

# Mineral and Vitamin Status on High-Fiber Diets: Long-term Studies of Diabetic Patients

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High-fiber diets have a beneficial impact on glucose metabolism of selected persons with diabetes mellitus. A major concern is the long-term effects of fiber intake on mineral and vitamin status. We measured serum concentrations of selected minerals and vitamins and also assessed three fat-soluble vitamins in 15 patients fed high-fiber diets for an average of 21 mo. Average values for serum calcium, phosphorus, alkaline phosphatase, iron, total iron-binding capacity, magnesium, and hemoglobin values were normal. Vitamin B<sub>12</sub> and folic acid concentrations in serum were also normal. Indirect assessment suggested that these patients had adequate intakes of the fat-soluble vitamins A, D, and K. These preliminary observations suggest that high-fiber diets containing a wide variety of natural foods are well tolerated for up to 51 mo; we failed to detect evidence suggesting mineral or vitamin deficiency in these patients. *DIABETES CARE* 3: 38–40, JANUARY–FEBRUARY 1980.

High-fiber diets may be useful in the treatment of selected patients with diabetes mellitus.<sup>1–4</sup> However, a major concern is that long-term use of high-fiber diets may lead to mineral or vitamin deficiencies.<sup>5,6</sup> Short-term studies have demonstrated variable changes in mineral balance after high-fiber diets<sup>5–8</sup> and decreases in serum folate levels.<sup>9,10</sup> Unfortunately, the chronic effects of high-fiber diets on mineral and vitamin status have not been well evaluated. Because diets containing large amounts of fiber may have beneficial effects in diabetic control, we have examined over a 21-mo period, in a preliminary fashion, the long-term effects of high-fiber diets on serum levels of minerals, folic acid, and vitamin B<sub>12</sub> and indirectly assessed three fat-soluble vitamins in 15 diabetic patients.

## METHODS

*Patients.* Fifteen patients with diabetes mellitus were studied. They averaged 50 yr in age with an average of 8-yr duration of diabetes. Eleven patients were lean (10 men and 1 woman) and 4 men were obese. Initially, 12 patients were receiving insulin, 2 were on sulfonylurea agents, and 1 was on no antidiabetes medication.

*Diets.* All patients were admitted to a metabolic ward and baseline measurements were made while on a control diet.<sup>4</sup> Subsequently, all patients were fed high-carbohydrate, high-fiber (HCF) diets<sup>4</sup> and received detailed instruction in high-fiber maintenance diets,<sup>2</sup> which provide 55%–60% of energy as carbohydrate and 25–35 g of plant fiber/1000 kcal.<sup>11</sup> These high-fiber maintenance diets provided approximately the following percentages of the recommended daily allowances (RDA): vitamin A, 40%; B<sub>6</sub>, 97%; B<sub>12</sub>, 51%; C, 781%; niacin, 109%; riboflavin, 109%; thiamine, 138%; calcium, 102%; phosphorus, 185%; magnesium, 119%; and iron, 174%.<sup>12</sup>

After discharge from the hospital the patients were seen at 3–8-wk intervals, adherence to the diet was encouraged, and food intake was estimated from multiple 24-h diet recalls and diet diaries maintained by the patients. Three patients were taking one multivitamin capsule per day before admission to the hospital. They were maintained after discharge on these vitamin supplements, which provided 100% of the RDA for vitamins A, B<sub>12</sub>, D, and folate. None of the other 12 patients received vitamin or mineral supplements before these follow-up measurements.

*Measurements.* On the control and high-fiber diets, measurements of hemoglobin, serum calcium, phosphorus, and alkaline phosphatase were obtained. After an average of

21 ± 3 mo (mean ± SEM, range 5–51) on the high-fiber diets, prothrombin and partial thromboplastin times, serum folate, vitamin B<sub>12</sub>, carotene, iron, total iron-binding capacity, and magnesium were measured. Body weights and fasting plasma glucose values were measured at each visit. All studies on blood were performed in the clinical laboratory by conventional analytic techniques.

## RESULTS

**Body weights and glucose metabolism.** Lean individuals maintained their body weights well on the high-fiber diets whereas four obese patients lost an average of 10 lb. While on the HCF or high-fiber diets, insulin therapy was discontinued in eight patients and sulfonylurea therapy in two. Despite lower doses or no medication, fasting plasma glucose values were lower by an average of 12 mg/dl on the high-fiber diets than on the control diets in the hospital.

**Dietary compliance.** Most patients followed the high-fiber maintenance diets remarkably well. Compared with their prescribed diet, carbohydrate intake averaged 97%, protein intake 113%, fat intake 96%, and plant fiber 103%. Despite the intake of an average of 50 g/day of plant fiber, no adverse gastrointestinal side effects were observed.

**Mineral values.** After an average of 21 mo, hemoglobin values were stable and there were no significant alterations in serum calcium, phosphorus, or alkaline phosphatase. Average values for serum iron, total iron-binding capacity, and magnesium were within the normal range (Figure 1), with only a few individual values outside.

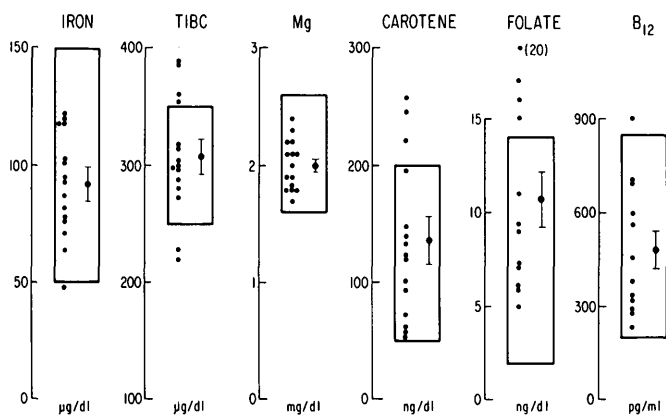


FIG 1. Serum iron, total iron-binding capacity (TIBC), magnesium (Mg) carotene, folate, and vitamin B<sub>12</sub> values in 15 patients fed high-fiber diets for an average of 21 mo. Normal ranges are indicated by boxes. Individual values are given (small dots) and mean values (larger dots) with SEM are presented to right of individual values.

**Vitamin assessment.** Serum folate and vitamin B<sub>12</sub> values were measured in the 12 patients who were not receiving vitamin supplements and all values fell within the normal range (Figure 1). The availability of vitamin D was assessed by measuring serum calcium phosphorus and alkaline phosphatase, and we have no evidence of vitamin D deficiency. Vitamin A levels were estimated by serum carotene measurements; all values were either normal or high (Figure 1). Vitamin K availability was assessed by measuring prothrombin and partial thromboplastin times; all these values were normal.

## DISCUSSION

Using serum levels to assess the status of selected minerals and vitamins, we failed to detect any deficiencies in patients who had received high-fiber diets for an average of 21 mo. Serum measurements may not have the sensitivity to detect minor inadequacies of these minerals and vitamins. Subtle deficits of trace minerals are especially difficult to detect clinically. Iron was the only trace mineral we evaluated. Despite these limitations, our study indicates that these diabetic patients tolerated high-fiber diets for up to 51 mo without evidence of calcium, iron, or magnesium deficiency.

Multiple mineral deficiencies have been observed in Iranian children who consume large quantities of whole-wheat bread.<sup>13</sup> However, only a limited number of investigators have evaluated prospectively the long-term effects of high-fiber diets on mineral status in adults. Vegetarians who have high-fiber intake usually maintain normal serum mineral levels if they carefully select their food.<sup>14,15</sup> Two long-term studies,<sup>16,17</sup> like ours, failed to detect evidence of mineral depletion. When wheat-bran supplements (24 g/day) were provided for over a minimum of 6 mo for 40 patients with diverticular disease, there were no significant changes in serum calcium, phosphorus, iron, or hemoglobin.<sup>16</sup> When two healthy subjects ate large quantities of whole-meal bread, transient negative balances of calcium and zinc were noted shortly after beginning the high-fiber diet; however, these imbalances returned to normal over a 21-mo span.<sup>17</sup> These observations<sup>17</sup> suggest that adaptive mechanisms may intervene to restore normal mineral homeostasis with long-term use of high-fiber diets. Although hypomagnesemia is fairly common among patients with diabetes,<sup>18,19</sup> none of our patients had subnormal serum magnesium levels despite their high fiber intake.

Only limited information is available about the long-term effects of high-fiber diets on vitamin metabolism. Several studies<sup>9,10</sup> have suggested that high-fiber diets might lead to a fall in serum folate levels. No abnormally low serum folate levels were observed in our patients. Diets that are restricted in animal products, as are ours, usually are somewhat deficient in vitamin B<sub>12</sub> content. Despite a low intake of vitamin

B<sub>12</sub>, surprisingly few vegetarians develop vitamin B<sub>12</sub> deficiency.<sup>15</sup> Serum vitamin B<sub>12</sub> levels were normal in all our patients, including those followed for as long as 36–51 mo.

Our observations suggest that normal mineral and vitamin levels were maintained over the 21-mo duration of this study. Thus, our data on 15 patients treated for diabetes indicate that a high-fiber diet can be formulated that supplies an adequate nutrient intake to prevent any discernible nutritional deficits. However, long-term studies will be necessary to determine the impact of high-fiber diets on trace mineral metabolism.

**ACKNOWLEDGMENTS:** This work was supported by the Veterans Administration and by a grant (1-RO1-AM20889-01) from the National Institutes of Arthritis, Metabolism and Digestive Diseases.

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