Absorption of nutrient energy in Southern Indian control subjects and patients with tropical sprue

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ABSTRACT Fecal energy excretion was measured by bomb calorimetry, in a group of 30 healthy volunteers and 15 patients with tropical sprue, to determine the absorption of nutrient energy. The mean energy absorption in the healthy volunteers (91.6%) was less than in similar subjects in temperate climates. The reduction of energy absorption in the volunteers, who all have tropical enteropathy, suggests that this condition leads to wastage of 5% of energy intake. In patients with tropical sprue the energy absorption was significantly lower. A strict metabolic balance study was not essential to detect energy malabsorbers.

KEY WORDS Energy, absorption, fecal energy loss, tropical sprue

Introduction

Optimal absorption of nutrient energy is one of the essential functions of the gastrointestinal tract. The routine clinical investigation of patients with malabsorption, measuring the absorption of fat, d-xylose, and vitamin B₁₂, does not directly estimate the absorption of energy. The diet in tropical developing countries is low in fat and has a low nutrient energy density, with high carbohydrate intake. The demonstration of steatorrhea, when individuals regularly consuming such diets are given 50 to 100 g of fat, may be of limited significance. The blood level or urinary excretion of the pentose, d-xylose, is not a direct measure of dietary carbohydrate absorption. Furthermore asymptomatic individuals in many tropical developing countries have morphological and functional abnormalities in the small intestine which has been designated nonspecific tropical enteropathy (NTE). In southern India, as a part of NTE, xylose malabsorption has been found in nearly 50% and steatorrhea in 10% of apparently healthy asymptomatic villagers (1). The exact pathogenesis of NTE is not known, although it is considered to be an adaptation to various environmental factors (2). It has been suggested that NTE may be responsible for a significant loss of nutrient energy in individuals (3).

The measurement of fecal energy losses by bomb calorimetry in individuals of known nutrient energy intake would provide a direct measure of energy absorption. This technique was used in a metabolic balance study in asymptomatic volunteer control subjects and in a group of patients with tropical sprue. The aim of the study was to evaluate the nutritional significance of NTE, especially low urinary xylose excretion, in asymptomatic individuals, and to quantitate energy malabsorption in patients with tropical sprue.

Materials and methods

Subjects studied

Thirty healthy adult volunteers from villages near Vellore with no history of diarrhea during the preceding

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2 months, and 15 patients with chronic diarrhea and malabsorption were admitted to a metabolic ward. The volunteers and patients were given a diet which was similar to the village diet, except that it contained 50 g of fat in the form of added butter. Adequate supervision in the metabolic ward ensured the completeness of 24-h fecal collections. Steatorrhea was shown by fecal fat of 6 g or more per day (4). Urinary excretion in 3 h of less than 20% of an oral dose of 5 g of d-xylose indicated xylose malabsorption (5). Vitamin B_{12} malabsorption was diagnosed when less than 0.2% of a 1 µg oral dose of Co^{57} vitamin B_{12} was found per liter of plasma, 8 h after oral administration (6). Fecal nitrogen was measured daily during the 7-day balance period by the micro Kjeldahl method (7). On the basis of fecal fat, d-xylose, and vitamin B_{12} absorption, during the 1st wk in hospital, the 30 healthy volunteers were divided into three groups, 17 with all standard tests of absorption normal, eight with xylose malabsorption only, and five with mild steatorrhea (Table 1). The 15 patients with tropical sprue had diarrhea for 1 month to 3 yr, weight loss, anorexia and abdominal distension. None of the patients malabsorbed fat, xylose, and vitamin B_{12}, while the other six had malabsorption of fat and xylose only (Table 1). There were morphological abnormalities in the jejunal mucosa (8) and conditions which could give rise to secondary malabsorption were excluded by detailed investigations as described elsewhere (9). This study was approved by the research committee of the institution.

Energy balance

After detailed base-line studies during the 1st week in the metabolic ward, the patients were maintained on the same diet with mean caloric intake of 2600 kcal per day of 60 g of protein, 50 g of fat, and 500 g of carbohydrates. Some of the subjects wanted more food at lunch and dinner and extras in the form of boiled rice with about 60 g of protein, 50 g of fat, and 500 g of carbohydrates. During the balance period of 7 days, the exact dietary consumption was measured. All stools passed by the subjects were carefully collected and kept in a refrigerator. Fecal collections 24 h were homogenized and aliquots taken for assay of fecal fat, nitrogen, and calo-

| TABLE 1 |
| Tests of intestinal absorption in the volunteers and patients* |
| Fecal fat | Fecal nitrogen | d-Xylose % in 5-h urine | Mean cal intake | Mean fecal cal | % Cal absorption |
| g/24 h | g/24 h | kcal | kcal |
| Control volunteers | | | | |
| Normal absorption (n = 17) | 4.7 (0.7) | 3.3 (0.9) | 29.2 (4.0) | 2819 (111) | 239 (53) | 91.5 (1.8) |
| Xylose malabsorption (n = 8) | 4.9 (0.8) | 2.8 (1.1) | 11.1 (5.1) | 2823 (202) | 205 (73) | 92.8 (2.5) |
| Steatorrhea (n = 5) | 7.9 (1.2) | 4.2 (0.9) | 23.8 (2.9) | 2742 (242) | 264 (69) | 90.2 (2.4) |
| Patients Tropical sprue (n = 15) | 13.0 (5.7) | 3.9 (1.2) | 13.5 (4.8) | 2645 (325) | 393 (85) | 84.7 (4.5) |

* Vitamin B_{12} absorption was normal in all the volunteers. Nine of the patients had vitamin B_{12} malabsorption. Figures in parentheses are SD. Mean fecal calorie excretion of the total group of volunteers (n = 30) was 234 kcal (± 59.5) and the mean percentage absorption of calories by the group was 91.6 (± 2.1).
FIG 1. Fecal calorie excretion and percentage of ingested calories absorbed in the four groups of subjects. N, controls with all tests of absorption normal; X, controls with isolated malabsorption of xylose; S, controls with isolated steatorrhea; M, patients with tropical sprue. The dotted lines and bars indicate mean ±2 SD of the normal control group. The four patients in group M whose fecal energy losses were in the range of the normal subjects are the same four who were in the normal range when percentage of ingested calories was calculated.

FIG 2. Correlation between fecal calorie excretion and fecal fat and fecal nitrogen.

Discussion

The absorption of dietary energy is more than 95% in subjects without malabsorption and fat ranged from 66.1% in patients with tropical sprue to 84.3% in controls with steatorrhea (Table 2). In most of the groups about a third of the fecal calories could not be accounted for by the fecal fat and nitrogen (Table 2).
in temperate climates (10, 11), but in normal volunteers in southern India, it was only 91.6%. The reduced efficiency of energy absorption may be significant in the pathogenesis of malnutrition in this population on marginally deficient nutrient intake. NTE or dietary fiber may be two possible factors contributing to decreased efficiency of nutrient energy absorption. Increasing dietary fiber intake to 40 g/day reduced the efficiency of energy absorption to 90% in temperate zone controls (10). Our subjects, all with NTE, were taking a diet similar to the rural diet containing 30 to 40 g of neutral detergent fiber per day (unpublished observations). Since NTE is an adaptation of the intestinal mucosa to the luminal environment (2), dietary fiber may also play a role in its pathogenesis, especially as it may alter intestinal mucosal morphology (12).

Fecal fat and nitrogen could not account for nearly a third of the fecal energy losses, probably due to unabsorbed carbohydrates. It is not possible to predict the extent of energy or carbohydrate malabsorption by assessing the absorption of d-xylose in healthy individuals, as isolated xylose malabsorption did not correlate with energy malabsorption (Fig 3). It has been shown that, although digestibility of available carbohydrates in temperate zone individuals is considered to be nearly complete (10, 11), 6 to 9% of dietary starch may be unabsorbed and enter the colon (13). Unabsorbed carbohydrate in the colon supports bacterial growth and multiplication, and the high fecal nitrogen in the present study suggests a large fecal bacterial mass (14, 15). The number of bacteria per gram of feces in southern Indian and temperate zone controls is similar when estimated by quantitative aerobic and anaerobic cultures (16). Since the fecal weight in southern Indian controls is two to three times more than in temperate zone controls, the total bacterial mass is likely to be considerably higher, although it has not yet been quantitated by physical methods (17).
Energy absorption and fecal excretion was in the normal range in four of the patients with tropical sprue who had malabsorption by other criteria. Although this suggests that the energy balance of these individuals was not adversely affected by the disease, follow up of a larger group of patients is necessary to evaluate the usefulness of this test in the malabsorption syndrome (11). The results presented here suggest that a cumbersome balance procedure is not essential, as it did not improve discrimination over mean fecal energy excretion (Fig 1). In subjects with energy intake around 2600 cal, the determination of mean 3- or 7-day fecal energy excretion gives a good estimate of the capacity of the intestine to absorb energy. The test can therefore be carried out in an outpatient or general ward situation and is no more cumbersome than fecal fat estimation.

References