DISCUSSION

Regarding intestinal absorptive function,

the intestinal uptake of sugars has been the most studied due to their water-soluble nature as well as availability of detailed information about their metabolism and nutrition. From the study of the factors affecting absorption, protein deficiency states emerge out to be the most important. The prevalence of PCM in India is very high; therefore a thorough understanding of its etiology and the alterations induced in various organ system of the body is essential. Keeping these facts in mind, the present study was conducted to determine the role of protein malnutrition on the intestinal uptake of D-glucose and xylose, in weanling rats. In our study we have reduced the protein content in the experimental rats diet with compensatory increase in the starch to balance the energy requirements of the animals. In this way we have tried to show the effect of only protein malnutrition and have not included the effect of calorie malnutrition on the absorption of sugars in the study. Rose et

al (11) had showed that protein deficiency causes a lengthening of synthetic phase(s), thereby impairing the functional capacities of small intestine. The study was thus conducted on growing rats, as their requirement for calorie and protein required for growth are considerably large in comparison to the adult animals. Our results have indicated a diminution of intestinal glucose absorptive capacity of protein deficient rats. Glucose is basically absorbed and transported by secondary active transport with Na<sup>+</sup> (co-transport, or symport, the sodium dependent glucose transport). Hopfer et al demonstrated that absorption of D-glucose from rat small intestine was ten times faster as compared to L-glucose (12). Similar to our findings, a decreased transport of amino acids has also been reported (13). The studies conducted on malnourished children have also shown a significant reduction of intestinal absorptive capacity for glucose (14, 15). In contrast to our findings Lifshitz et al (4) observed an increase of glucose absorption in protein deficient but in older rats. The importance of aging in intestinal absorption has also been reported. The reduction of intestinal absorption of glucose in protein deficient rats in our experiment can be attributed either to the reduction of absorptive capacity of individual intestinal cells or as a result of decrease of absorptive cell population per unit of dry tissue. Regarding the absorption of pentoses (xylose) there is a view that these are absorbed by simple diffusion. Since no protein carriers are involved in their transport, the absorption of pentoses is unaffected by protein malnutrition. Our results show an increased

xylose absorption, which can be attributed to energy deficit states during which the energy needs are met by oxidizing xylose.

In a longitudinal study, the effect of nutritional rehabilitation on gastrointestinal function in kwashiorkor and marasmus has been shown (16). Similar effect of maternal protein deprivation on the development of neonatal intestinal function in rats has been also observed (17). In a related study, Nagpaul JP et al demonstrated the effect of steroidal oral contraceptive on intestinal absorptive functions in protein deficient rats (18). Similarly, other studies have also demonstrated the effect of sulfasalazine on adaptive and functional changes in intestine of normal and protein calorie malnourished rats (19). Recently it has been found that even mild to moderate malnutrition decreases the digestion and absorption of carbohydrates throughout the small intestine (20, 21).

The body normally does not absorb D-Xylose, however, it starts taking up D-Xylose during the malabsorption. Protein malnutrition may lead to malabsorption of Glucose due to villous atrophy conversely an increased uptake of D-Xylose - an indicator, of malabsorption. The study can be correlated to the Protein Calorie malnutrition, of which we have only considered the protein malnutrition. However there is an indication that protein malnutrition may adversely affect the absorption of hexoses due to intestinal atrophy thereby leading to a calorie deficient state.

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