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Water Supplementation Enhances the Effect of High-Fiber Diet on Stool Frequency and Laxative Consumption in Adult Patients with Functional Constipation

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ABSTRACT

BACKGROUND/AIMS: The purpose of this study was to determine the effects of a high-fiber diet and fluid supplementation in patients with functional chronic constipation

METHODOLOGY: One hundred and seventeen patients with chronic functional constipation (aged 18-50 years) were randomly divided into two treatment groups. For two months both groups consumed a standard diet providing approximately 25 g fiber per day. Group 1 (58 patients) was allowed *ad libitum* fluid intake, while Group 2 was instructed to drink 2 liters of mineral water perday. Compliance was monitored throughout the study and results were assessed in terms of bowel-movement frequency and laxative use.

RESULTS: Fiber intake was similar in the two groups, while total daily fluid intake in Group 2 (mean 2.1 liters) was significantly greater than that of Group 1 (1.1 liters) ($p<0.001$). In both groups, there were statistically significant increases in stool frequency and decreases in laxative use during the two-month trial, but both changes were greater in Group 2 (stool frequency: $p<0.001$ vs. Group 1; laxative use: $p<0.001$ vs Group 1).

CONCLUSIONS: A daily fiber intake of 25 g can increase stool frequency in patients with chronic functional constipation, and this effect can be significantly enhanced by increasing fluid intake to 1.5-2.0 liters/day.

INTRODUCTION

A high-fiber diet is currently the treatment of choice for chronic functional constipation (1). Although individual responses can vary widely (2), increased fiber intake has been shown to augment fecal weight in healthy subjects (3). In many cases, however, the positive effects seem to diminish over time, suggesting that the colon somehow adapts to the increased fiber load (4). Chronic functional constipation is known to depend on numerous factors, including personality type, psychological stress, activity levels, drug use and socio-economic conditions (5). Low fluid intake is also thought to play an especially important role, and in clinical practice constipated patients are frequently advised to increase their daily intake of liquids (6-7), even though the efficacy of such measures has never been demonstrated in controlled studies.

In a study conducted by general practitioners in Germany, there was no evidence that an increased fluid intake alone had any therapeutic effect in cases of chronic constipation (8). In contrast, a study conducted on healthy, non-constipated subjects showed that daily fluid intake had a significant influence on both bowel-movement frequency and fecal mass (9). The present study was conducted to verify the possible effects of fluid supplementation and a high-residue diet in a group of adults with chronic functional constipation.

METHODOLOGY

The study was carried out in five Gastroenterology Units in Italy (2 in Rome, 1 in Chieti, Polla and Bologna) between October 1995 and April 1996. A total of 141 patients (aged 18-50 years) with functional constipation agreed to take part in the study after its objectives, methods and risks had been fully explained. Functional constipation was defined according to the "Rome criteria" (10). All of the patients had a history of constipation ranging from one to fifteen years with < 3 bowel movements/week. None had symptoms that were compatible with outlet delay (suspected obstructed defecation) (11). Organic causes had been excluded in all cases by double contrast radiographic studies of the large intestine or colonscopy performed within the 12 months preceding the study. Other exclusion criteria were neurologic disease, diabetes, diverticulosis, connective tissue and autoimmune disease, cardiac disease or previous bypass procedures, hypertension, hyperthyroidism, chronic liver disease, acute or chronic renal failure, inflammatory bowel disease or tumors, and regular use of drugs known to interfere with gastrointestinal function.

The patients were randomly assigned to one of two treatment regimens. Group 1 was placed on a diet that supplied approximately 25 g of fiber/day with *ad libitum* fluid intake **(Table 1)**. Group 2 was placed on the same diet and instructed to drink two liters of mineral water/day, preferably between meals. The mineral/ion content of the supplemental water consumed by Group 2 (Acqua ULIVETO-Terme Uliveto, Pisa, Italy) is also shown in **Table 1**. Neither of the groups was allowed to take crude fiber preparations during the treatment period, which lasted two months.

At the beginning of the study baseline body weight and serum electrolyte levels were recorded for each patient. A questionnaire was used to obtain information on the patient's physical activity level (number of hours/day spent in work-related and/or recreational activity), weekly bowel-movement frequency (based on the two weeks preceding the initiation of the study) and weekly laxative use (number of doses taken during the two weeks preceding the study). Normal dietary habits were also recorded based on reported food/liquid intake during three days of the preceding week, as previously described (12). During the study itself, each patient kept a diary to record bowel movements, laxative use and daily food and fluid intake. Every 15 days and at the end of the study, the patient was interviewed and 3-day food records were obtained, as described above. Heart rate and blood pressure were also recorded during each visit. Compliance was assessed on the basis of patient diaries, and, in Group 2, the number of mineral-water bottles returned to the investigating center. After the first month of treatment and at the end of the study, serum electrolytes were also re-evaluated.

Dietary data were analyzed by means of a database containing over 3500 items based on food tables supplied by the Italian National Institute of Nutrition (13). The results were subjected to statistical analysis based on the Student's t test for paired and unpaired (parametric) data, the Wilcoxon matched pairs test and the Mann-Whitney U test for non-parametric data. Logistic regression analysis was used to identify independent

TABLE 1 Daily Nutrient Intakes Provided by the Standard Diet during the Study and Ion Contents of Supplemented Water.

Diet		Water	
Energy (Kcal)	2230	Daily intake (L)	2
Proteins*	20.5%	pH	6.41
Fats*	29.5%	Na+ (mg/L)	113.7
Carbohydrates*	50%	K+ (mg/L)	11.6
Fiber (g/day)	25	Mg++ (mg/L)	30.5
Mg++ (mg/day)	356	Ca++ (mg/L)	206.1
Ca++ (mg/day)	1010	HCO3- (mg/L)	689.3
		Osmolality (mOsm/kg H2O)	36.413

* percent of total energy

variables and correlation was assessed with the Spearman test. A p-value of <0.05 was considered significant.

RESULTS

Of the 141 patients enrolled in the study, 24 (10 in Group 1 and 14 in Group 2) were excluded from the final analysis because of incomplete data series or poor compliance. The final study population was thus composed of 117 subjects. As shown in **Table 2,** the principal clinical and nutritional characteristics of the two groups were comparable at baseline, but Group-1 patients were slightly older than those of the water-supplemented group. **Table 3** shows the mean variation in clinical and dietary parameters (with respect to baseline findings) observed at the end of the two-month treatment period. There was a small, but significant, decrease in the mean body weight of Group 1, while that of Group 2 showed no variation. The daily intake of calories, fiber and water increased with respect to baseline in both groups. In Group 1 the higher fluid intake was probably due to greater thirst related to higher food intake with respect to pre-trial habits, while that of Group 2 reflected the prescribed mineral-water supplement. At the end of the study, bowel-movement frequency was significantly increased and laxative use was significantly less frequent in both groups, but the changes observed in the water-supplemented group were significantly greater than those observed in Group 1 (**Table 4**). Within the study population as a whole, the changes observed in bowel-

TABLE 2 Baseline Clinical and Nutritional Data of Patients Studied

	Group 1 (n=58)	Group 2 (n=59)
Age (yrs)$	42.5±13.6#	35.5±11.3
Sex (M:F)	20:38	23:36
Body weight (Kg)$	64.3±10.0	62.3±12.4
Fiber intake (gr/day)$	12.9±3.1	12.7±2.7
Fluid intake (L/day)$	1.0±0.2	1.0±0.4
Calory intake (Kcal/day)$	1764±306	1757±396
Daily physical activity* (hrs/day)$	8.2±2.8	7.8±2.8

Group 1: no water supplemented, Group 2: water supplemented

* Number of hours/day spent in work-related and/or recreational physical activity

$ Results expressed as mean ± (SD)

# $p < 0.05$ compared to Group 2

TABLE 3 Mean Variations in Dietary Parameters at the End of Treatment Period

	Group 1			Group 2		
	Pre-trial	Post-trial	Δ[a]	Pre-trial	Post-trial	Δ a
Body weight (Kg)	64.3±10.0	63.6±9.7*	-1%	62.3±12.4	62.1±11.6	-0.3%
Calory intake (Kcal/day)	1764±306	2237±371*	+26%	1757±396	2239±386*	+27%
Fiber (gr/day)	12.9±3.1	21.9±2.3*	+69%	12.7±2.7	21.0±2.5*	+65%
Fluid intake (L/day)	1.0±0.2	1.1±0.2*	+14%	1.0±0.4	2.1±0.1*	+110%#

Group 1: no water supplemented

Group 2: water supplemented

a: Change between pre- and post-trial values

* $p<0.001$ when compared to pre-trial levels

# $p<0.001$ when compared to Group 1Δ

TABLE 4 Stool Frequency, Laxative use and Mean Variations at the End of the Treatment Period

	Stool frequency (no/week)			Laxative use (doses/week)		
	Pre-trial	Post-trial	Δ[a]	Pre-trial	Post-trial	Δ[a]
Group 1	2.0±1.5	3.3±1.8*	+1.3	1.5±2.4	0.7±1.8*	-0.8
Group 2	1.8±1.5	4.2±1.3*	+2.4#	2.5±2.4	0.3±0.8*	-2.2#

Group 1: no water supplemented

Group 2: water supplemented

a: changes between pre- and post-trial values

* $p<0.001$ when compared to pre-trial levels

# $p<0.001$ when compared to Group 1

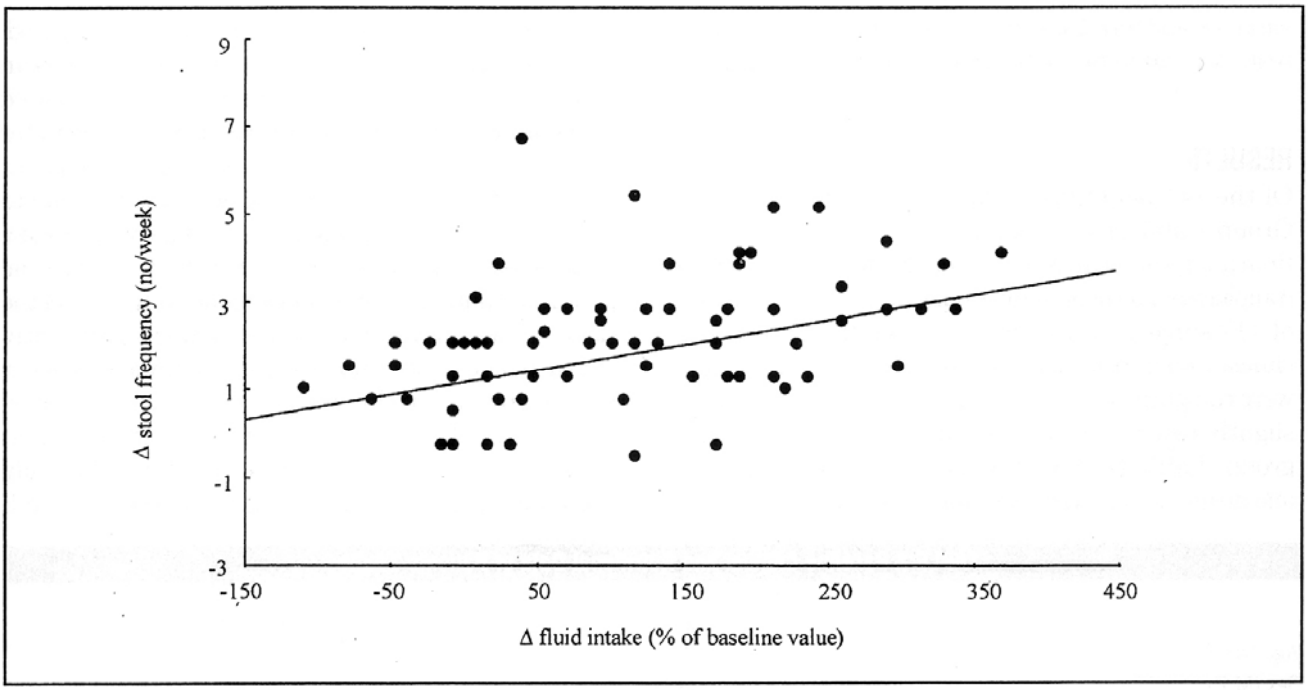

FIGURE 1: Correlation between changes (Δ) in stool frequency and fluid intake in the total study group. Sperman R=0.46 - p<0.005

movement frequency displayed a positive correlation with the changes in fluid intake (**Figure 1**). Logistic regression analysis revealed that this correlation was independent from fiber intake (data not shown). There were no significant variations in serum calcium or magnesium levels during the study.

DISCUSSION

Epidemiological studies conducted in the 1970s demonstrated that stool weight and oro-anal transit time were related to dietary fiber intake (14-15), leading to the popular view that low-fiber diets were the main cause of constipation in western countries (4). Later studies showed that the role of dietary fiber in functional constipation was less important than it had first seemed (16), and other factors were proposed as possible causes of constipation in adults (5) and in elderly subjects (11,17). In addition, the effects of fiber supplementation on stool output, fecal weight and transit time seems to be more evident in healthy subjects than in those suffering from constipation (2). However, a recent, prospective study has demonstrated that wheat bran is at least more effective than placebo in improving bowel-movement frequency and oro-anal transit time in patients with chronic functional constipation (1). In the constipated patients enrolled in our study, a significant increase in dietary fiber intake (from a baseline average of 12 gr/day to a mean of 21 gr/day) lasting two months led to significant improvements in bowel-movement frequency and laxative use. Compliance was satisfactory in all of the patients included in the final analysis, and in all probability these improvements can be attributed primarily to the high-fiber diet. The influence of psychological factors (e.g. the effects of participating in a controlled clinical trial, the reassuring presence of the physician on a regular basis) on the results obtained is difficult to estimate.

Our findings also show that the results achieved with dietary fiber can be significantly enhanced by a daily intake of approximately 1,5 L of mineral water containing 30.5 mg/L of magnesium and 206.1 mg/L of calcium. In fact, there was a positive correlation between the changes observed in stool frequency and daily fluid intake. The fact that the patients of Group 1 were slightly older than those of Group 2 is probably not significant, since the mean duration of constipation was similar in the two groups. In a recent study conducted on non-constipated volunteers, Klauser et al (9) also observed a correlation between fluid intake and

stool frequency. In these subjects, whose dietary fiber was not modified during the study, simple fluid restriction (i.e., <500 ml/day in the form of water and other beverages) significantly reduced the weekly frequency of bowel movements with respect to that observed during a control period in which fluid intake was 2500 ml/day. These investigators concluded that low fluid intake might be a contributing factor in some cases of idiopathic constipation, but it is not easy to establish a reliable cut-off between adequate and inadequate fluid intake. At baseline, our constipated patients had an average daily fluid intake of approximately 1 liter. It is difficult to identify the mechanisms that may have led to the positive effects we observed. The simplest explanation is that the fluid load increases the intestinal water content, producing softer feces and facilitating their transit through the gastrointestinal tract. We cannot confirm this hypothesis since fecal weight and characteristics were not examined. However, it is important to recall that liquids that are not osmotically bound to non-absorbable material like fiber are rapidly absorbed into the bloodstream and excreted by the kidneys. An increase in the intestinal water content generally occurs when the water load exceeds the absorptive capacity. In our study the amount of mineral water actually consumed by each patient of the supplemented group was approximately 1.5 liters /day. This supplementary intake was accompanied by an understandable reduction in the consumption of other beverages, but the mean fluid intake of Group 2 (2.1±0.1 L/day) was still consistently higher than that of Group 1 (1.1± 0.2 L/day). At any rate, it is difficult to determine whether the quantity of water consumed by the former patients could have produced any significant increase in intestinal water content. Although caloric intake was increased in both groups, Group 1 experienced a slight, but significant, decrease in body weight, which can be attributed to the diminished absorption of nutrients, and fats in particular, caused by the displacing effects of dietary fiber (18). This effect was not seen in Group 2, indicating that at least some of the supplementary water was, in fact, absorbed and retained. The mineral water used for supplementation contains 30.5 mg of magnesium and 206.1 mg of calcium per liter, and it is theoretically possible that these minerals contributed to the laxative effect of fluid supplementation. Magnesium, in particular, might form sulfate or citrate salts that would promote fluid retention in the digestive tract and indirectly alter motility (7).

It has been hypothesized that the increased bowel-movement frequency produced by water supplementation is, in part, mediated by hormones, such as arginine-vasopressin or ADH (9). These hormones are involved in the regulation of extravascular osmolarity and intra-vascular volume, and they also seem to influence colonic absorption and motility. Hard data to support this hypothesis are currently lacking, and the effect of vasopressin on colonic motility is particularly controversial (19). In a recent study, continuous, subcutaneous infusion of arginine-vasopressin had no effect on stool output or gastrointestinal transit time in healthy volunteers (20). Similar results have been observed with intravenous infusion of physiological doses of ADH (21). Another possibility is that even a mild increase in fluid intake over a prolonged period of time provides a more intense stimulus for the gastrocolic response (22).

Our study might be criticized for its use of weekly bowel-movement frequency as the primary index of treatment efficacy, without any analysis of the patient's symptoms. Stool frequency is considered by some to be an unreliable index of constipation (11,23), because it is poorly correlated with symptoms such as straining, pain and a sense of incomplete evacuation (24). However, earlier studies indicate that the latter symptoms show little correlation with gut transit time, and it is now widely accepted that patient's perception of bowel function plays a more important role than disturbed motor function in self-reported constipation (25). Our objective was to verify the effects of a high-fiber diet and water supplementation on objective clinical parameters, regardless of the subjective opinion of the patients, and bowel frequency and laxative use seemed to be satisfactory in this sense.

In considering the potential clinical application of our findings, two points should be emphasized. First, compliance can probably be expected to decrease over time. As far as the fiber intake is concerned, crude fiber preparations may be

successful in overcoming this problem. Second, the results we observed in our study population, which had a mean age of 38.8 12.8 years, may be less evident in elderly patients, since different factors seem to contribute to the disorder in this age group. (10,11,26). With these limitations in mind, however, it would appear that regular consumption of large quantities of liquids can be a safe and effective adjunct to a high-residue diet in the treatment of functional constipation.

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