Digestive Diseases and Sciences, Vol. 41, No. 8 (August 1996), pp. 1631–1635

Factors Influencing Frequency of Flatus Emission by Healthy Subjects

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The purpose of the present study was to measure the frequency of flatus emission by 25 healthy subjects and to determine if factors commonly thought to influence flatulence actually correlate with the frequency of gas passage. Over a one-week period on their usual diet, subjects passed gas 10 ± 1 times/day [upper limit of normal (mean + 2 SD): 20 times/day]. The addition of the nonabsorbable disaccharide lactulose (10 g/day) to the diet significantly ($P < 0.01$) increased flatus frequency to 19 ± 2.4 times per day. Gender, age, and the ability of an individual's colonic flora to produce methane had no significant influence on flatus frequency either on the basal or lactulose-supplemented diets. Some subjects consistently passed gas more often than did others. These individual differences appeared to result, in part, from differences in the ability of the flora to produce gas from a given quantity of fermentable material.

KEY WORDS: flatulence; hydrogen gas; methane; lactulose.

While a sizable fraction of the population believes that they suffer from a problem with intestinal gas, data on what constitutes "normal" with regard to the passage of rectal gas are very scarce. For example, there has been much anecdotal speculation concerning such mundane questions as whether some subjects consistently pass more gas than others and whether age and gender influence flatus excretion, but these topics have not been scientifically studied. This lack of normative data limits the ability of the physician to respond rationally to patients who believe that they have a flatulence problem.

We recently carried out an extensive study of a variety of gaseous symptoms in healthy controls. The purpose of this paper is to present information on the frequency of flatus emission by normal subjects and the influence of several factors that are thought to enhance flatulence or its emission frequency.

MATERIALS AND METHODS

Twenty-five healthy subjects (13 women, 12 men) ranging in age from 21 to 59 took part in the study. Flatus excretion was monitored for one-week periods while the subjects' normal diet was supplemented, twice a day, with (1) 20 g of an absorbable soft drink flavoring (Tang) or (2) 5 g of the nonabsorbable disaccharide, lactulose, mixed with 20 g of Tang. The supplements were dissolved in one cup of water and ingested with breakfast and dinner.

Subjects scrupulously recorded the time of each passage of flatus by making a check mark at the appropriate time on a 24-hr scale.

The methane (CH_4) -producing status of the subjects was determined by breath analysis carried out at a time when the subjects were taking neither supplement. The CH_4 concentrations of atmosphere and end-alveolar air collected via a commercial apparatus (Gasampler, Quintron, Milwaukee, Wisconsin) were measured, and breath CH_4 concentration was expressed as parts per million above the atmospheric concentration (approximately 2 ppm). Thirteen subjects with an average breath CH_4 concentration of 27.3 ± 4.6 were deemed to excrete appreciable CH_4 while the other 12, whose breath CH_4 concentration averaged

Manuscript received December 8, 1995; revised manuscript received March 25, 1996; accepted May 23, 1996.

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Supported in part by the Department of Veterans Affairs, and the National Institute of Diabetes and Digestive and Kidney Diseases DK-13093.

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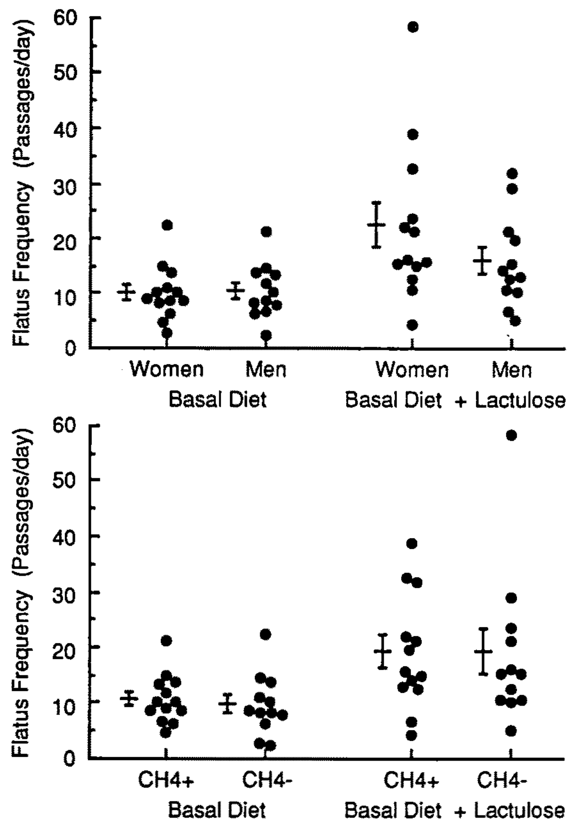

Fig 1. Flatus frequency of men versus women (upper panel) and methane producers versus methane nonproducers (lower panel) on the basal and laculose supplemented diets.

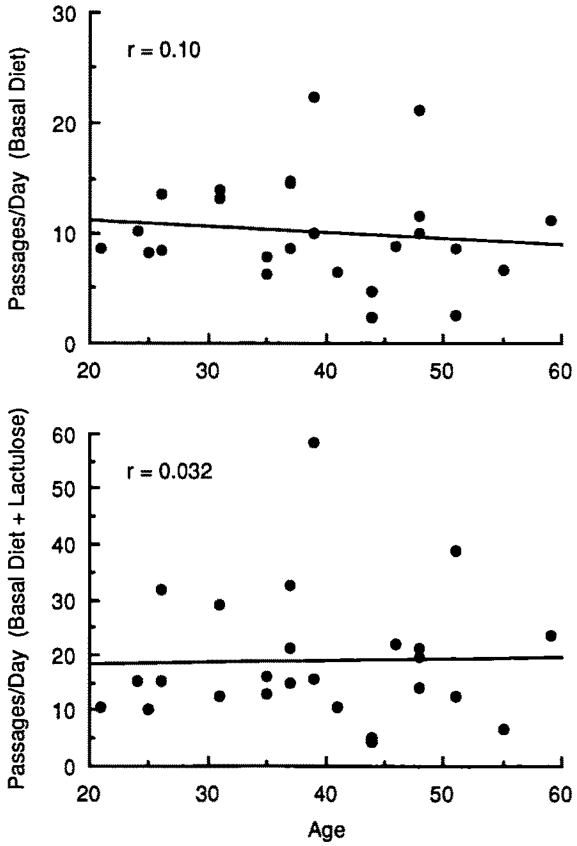

Fig 2. Correlation between age of subject and flatus frequency on the basal (upper panel) and lactulose supplemented (lower panel) diets.

0.5 ± 0.3 ppm, were considered to be negligible CH_4 producers. Methane concentrations were measured by gas chromatography using a flame ionization detector.

Unless otherwise designated, data are expressed as mean ± 1 SEM. Means were compared using Wilcoxon's signed-rank test, and significant differences were defined as $P < 0.05$. To determine if the emission frequency of each individual tended to be consistent, the subject's frequency of emission was ranked (ie, from 1, highest frequency, to 25, lowest frequency) on each day. This ranking was then correlated with the rankings on the other six days of the study. Pearson correlation coefficients were calculated between all possible combinations of days to estimated test–retest reliability (1).

The study was approved by the Human Studies Subcommittee of the VA Medical Center, Minneapolis, and all subjects gave written informed consent.

RESULTS

During the control period the mean frequency of gas passage of the 25 subjects was 10 ± 1.0 times per day and this value increased significantly ($P < 0.01$) to 19 ± 2.4 times/day when 10 g/day of lactulose was added to the diet. As shown in Figure 1 (upper panel), there was no significant difference in flatus frequency between men (11 ± 1.4) and women (10 ± 1.3) during the basal period ($P > 0.5$) or the lactulose period (men: 16 ± 2.4; women: 22 ± 4; $P = 0.20$).

Figure 1 (lower panel) shows the flatus frequency of the 13 methane producers and 12 methane nonproducers during the control and lactulose periods. Methane-producing status did not significantly ($P > 0.20$) influence the frequency of gas passage during either test period.

Figure 2 shows the relationship of age and flatus frequency. There was no significant correlation between age and flatus frequency during the basal or lactulose-supplemented periods.

Some subjects consistently appeared to pass gas far more frequently than did others. Figure 3 shows the mean daily flatus excretion rate during the control period for the five subjects with the highest (mean: 17 ± 1.8) and lowest (mean: 4.5 ± 0.9 per day) daily frequencies. This apparent consistency of individual subjects was confirmed by the finding that a ranking of the subject's frequency on a given day significantly

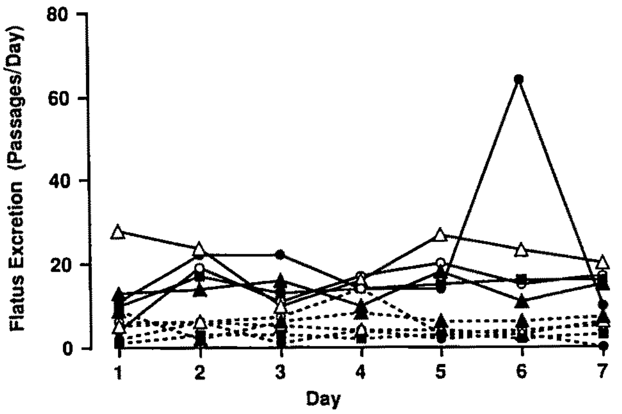

Fig 3. Daily flatus frequency during the one-week period on the basal diet of the five subjects with the highest (—) and the five with lowest (····) frequencies.

correlated ($P < 0.05$) with the ranking on all other days for 32 of the 42 daily comparisons.

As shown in Figure 4 (upper panel), the correlation coefficient of the flatus emission rate during the control versus the lactulose feeding periods was 0.70 ($P < 0.001$). There was a less good, but still significant, correlation ($r = 0.39$, $P = 0.05$) between the baseline emission frequency and the increment over the basal frequency during the lactulose period (Figure 4, lower panel).

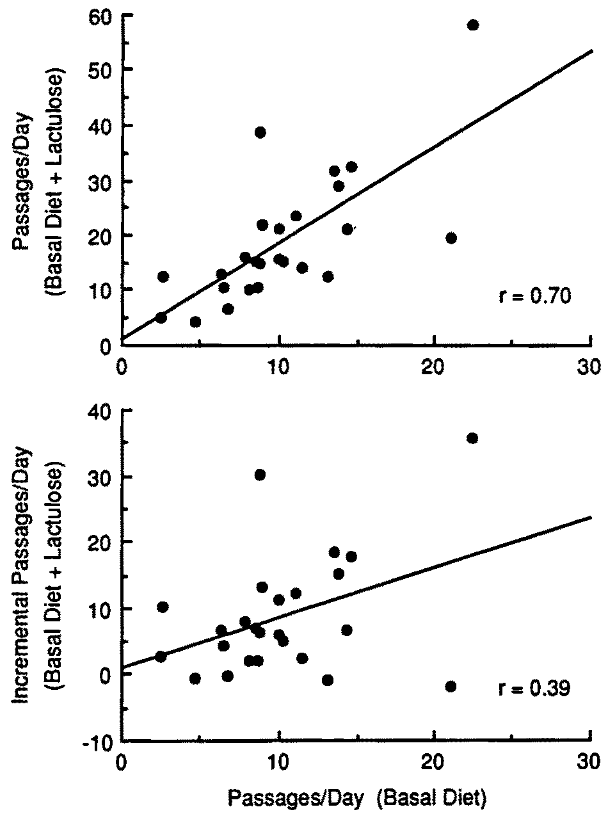

Fig 4. Correlation between the average daily flatus frequency of the 25 subjects during the week on the basal diet versus average daily frequency on the lactulose supplemented diet (upper panel), and average daily increment in frequency (over the basal level) during the week on the lactulose supplemented diet (lower panel).

DISCUSSION

Flatulence generally has been the province of lay conjecture and scatological humor rather than serious scientific investigation. As a result, there is a paucity of simple, basic information concerning what constitutes normal with regard to flatulence.

The goal of the present study was to obtain data on rectal gas excretion by healthy subjects. Unlike the situation with other excretory products, long-term quantitative collections of flatus are extremely difficult to obtain. The rectal tube provides quantitative collections but is uncomfortable, tends to plug, and cannot not be used for prolonged periods in free-living subjects. Recently, a technique has been described in which the subject is housed in an airtight chamber, and the excretion rates of H_2 and CH_4 are determined from the increase in their concentrations in the air supply to the chamber (2). Unfortunately, this elegant technique cannot be used by the practicing physician to assess complaints of flatulence.

In the present study we carefully assessed the one aspect of flatulence that can be readily monitored in clinical practice, the frequency of flatus passage. This technique obviously is not quantitative, since the volume of rectal gas is the product of emission frequency times average volume per emission, and individual gas passages have been reported to vary in volume from 33 ml to 125 ml (3). However, to the extent that the average volume per passage is relatively constant from one individual to the next, frequency provides a semiquantitative indicator of the volume of gas passed.

During the control period (regular diet supplemented with Tang), the 25 healthy subjects passed gas an average of 10 ± 1.0 times/day with an upper limit of normal (mean + 2 SD) of 20 times per day. The mean value of 10 times/day falls midway between the 8 times/day previously reported for 10 British subjects (3) and 13.6 times/day for seven American male medical students and residents (4).

It is commonly believed that ingestion of nonabsorbable, fermentable carbohydrates (via provision of substrate for colonic bacteria) is a major cause of excessive flatulence. This concept was documented in the present study, which showed that supplementation of the normal diet with 10 g/day of lactulose, a nonabsorbable disaccharide, significantly increased flatus frequency to 19 ± 2.4 times/day.

In contrast to the belief of most women, the flatus frequency of men and women did not significantly differ during either the basal or the lactose-supplemented periods (see Figure 1).

Complaints concerning flatulence are said to increase with increasing age. While the age range (22–59) in the present study was relatively narrow, no trend was observed to link age and flatus frequency on the basal or the lactulose supplemented diets (see Figure 2).

Hydrogen often constitutes a sizable fraction (up to 80%) of flatus (3). Bacteria both produce and consume this gas, and the quantity of H_2 available for excretion usually is only a trivial fraction of total production. Thus, efficiency of H_2 consumption might be expected to be an important determinant of flatus frequency. The type of colonic bacteria that consume H_2 varies markedly from individual to individual. About 40% of the population has a methanogenic flora that utilizes H_2 to reduce CO_2 to CH_4 (6). Since 4 mol of H_2 and 1 mol of CO_2 are consumed in the process of producing 1 mol of methane, this reaction theoretically should result in a marked reduction in total colonic gas volume (7). An additional roughly 35% of the population has a colonic flora that uses H_2 to reduce sulfate to sulfide, while the remaining 35% consume H_2 via relatively poorly defined mechanisms, perhaps acetogenesis (8). Since methanogenic feces consume H_2 far more rapidly than do sulfate-reducing or acetogenic feces (9), it has been suggested that induction of a methane-producing flora might be useful in nonmethanogenic subjects with flatulence problems (5). The present study, however, showed no appreciable difference in the flatus frequency of methane producers versus nonproducers (see Figure 1). Given the very high efficiency with which H_2 is consumed by methanogens relative to that of the other H_2-consuming mechanisms (9), this result was somewhat unexpected. A possible explanation is that the composition of the colonic flora changes as fecal material moves from the left to the right colon. Methanogens reside primarily in the left colon, whereas the bacterial fermentation reactions that release H_2 from soluble carbohydrates such as lactulose occur primarily in the right colon (10). As a result, H_2 produced in the right colon may be rapidly propelled past the semisolid to solid feces in the left colon, thus limiting the access of methanogens to this H_2.

Although never tested, there is a widespread belief that some individuals are consistently more flatulent than others. Perusal of our data suggested that this concept was correct. For example, as shown in Figure 3, five of our 25 subjects passed gas an average of only 4.5 ± 0.9 times per day during the one-week basal period, while five other subjects passed gas a mean of 17 ± 1.8 times per day. More rigorous statistical analysis confirmed that a subject's flatus frequency tended to be relatively constant from one day to the next. Individual differences in emission frequency during the basal period extended to the lactulose period, as evidenced by the statistically significant correlation coefficient ($r = 0.70$, $P < 0.01$) between the mean daily frequencies observed for individuals for the two treatment periods (see Figure 4, upper panel).

The lactulose data provide an insight into why some individuals consistently excreted gas more frequently than did others. The strong positive correlation that existed between flatus frequency on the basal and lactulose supplemented diets indicates that the factor that determined this frequency was acting during both dietary periods. If this factor were solely the ability of the flora to produce gas from a given quantity of fermentable substrate, the increment in frequency when lactulose was added to the diet should be directly proportional to the basal frequency. As shown in Figure 4, there was a significant positive correlation between the basal and incremental frequencies ($r = 0.39$, $P = 0.05$); however, this correlation was much weaker than that which existed between the total frequency observed on the basal versus the lactulose supplemented diets ($r = 0.70$, $P < 0.001$). These data suggest that individual differences in flatus frequency on the basal diet are partially accounted for by differences in gas production per gram of substrate fermented. Other factors, eg, differences in the availability of nonabsorbable, fermentable substrate in the basal diet, also appear to play a role in determining flatus frequency.

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