STUDIES IN COELIAC DISEASE : FAT ABSORPTION

BY

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Reasons were given in 1948 (Sheldon) for thinking that in coeliac children starch intolerance might be of greater etiological significance than a failure to absorb the products of fat digestion. In a later communication (Sheldon, 1949), from a study of fat balances in a group of fifteen children with coeliac disease, it was concluded that withdrawal of starch from the diet was accompanied by a rise in fat absorption averaging 15 per cent.

Dietary Dextrin and Fat Absorption

The mechanism by which dietary starch in coeliac children interferes with the absorption of fat is not at present understood, but the question arises whether this effect is attributable to undigested starch, or whether the first product of starch digestion, namely dextrin, also interferes with fat

absorption. To test this, it was decided to carry out fat balances on a small number of coeliac children, performing a balance first of all on a starch-free diet, and then repeating it after changing to a diet which should be not only starch-free, but the starch should be replaced as far as was practicable by dextrin.

The amount of dextrin in a normal diet is quite small, probably of the order of from 1 to 5 per cent. of the total carbohydrate, but the proportion of dextrin in the special starch-free diets that had been used in the previous balance experiments was definitely greater. A recent analysis of these diets shows that the dextrin content averaged 20 per cent. of the total carbohydrate, the remainder consisting of cane sugar, fructose, and glucose.

Previous experience with fat balance investigations had indicated that the period of a balance could be reduced from twelve to eight days without losing

TABLE 1

RESULTS OF FAT BALANCE INVESTIGATIONS ON FOUR CHILDREN WITH COELIAC DISEASE

Starch-free Diet			Starch-free Diet (with extra dextrin)	
Case	Diet	Percentage Fat Absorption (8-day period)	Diet	Percentage Fat Absorption (8-day period)
M.B.	Protein 88 g. Fat 68 g. Sugars 180 g. (20% dextrin)	94	Protein 54 g. Fat 61.5 g. Sugars 159 g. (40% dextrin)	84
C.L.	Protein 89 g. Fat 65 g. Sugars 189 g. (20% dextrin)	84	Protein 68 g. Fat 66.5 g. Sugars 208 g. (50% dextrin)	75.5
C.I.	Protein 104 g. Fat 57 g. Sugars 200 g. (20% dextrin)	88.5	Protein 66 g. Fat 67 g. Sugars 208 g. (50% dextrin)	69
J.R.	Protein 77 g. Fat 49.5 g. Sugars 185 g. (20% dextrin)	92	Protein 77 g. Fat 40.5 g. Sugars 175 g. (26% dextrin)	70
	Average	90		75

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reliability, and therefore each balance was carried out over two consecutive periods of four days, the results being totalled to give an eight-day figure. The investigation was performed on four coeliac children, and the results are set out in table 1.

The first three cases are strictly comparable to each other, as at the completion of the balance on the first diet the high dextrin diet was started, and the second balance was carried out a month later. In the fourth case the first balance was conducted in July, 1948. The starch-free diet was then maintained, to the child's advantage, until the latter half of October, 1948, when it was changed to one containing 45 g. of starch. The fat absorption thereupon fell to 83 per cent. On November 12 the starch was removed from the diet and was replaced by an equal amount of dextrin, the 'dextrin balance' being started on November 22. The introduction of starch not only depressed the fat absorption, but was accompanied by a slight loss of weight and a setback in temperament, and it may be that these adverse effects were still operative at the time of the balance on the dextrin diet.

It will be seen that a high content of dextrin in the diet produced much the same effect in lowering the absorption of fat as has been previously reported to occur when starch was given. In addition the children became capricious and difficult to feed, and more irritable. For these reasons the high dextrin diets were abandoned because they proved to be just as unsuited to coeliac children as diets containing starch.

Dietary Starch and Fat Absorption in Pancreatic Fibrosis

The demonstration that starch in the diet of coeliac children depresses their capacity to absorb fat raises the problem of whether this is peculiar to coeliac children or applies also to other forms of steatorrhoea. In pancreatic fibrosis we have another disease of childhood which surpasses even coeliac disease in the severity and persistence of its steatorrhoea, and it was therefore decided to repeat on a group of four children suffering from pancreatic fibrosis the fat balance experiments that had previously been carried out on coeliac children.

The methods have been already described (Sheldon, 1949) and therefore need not be repeated here. The fat balances were carried out over two consecutive four-day periods, the results being totalled to give an eight-day balance. The first three children underwent a fat balance while receiving a starch-containing diet, and were then changed to a starch-free diet, and after an interval of twelve, fourteen, and nine days respectively their fat balance was repeated while they were on the second diet. The experiment on the fourth child was reversed, beginning with a fat balance during a starch-free diet, and then changing to a starch-containing diet, the second balance beginning eight days after the change of diet.

Throughout the tests none of the children received pancreatin.

The diagnosis of fibro-cystic disease of the pancreas in each child was based not only upon the

TABLE 2

RESULTS OF FAT BALANCE INVESTIGATIONS ON FOUR CHILDREN WITH PANCREATIC FIBROSIS

Case	Age (in years)	Starch-containing Diet		Starch-free Diet	
		Diet	Percentage Fat Absorption (8-day period)	Diet	Percentage Fat Absorption (8-day period)
D.C.	10	Protein 42 g. Fat 50 g. Sugars 65 g. Starch 111 g.	38	Protein 80 g. Fat 50 g. Sugars 135 g. No starch	32
A.F.	1½	Protein 48 g. Fat 59 g. Sugars 57 g. Starch 43 g.	45	Protein 61 g. Fat 76 g. Sugars 176 g. No starch	44
A.T.	4½	Protein 44 g. Fat 58 g. Sugars 123 g. Starch 99 g.	76	Protein 52 g. Fat 62 g. Sugars 142 g. No starch	81
A.H.	6½	Protein 73 g. Fat 80 g. Sugars 61 g. Starch 114 g.	38	Protein 74 g. Fat 79 g. Sugars 175 g. No starch	37
		Average ..	49·25		48·5

classical clinical picture, in which the nutritional calamity resulting from the pancreatic disorder was accompanied by chronic suppuration in the lungs, but also by demonstrating the complete absence of tryptic activity in the duodenal juices. On one of the children Dr. Payne kindly performed blood amino-nitrogen curves after meals of casein and casein hydrolysate, obtaining results that have been described by West et al. (1946) as typical of this disease.

The results of the investigation are set out in table 2. The averaged results of the four children indicate that fat absorption is considerably lower in pancreatic fibrosis than in coeliac disease, and the presence or absence of starch in the diet makes no appreciable difference to the level of fat absorption. Thus with starch in the diet the fat absorption averaged 49.25 per cent, and with no starch in the diet the fat absorption averaged 48.5 per cent. It would therefore appear that whilst in coeliac disease the presence of starch in the diet lowers the capacity for fat absorption, this is not true of all forms of steatorrhoea; it does not apply to the steatorrhoea that occurs in pancreatic fibrosis.

Chylomicron Counts

The older view of the physiology of fat absorption, namely that all fat has to be digested to fatty acids and glycerol before being absorbed into the lacteal system has been challenged by Frazer (1943). He has shown that a proportion of the dietary fat is finely emulsified in the upper intestine, and is absorbed as particles of fat into the lacteals, whence it is carried via the systemic circulation to the various fat depots in the body. The fat that escapes emulsification is digested to fatty acid and glycerol, and as such is absorbed into the portal system, to pass direct to the liver. With Stewart (1937), he has described a technique by which the finely emulsified fat particles in the serum can be counted. If a count is made on a fasting person, and then repeated at half-hourly intervals for three or four hours after a fatty meal, a lipaemia becomes apparent an hour after the meal, and reaches a maximum after two to three hours. By plotting these counts, a chylomicron curve indicative of particulate fat absorption is obtained. The method is similar to that used in arriving at a blood sugar curve after a meal of glucose, but differs in one important respect, for glucose after absorption into the portal system has to traverse the liver before reaching the systemic circulation, whereas particulate fat passes directly from the intestine into the lacteals, thoracic duct, and systemic circulation, and so avoids the liver.

The fat balances on coeliac children, to which reference has already been made, demonstrated a deficiency in fat absorption. By means of chylomicron curves, it was hoped to ascertain whether particulate fat absorption was defective, for were this not the case, the implication would be that coeliac children fail to absorb fat entirely at the expense of fat digestion and its absorption as fatty

acid and glycerol. Our results show that in active coeliac disease (before recovery has set in) the chylomicron curve tends to be flat, indicating that defective particulate fat absorption accounts, at any rate in part, for the low fat balances. This accords with the statement of Frazer (1946) that patients suffering from idiopathic steatorrhoea (non-tropical sprue), who absorb only some 70 per cent. of their dietary fat, do so without any apparent lipaemia as judged by chylomicron curves.

We have no means of showing whether the digestion of fat and the absorption of fatty acid and glycerol is also diminished, and therefore whether both routes of absorption of fat are reduced in coeliac children. We have, however, been able to confirm the finding of Farber et al. (1943), that the production of lipase in the duodenal contents of coeliac children is normal, and there is no reason to suppose that the action of this enzyme is defective.

The chylomicron counts have been performed by one of us (A.M.), following the technique described by Frazer and Stewart. The children received no meal after midnight. Next morning a fasting sample of blood was withdrawn from a finger, and a meal of butter, 1 g. per kg. body-weight, was then given, further blood samples being taken at half-hourly intervals for three or three and a half hours. The serum obtained from centrifuging the samples was examined under dark ground illumination, and the bright fat particles (of 0.5μ diameter) in a $1/12$ field were counted. Four counts were made on each specimen, and from these an average figure was obtained.

The results are shown in figs. 1-3. Fig. 1 shows

FIG. 1—Controls.

the curves obtained from six children between two and eight years old, whose digestion and stools were considered to be normal. These children acted as

FIG. 2—Before recovery.

controls. Their chylomicron curves show a rise in the number of fat particles per field in the first hour, the rise reaching a maximum in two to three hours. The maximum rise from the fasting level in these children averaged fifty-three particles per field.

Chylomicron curves have also been obtained from sixteen children with coeliac disease. Fig. 2 shows the curves from eight of these children, shortly after their admission to hospital, and before any clinical improvement had become apparent. It is evident that these curves, viewed as a whole, are much flatter than those of the control children, and the maximum rise from the fasting level in this group averaged twenty particles per field.

The remaining eight coeliac children were examined some weeks after admission to hospital,

FIG. 3—During recovery.

when their clinical state was steadily improving under the influence of a starch-free diet. Their chylomicron curves are shown in fig. 3, and it can be seen that in the aggregate they differ considerably from those in fig. 2, but approximate to the normal control curves in fig. 1. The maximum rise from the fasting level in these children averaged forty-three particles per field.

In view of the improvement in fat absorption which coeliac children experience when starch is removed from the diet, it was natural to enquire whether the chylomicron curves were affected if, immediately before the investigation, the children had been receiving a starch-containing or a starch-free diet. Figs. 4 and 5 show the effect of regrouping the curves from figs. 2 and 3 according to whether

FIG. 4—During starch-free diet.

FIG. 5—During starch-containing diet.

the preceding diet contained starch or was starch-free. The maximum rise from the fasting level in figs. 4 and 5 were the same, averaging thirty-three particles per field, and the two sets of curves are roughly similar. Our results suggest that in coeliac children the chylomicron curve is influenced more by the stage of the illness than by the composition of the diet immediately preceding the test. When the disease is active, particulate fat absorption appears to be defective; clinical improvement is accompanied by improvement in particulate fat absorption.

It is of interest that these results accord with those obtained by Kellett (1932) who reported a similar investigation made on three children with coeliac disease.

Summary

In children with coeliac disease, a high content of dextrin in the diet (26 to 50 per cent. of the carbohydrate as dextrin) lowers the capacity to absorb fat much as does starch.

In children with pancreatic fibrosis, the presence or absence of starch in the diet does not appear to

affect the capacity to absorb fat. In this respect, pancreatic fibrosis is in contrast to coeliac disease.

Chylomicron counts in coeliac disease indicate that defective absorption of particulate fat accounts, at any rate in part, for the failure to absorb fat adequately. Clinical improvement is accompanied by improvement in particulate fat absorption.

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