Association Between Physical Activity, Fiber Intake, and Other Lifestyle Variables and Constipation in a Study of Women

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OBJECTIVE: Because the risk factors for constipation in the general population are poorly defined, we examined the association between age, body mass index, and selected lifestyle and dietary factors with the prevalence of constipation in the Nurses' Health Study.

METHODS: A total of 62,036 women, aged 36–61 yr and free of cancer, responded to mailed questionnaires in 1980 and 1982, which assessed bowel movement frequency, dietary, and lifestyle factors. Constipation was defined as two or fewer bowel movements weekly.

RESULTS: A total of 3327 women (5.4%) were classified as having constipation. Age and body mass index were inversely associated with constipation (*p* for trend < 0.0001). In multivariate analysis, women who reported daily physical activity had a lower prevalence of constipation (prevalence ratio [PR] = 0.56, 95% CI = 0.44–0.70). Women in the highest quintile of dietary fiber intake (median intake 20 g/day) were less likely to experience constipation (PR = 0.64, 95% CI = 0.57–0.73) than women in the lowest quintile (median intake 7 g/day). The PR for constipation for women who both reported daily physical activity and were in the highest quintile of fiber intake was 0.32 (95% CI = 0.20–0.54) compared with those with physical activity less than once weekly and those who were in the lowest quintile of fiber intake. Higher frequency of aspirin intake was associated with an increasing prevalence of constipation (PR = 1.38, 95% CI = 1.17–1.62). Current smoking and alcohol use were inversely associated with constipation.

CONCLUSIONS: Our data suggest that moderate physical activity and increasing fiber intake are associated with substantial reduction in the prevalence of constipation in women. (Am J Gastroenterol 2003;98:1790–1796. © 2003 by Am. Coll. of Gastroenterology)

INTRODUCTION

Constipation represents the most common outpatient digestive complaint in the United States and accounts for about 2.5 million physician visits annually (1). The greatest number of physician visits for constipation occurs in adults 65 yr of age and older (1). Patients tend to define constipation in terms of function, such as straining, incomplete defecation, and hard stool consistency (2). In contrast, physicians and investigators usually define constipation by stool frequencies twice weekly or less. According to an international classification, individuals with fewer than three bowel movements per week may be considered to be constipated (3, 4). Depending on the definition of constipation, the reported prevalence is as high as 34% in older women (over age 65 yr) (5, 6) and 30% in older men (7).

Despite the high prevalence, morbidity, and substantial cost as a result of physician visits and over-the-counter laxatives, the etiology of constipation or low bowel movement frequency among adults in the general population has received little systematic investigation. Numerous possible etiological factors have been proposed for idiopathic constipation, but their evaluation has frequently been from uncontrolled studies, short-term interventions, or anecdotal reports. Data from large-scale epidemiological studies are sparse. Using data from the first National Health and Nutrition Examination Survey, constipation was found to be more frequent in women, those with daily inactivity, low income, poor education, higher consumption of coffee and tea, and with some dietary variables, including lower fruit and vegetable consumption (8).

Because of the paucity of relevant data, we investigated the associations between age, body mass index (BMI), physical activity, dietary fiber intake, and other selected lifestyle variables (suspected or known risk factors) with prevalence of constipation, defined as two or fewer bowel movements weekly, in a large cohort of women. Because of the detailed information on multiple demographic, dietary, and lifestyle data, and the large sample size, we were able to control for many factors simultaneously and to determine the independent influence of each factor.

MATERIALS AND METHODS

Study Population and Assessment of Variables

The participants were a subset of women of the Nurses' Health Study, an ongoing prospective study among 121,700 female registered nurses in the United States. At enrollment in 1976, participants, who were 30–55 yr old and married, completed a mailed questionnaire that inquired about known or suspected risk factors for cancer and cardiovascular disease, anthropometric measures, physical activity, reproductive factors, other lifestyle exposures, family history of related diseases, and medical history. Beginning in 1980, a semiquantitative food-frequency questionnaire was administered. Physical activity was assessed through the following questions: "At least once a week, do you engage in any regular activity similar to brisk walking, jogging, bicycling, etc, long enough to work up a sweat? If yes, how many times per week?" Details of the design and follow-up of this cohort have been described previously (9, 10).

Women provided information about their bowel movement frequency on the 1982 Nurses' Health Study questionnaire that was mailed to the entire cohort. Possible answers for bowel movement frequency were more than once daily/daily/every other day/every 3–4 days/every 5–6 days/once a week, or less. On the 1982 questionnaire, we also queried participants about use of laxatives, including softeners, bulking agents, and suppositories. Possible answers were laxative use daily/at least once a week/one to four times a month/less than once a month/never. The reasons for laxative use and type of laxatives were not assessed.

The analyses for this study were limited to women who responded to the bowel movement frequency question in 1982 (n = 92,106). We excluded women who reported a diagnosis of ulcerative colitis before 1982 (n = 651) or who reported a cancer diagnosis other than nonmelanoma skin cancer preceding and including 1982 (n = 3,015). Because laxatives influence bowel movement frequency, we excluded laxative users from the main analysis (n = 26,404), but included them in an alternative analysis. A total of 62,036 women were included in the main analysis; of these, 3,327 reported bowel movement frequency every third day or less.

Statistical Analysis

We used logistic regression models to control simultaneously for multiple variables (11). We included in the models variables that are suspected or established risk factors for constipation, defined as two or fewer bowel movements weekly. Variables included age (six 5-yr categories), BMI (10 categories), nonoccupational physical activity (frequency of exposure; five categories), smoking history (never, past, current), aspirin use frequency (five categories), number of medications (five categories), and intake of alcohol (six categories), coffee (six categories), and dietary fiber (quintiles). We also considered menopausal status and postmenopausal hormone replacement use as covariates. In

the alternative analysis that included laxative users, laxative use was analyzed as a categorical variable (daily/weekly/monthly/less than monthly laxative use).

For age, BMI, postmenopausal status and hormone use, smoking history, and aspirin use, we used the status of 1982, and for physical activity, alcohol, coffee, and fiber intake, we used the covariate status of 1980, the year the food-frequency questionnaire was first administered. BMI (12), physical activity (13), fiber (14), alcohol (15), and coffee (16) have been shown previously to be reported with moderate-to-high accuracy using our methodology.

Prevalence ratios (PRs) for constipation were estimated by the ORs and 95% CIs for each category of dietary and other variables. In the multivariate analysis, the trends were tested using a single ordinal variable in a logistic regression model to represent the ordered categories of a prediction variable. The p values for the trends are two sided.

RESULTS

For all variables considered, results for the age-adjusted and multivariate analyses were similar (Table 1 and Fig. 1).

Age

In the multivariate analysis, age was inversely associated with constipation (p for trend < 0.0001). Compared with 35 to 39-yr-old women, women aged 60 yr and older had a multivariate-adjusted PR of constipation of 0.41 (95% CI = 0.32–0.52).

BMI and Physical Activity

BMI was inversely related to constipation (p for trend < 0.0001); women with a BMI > 29 kg/m^2 had a multivariate-adjusted PR of 0.48 (95% CI = 0.39–0.58) compared with women with a BMI < 21 kg/m^2. There was no association up to a BMI of 26 kg/m^2; then, the risk decreased with increasing BMI. Increased physical activity was associated with a reduced prevalence of constipation (p for trend < 0.0001). Women who reported physical activity two to three times per week had a multivariate-adjusted PR of 0.65 (95% CI = 0.59–0.71) and women who reported daily physical activity had a multivariate adjusted PR of 0.56 (95% CI = 0.44–0.70) compared with women with physical activity less than once weekly.

Medication, Including Aspirin Intake and Postmenopausal Hormone Use

Total number of medications was not associated with PR of constipation (p for trend = 0.09). Women who used three or more drugs per day (aspirin and hormone replacement not included, but controlled for) had a PR of constipation of 1.00 (95% CI = 0.75–1.34) compared with women who took no drugs. Increasing frequency of aspirin intake was associated with a higher prevalence of constipation (p for trend < 0.0001). Women who used 15 or more aspirin tablets per week had a multivariate adjusted PR of 1.38 (95% CI = 1.17–1.62) for constipation compared with

Table 1. Association Between Physical Activity, Fiber Intake, and Other Lifestyle Factors and Prevalence of Constipation Among 60,036 Women

Age in 1982 (yr)	35–39	40–44	45–49	50–54	55–59	≥60	p for Trend
No. of cases	712	797	681	581	467	89	
PR (univariate)	1.00	0.82	0.68	0.64	0.51	0.38	
PR (multivariate)*	1.00	0.83	0.70	0.67	0.54	0.41	<0.0001
(95% CI)	Ref.	0.75–0.92	0.63–0.79	0.59–0.76	0.46–0.62	0.32–0.52	

BMI	<21	21–21.9	22–22.9	23–23.9	24–24.9	25–25.9	26–26.9	27–27.9	28–28.9	>29	p for Trend
No. of cases	337	418	466	458	371	345	379	234	175	144	
PR (age adjusted)	1.0	1.10	1.07	1.03	1.03	1.07	0.90	0.88	0.67	0.55	
PR (multivariate)	1.0	1.10	1.07	1.01	1.00	1.02	0.85	0.83	0.61	0.48	<0.0001
(95% CI)	Ref.	0.95–1.28	0.92–1.23	0.87–1.17	0.86–1.17	0.88–1.20	0.73–0.99	0.69–0.98	0.50–0.73	0.39–0.58	

Physical Activity	Less Than Once Weekly	1/Wk	2–3/Wk	4–6/Wk	Daily	p for Trend
No. of cases	1454	671	782	340	80	
PR (age adjusted)	1.00	0.84	0.65	0.65	0.56	
PR (multivariate)*	1.00	0.84	0.65	0.65	0.56	<0.0001
(95% CI)	Ref.	0.77–0.93	0.59–0.71	0.57–0.73	0.44–0.70	

No. of Medications†	None	1 Drug/Day	2 Drugs/Day	≥3 Drugs/Day	p for Trend
No. of cases	2337	742	197	51	
PR (age adjusted)	1.00	0.93	0.84	0.90	
PR (multivariate)*	1.00	0.95	0.91	1.00	0.09
(95% CI)	Ref.	0.87–1.03	0.78–1.06	0.75–1.34	

Aspirin Intake	Never	1–3/Wk	4–6/Wk	7–14/Wk	≥15/Wk	p for Trend
No. of cases	1980	545	377	256	169	
PR (age adjusted)	1.00	1.03	1.00	1.09	1.30	
PR (multivariate)*	1.00	1.03	1.03	1.14	1.38	0.001
(95% CI)	Ref.	0.93–1.14	0.92–1.15	0.99–1.30	1.17–1.62	

Postmenopausal Hormone Use	Never	Past	Current	Premenopausal
No. of cases	876	279	277	1895
PR (age adjusted)	1.00	0.91	1.09	0.94
PR (multivariate)*	1.00	0.92	1.07	0.92
(95% CI)	Ref.	0.80–1.06	0.93–1.23	0.83–1.02

Smoking Status	Never	Past Smoking	Current Smoking
No. of cases	1517	979	831
PR (age adjusted)	1.00	1.00	0.89
PR (multivariate)*	1.00	1.04	0.81
(95% CI)	Ref.	0.95–1.13	0.74–0.89

Daily Alcohol Intake (g)	0	0.8	1.8	4.7	7.7	12.9	30.4	p for Trend
No. of cases	1329	545	383	288	272	291	219	
PR (age adjusted)	1.00	1.05	1.11	0.95	1.03	0.87	0.72	
PR (multivariate)*	1.00	1.06	1.09	0.94	0.99	0.83	0.66	<0.0001
(95% CI)	Ref.	0.95–1.18	0.97–1.23	0.82–1.07	0.86–1.14	0.73–0.95	0.57–0.77	

Daily Coffee Intake (Cups)	Never	<1/Wk	Several Times/Wk	1/Day	2–3/Day	4–6/Day	≥6/Day	p for Trend
No. of cases	1043	83	162	293	932	516	298	
PR (age adjusted)	1.00	0.77	0.91	0.81	0.89	0.97	1.14	
PR (multivariate)*	1.00	0.76	0.90	0.79	0.89	0.97	1.17	<0.0001
(95% CI)	Ref.	0.60–0.95	0.76–1.07	0.69–0.91	0.81–0.98	0.87–1.09	1.02–1.34	

Total Fiber Intake (g)	7.1	10.2	12.5	18.1	20.2	p for Trend
No. of cases	742	635	959	544	447	
PR (age adjusted)	1.00	0.87	0.83	0.78	0.65	
PR (multivariate)*	1.00	0.86	0.79	0.77	0.64	<0.0001
(95% CI)	Ref.	0.77–0.96	0.72–0.89	0.69–0.87	0.57–0.73	

* Multivariate PR is from a logistic regression model containing age, BMI, smoking status, postmenopausal hormone use and status, physical activity, aspirin use, number of medications, alcohol, coffee, and fiber intake.
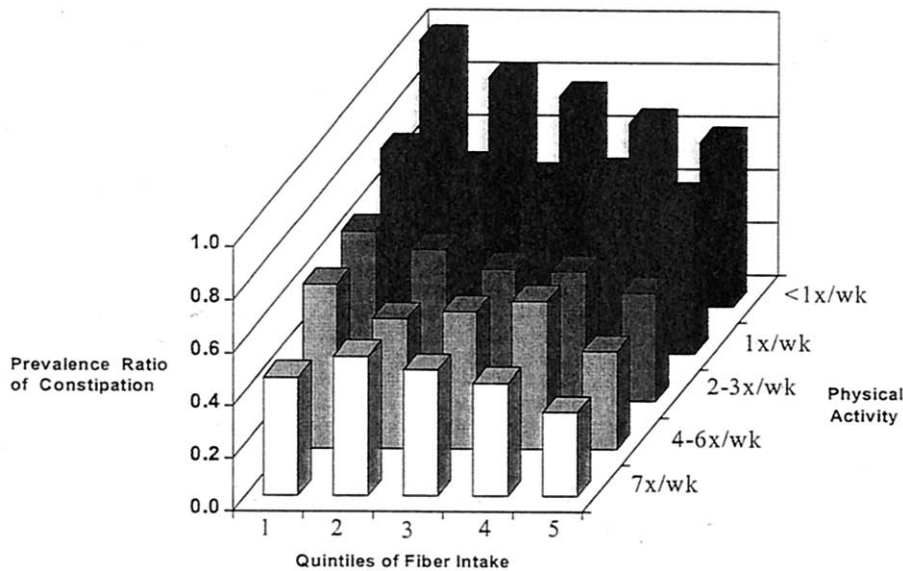   † Aspirin not included.

Figure 1. Combination of physical activity and fiber intake and prevalence of constipation.

women who never used aspirin. Postmenopausal hormone use was not associated with constipation (multivariate-adjusted PR = 1.07, 95% CI = 0.95–1.23) for women with current hormone use compared with women who never used hormones.

Smoking, Alcohol, and Coffee Consumption

Relative to never smoking, current smoking was associated with a slightly reduced multivariate-adjusted risk (PR = 0.81, 95% CI = 0.74–0.89), whereas past smoking had no association with constipation (PR = 1.04, 95% CI = 0.95–1.13). Daily alcohol consumption was inversely associated with constipation (p for trend < 0.0001), though at least one drink (approximately 12 g of alcohol) per day was required to observe the lower prevalence. Women with a median daily alcohol intake of 30.4 g had a multivariate adjusted PR of 0.66 (95% CI = 0.57–0.77) compared with women who did not drink alcohol. Coffee intake seemed to have a nonlinear relation with constipation. Women who drank six or more cups of coffee daily had a slightly increased multivariate-adjusted PR of 1.17 (95% CI = 1.02–1.34) for constipation compared with women who did not drink coffee. Low coffee intake (one cup/day or less), however, was inversely associated with constipation (PR for one cup/day = 0.79, 95% CI = 0.69–0.91) compared with women who did not drink coffee.

Dietary Fiber

Higher dietary fiber intake was associated with a decreased prevalence of constipation (p for trend < 0.0001), even though the median fiber intake for women in the highest quintile was 20 g daily, which is below the recommended fiber intake of 30 g/day. Women in the highest quintile of fiber intake had a multivariate adjusted PR of 0.64 (95% CI = 0.57–0.73) compared with women in the lowest quintile of fiber intake (median daily fiber intake of 7 g). The median

daily fiber intake was relatively low for the whole cohort (12 g daily), and only 1% had a fiber intake of more than 30 g daily.

In a further analysis (Fig. 1), we classified women simultaneously by both physical activity and dietary fiber intake. In the multivariate analysis, the PR for constipation for women who both reported daily physical activity and were in the highest quintile of fiber intake was 0.32 (95% CI = 0.20–0.54) compared with those with physical activity less than once weekly and those who were in the lowest quintile of fiber intake. For women who reported physical activity two to three times per week and were in the highest quintile of fiber intake, the PR of constipation was 0.41 (95% CI = 0.33–0.50) compared with those with physical activity less than once weekly and those who were in the lowest quintile of fiber intake. The alternative analysis including laxative users showed similar results as the main analysis (data not shown).

DISCUSSION

Constipation is common in Western countries (17), possibly related to diet and lifestyle factors. Our study found that regular physical exercise and higher fiber intake were associated with reduced risk of constipation even after controlling for numerous factors. Women who were physically active daily and had approximately 20 g daily of fiber had a 3-fold lower prevalence of constipation compared with women who rarely exercised and had about 7 g daily of fiber.

Some authors (18–21) suggest that low bowel movement frequency is associated with functional abnormalities of the colon, which usually tend to worsen with aging. However, in our study, as well as in other studies (7, 22–24), age was inversely associated with bowel movement frequency. Co-

lonic transit may slow with aging but is highly variable (25). Although the majority of older people have stool frequencies in the normal range, laxative use increases with aging (8, 24). The study of Whitehead *et al.* showed that the use of laxatives is affected more by the desire to have a bowel movement than by actual frequency (7). Furthermore, the increase in laxative use with aging (8, 24) may result from the elderly having more defecation problems such as straining or suffering from hard stool consistency (7, 22, 24).

Another possible explanation for the inverse association between age and low bowel movement frequency in women may be the decreasing estrogen plasma levels after menopause. Increasing estrogen in the luteal phase of the menstrual cycle is associated with prolonged intestinal transit time (26), and diseases related to increased estrogen plasma levels have been shown to be associated with low bowel movement frequency (27–29). Data are not available about bowel movement frequency and aging in men in our study. However, most studies show that men are less likely to suffer from constipation than women (4, 6, 7, 30). In our study, current postmenopausal hormone use was associated with a slight, though not statistically significant, increased risk of low bowel movement frequency.

Increasing BMI was inversely associated with low bowel movement frequency. In other studies (8, 25, 31), BMI had no influence on colonic transit times or bowel movement frequency. The reason for this inverse association is not clear. However, within the normal range of BMI (<26 kg/m^2), we observed no relation with constipation.

We found an inverse association between physical activity and low bowel movement frequency. In our study, physical activity only two to six times a week was associated with a 35% lower risk of constipation and daily activity with a 44% lower risk relative to less than once daily. A review of studies of the influence of exercise on the GI tract indicates that the urge to defecate and bowel movements are frequently reported during and after exercise (32). However, results from other studies on the association between low bowel movement frequency and physical activity are inconsistent. One crossover trial (33) found a significant decrease in whole gut transit time during the exercise period, but defecation frequency did not change. Another trial in healthy young men (34) and one trial in young healthy subjects found no association between moderate physical activity and bowel transit (35). All three trials included small numbers of subjects, and none included reports of the subjects' bowel habits. In another study (36), two groups, one of which trained for 30 min at 70–80% of age-predicted maximal heart rate three times weekly for 6 wk, were tested before and after the training program. Although the running group's average transit time decreased from 35 to 24 h, the control group remained unchanged at 45 h (36). Contrary to most trials, several other cross-sectional studies found an inverse association between physical activity and constipation (8, 23, 24, 31, 37). In the first National Health and Nutrition Examination Survey, low physical activity level

was associated with a 2-fold risk of constipation (24). Exercise increases propulsive movements in the large intestine (38), and hormonal changes and mechanical effects during exercise may alter GI function. Other mechanisms for the influence of exercise are possible. For example, higher energy expenditure increases energy intake requirements, which may influence the total amount of dietary fiber consumed. However, in our analyses, controlling for fiber and further for energy intake did not appreciably change the results for physical activity. As shown in Figure 1, the associations for physical activity and fiber and bowel movement frequency were independent. The lowest risk was in the most active women with the highest fiber intake. Thus, the combination of a high-fiber diet and a high level of physical activity would tend to lead to the lowest risk for constipation.

The linearly increasing risk of constipation with increasing aspirin intake was also seen in two cross-sectional studies (30, 39) and in several large case–control studies and trials (40–43). Constipation as a side effect is also known for other nonsteroidal anti-inflammatory drugs (41, 42). The mechanism by which nonsteroidal anti-inflammatory drugs reduce bowel movement frequency remains unknown.

Our finding that smoking is inversely associated with constipation is supported by two other studies (44, 45). In a study by Cummings *et al.* (44), smoking withdrawal induced constipation, and in a study by Rausch *et al.* (45), transdermal application of nicotine increased rectosigmoidal emptying, suggesting that nicotinic acid may influence bowel motility (45).

Alcohol intake exceeding 12 g/day was inversely associated with constipation. Alcohol withdrawal has been associated with increasing intestinal transit time (46), and heavy alcohol consumption is associated with diarrhea (47) because of inflammation of the colonic mucosa and neurotoxicity observed with alcohol (46, 47). However, we observed an inverse association at moderate levels that are unlikely to be associated with these adverse effects of heavy drinking.

Coffee intake of more than six cups per day was associated with a slightly increased risk of low bowel movement frequency, whereas low-to-moderate consumption was associated with a reduced risk of constipation. In the study by Sandler *et al.* (8), constipated subjects reported higher consumption of coffee compared with controls. Coffee is known to induce an increase in colonic motility limited to the rectosigmoid region within 4 min of ingestion and lasting at least 3 min (48). This influence of coffee on rectosigmoid responses appeared primarily in men and women who claimed that coffee induced a desire to defecate (53% of women and 19% of men). The speed of the response indicated that coffee may induce a gastrocolonic response, possibly by acting on receptors in the stomach or small bowel and mediated by neural mechanisms or by GI hormones. Our observed association between large amounts of coffee and low constipation might be a result of coffee-induced

diuresis leading to dehydration, which has been associated with constipation (49) or to other unknown mechanisms.

Associations between dietary factors and constipation should be interpreted with caution because the reported diet may reflect changes in food decision caused by constipation. In our study, fiber intake was inversely associated with low bowel movement frequency. In intervention trials, adding fiber to specific diets increased bowel movement frequency (50, 51). The positive relationship between fiber intake and stool weight is well established (52). Other studies found a weak or null association between fiber intake and bowel movement frequency (8, 24, 28, 31, 37), possibly because of small sample size or a tendency for people who suffered from constipation to increase their fiber intake. In our study, the combination of higher fiber intake and regular physical activity was associated with a large decrease in prevalence of constipation. We are not aware of any study that examined the combination of these variables.

The large size of our study (62,036 women) allowed us to examine several demographic and dietary characteristics for a more complete description of low bowel movement frequency in U.S. women. A major strength of our study is the ability to control for known or suspected risk factors for low bowel movement frequency. One limitation of our study is that the question about bowel movement frequency was based strictly on self-report. However, nurses in this population have been shown to report a variety of medical factors with high accuracy. Although there are alternative ways to assess constipation, bowel movement frequency can be used most feasibly in a large population. However, bowel movement frequency represents only one component of the spectrum of constipation, and whether the same relationships we observed would hold for other clinical subtypes of constipation is not known.

Another limitation is that we may have underestimated absolute fiber intake because our food-frequency questionnaire in 1980 did not assess all sources of fiber. However, this diet questionnaire adequately ranked individuals by quintile of fiber intake, and in a subset of participants who completed detailed daily dietary records, the absolute intakes of fiber assessed by questionnaire and by dietary records were comparable (14). We do not know if higher intakes of fiber would further reduce risk of constipation. Another limitation is also that we did not assess fluid intake in the 1980 food-frequency questionnaire, so we could not exclude residual confounding by water intake.

A variety of lifestyle factors may influence the risk of constipation. Some of these factors, particularly regular physical activity and higher fiber intake, seem to be beneficial regarding constipation. Combining regular physical activity and increasing fiber intake may represent an important, inexpensive, and feasible therapeutic measure for this widespread digestive complaint. The possible influence of other factors, including BMI, aspirin use, alcohol, and coffee, on bowel movement frequency need to be considered in relation to their other effects on overall health status.

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