Improved lactose digestion and intolerance among African-American adolescent girls fed a dairy-rich diet

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ABSTRACT

Objective To determine whether African-American adolescent girls who were fed a dairy-rich diet for 21 days could adapt to lactose, experiencing an overall improvement in lactose tolerance as well as a decrease in hydrogen gas production.

Design Twenty-one–day dietary intervention study.

Subjects/setting Seventeen of 21 African-American girls (aged 11 to 15 years) enrolled in a calcium metabolism study chose to participate in the lactose tolerance study. Subjects were screened for any diseases, conditions, or medications that might alter calcium metabolism or colonic fermentation. Subjects were housed in a fraternity on the Purdue University, West Lafayette, Ind, campus, and were supervised 24 hours a day.

Intervention Subjects consumed a dairy-based diet averaging 1,200 mg calcium and 33 g lactose per day for 21 days. Lactose digestion was assessed by an 8-hour breath hydrogen test on days 1 and 21, and symptoms of intolerance (abdominal pain, bloating, flatulence, and diarrhea) were evaluated hourly on a ranked scale during the breath hydrogen tests and once each evening during the 21-day feeding period.

Main outcome measures A comparison of breath hydrogen production and gastrointestinal symptoms at the beginning and end of the study.

Statistical analyses performed The Wilcoxon signed ranks test was used to compare the area under the curve for the 2 breath hydrogen tests. Spearman's p test for trend was used to determine whether there was a change in symptoms. All statistical analyses were 2-tailed and significance was set at P=.05.

Results Fourteen of the 17 subjects had lactose maldigestion. Breath hydrogen excretion decreased significantly (P<.03) from the beginning (148.3±27.0 ppm×hours) to the end (100.7±19.3 ppm×hours) of the 21-day period. Gastrointestinal symptoms were negligible during both the breath hydrogen tests as were symptoms during the 21-day period.

Applications/conclusions The diet was well tolerated by the subjects. Furthermore, the decrease in breath hydrogen suggests colonic adaptation to the high-lactose diet. The results indicate that lactose maldigestion should not be a restricting factor in developing adequate calcium diets for this population. The existence of lactose maldigestion does not result in lactose intolerance in this population when it is fed a dairy-rich diet. *J Am Diet Assoc. 2000;100:524-528.*

Lactose maldigestion is the inability to completely digest lactose, the major carbohydrate found in milk (1). Intestinal digestion of lactose involves the breakdown of lactose into glucose and galactose by a membrane-bound lactase, located on the brush border of the small intestine (1,2). The resulting monosaccharides are rapidly absorbed into the portal circulation. In people with lactose maldigestion, a portion of the lactose load is not digested in the small intestine; it passes into the large intestine, where it is fermented by the colonic microflora. The fermentation produces short-chain fatty acids and gases, including hydrogen, carbon dioxide, and sometimes methane (1-3).

Approximately 75% of the world's population loses the ability to completely digest a physiological dose of lactose after infancy (1,4). When lactose maldigestion occurs in the absence of a gastrointestinal disease, it is known as primary lactase nonpersistence (4-6) and is directly related to the loss of the majority of intestinal lactase activity. It is estimated that 70% of adult African-Americans are lactose maldigesters (2). Lactose maldigestion may be evident in this population as early as age 3 (5). Furthermore, the percentage of African-Americans with lactose maldigestion approaches the adult average by 8 or 9 years of age (6,7). In some studies of African-American adolescents, the prevalence of lactose maldigestion has been reported to be as high as 83% (5).

People with lactose maldigestion may experience symptoms of intolerance depending on the dose of lactose consumed (8),

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gastrointestinal transit (8,9), the nature of the dairy food consumed (10,11), and the ability of the colon to metabolize the lactose (12,13). Symptoms of lactose intolerance may include abdominal pain, bloating, flatulence, and acute diarrhea (1,4,12). Most, if not all, people with lactose maldigestion are able to tolerate a glass of milk at a meal without developing any significant symptoms (4). Lactose consumed as part of a meal is also better tolerated than lactose consumed in milk or water as a result of the slower transit of lactose in a meal (9). Furthermore, several studies have reported that people with lactose maldigestion develop improved tolerance to lactose following repeated exposure (12,13). The mechanism for this adaptation is most likely an alteration in the metabolic activity of the colonic microflora. This improved tolerance is accompanied by a decrease in colonic hydrogen production and increased microbial β-galactosidase activity (3,12,13). No studies have been conducted to evaluate this improved tolerance in adolescent populations where calcium intakes of female and male African-American adolescents are 730 mg and 981 mg, respectively, whereas the adequate intake for this age group is 1,300 mg calcium per day (14). Our study was designed to evaluate lactose digestion and tolerance in a group of African-American adolescent girls consuming a dairy-based diet as part of a strictly controlled calcium metabolism study. We hypothesized that the subjects, who were fed a high-lactose diet, would adapt to lactose. They would experience an overall decrease in symptoms, as well as a decrease in hydrogen production, over the course of the study.

SUBJECTS AND METHODS

Subjects

Twenty-one adolescent African-American girls, aged 11 to 15 years, were enrolled as subjects in a calcium metabolism study at Purdue University nicknamed "Camp Calcium" (15). Of these 21 subjects, 17 chose to participate in the lactose tolerance study (mean age±SD=12.7±1.1 years). The subjects were screened prior to admittance into the study for disease and conditions that could affect calcium and intestinal metabolism. Subjects were rejected if they were taking any medications that could interfere with calcium metabolism or colonic fermentation (ie, antibiotics), or if they were taking any oral contraceptives. In addition, the subjects were required to be nonsmokers and within a range of 85% to 120% of normal weight for height. The subjects were asked whether they considered themselves to be lactose- or milk-intolerant. Because of the need to feed high calcium intakes, subjects who refused to drink milk were not included in the study. Informed consent was obtained from the parents and the protocol for the study was approved by the Committee on the Use of Human Research Subjects at Purdue University, West Lafayette, Ind.

Lactose Challenge

Subjects were challenged with 0.35 g lactose/kg body weight (in 1% milk) on day 1, prior to the calcium metabolism study, and again on day 21. The subjects consumed a dinner of iced tea, hamburger, and white rice at 6 PM on the night before the breath hydrogen test in order to reduce the baseline hydrogen production in the colon, as such a meal does not cause hydrogen production (16,17). An artificially sweetened frozen treat (lactose- and fiber-free) was served between 8 and 9 PM. On the morning of the test, subjects collected baseline breath hydrogen samples at 7:45 AM and 8 AM, followed immediately by a "breakfast" of 1% milk and another collection at 8:30 AM. Subjects collected breath samples and, in the presence of trained laboratory staff, recorded symptoms hourly for 8 hours following the milk challenge. Eight hours is sufficient time for the subjects' breath hydrogen to increase from baseline to peak and then return to baseline. Such a complete curve is necessary to compare the change in area under the curve from day 1 to day 21 (1,12). A lunch of hamburger, white rice, and iced tea was served at noon. Sample collection continued until 4 PM. On day 21, following the calcium metabolism study, the milk tolerance test was repeated. Breath samples on days 1 and 21 were immediately frozen and analyzed within 5 days of the challenges.

Dietetic practitioners can advise lactose-intolerant clients to include dairy foods with meals at levels that result in sufficient calcium to meet the Recommended Dietary Intakes

High Calcium, High Lactose Diet

From dinner on day 1 through lunch on day 21, subjects participated in a metabolic study of calcium metabolism (15). All subjects lived in a common, closely supervised environment. All food consumed was carefully monitored, and feces and urine were collected throughout this experimental period. Subjects consumed 1,211±76 mg calcium per day. Most of this calcium—approximately 1,100 mg/day—came from dairy sources, whereas bread and vegetable sources contributed the rest. On average, subjects consumed 4 servings of dairy foods containing an estimated 33 g of lactose per day during the metabolic study. Prior to the calcium metabolism study, subjects consumed approximately 17 g lactose per day. However, this amount was highly variable among subjects. Dairy foods were consumed at each meal and often at snack times, such that the consumption of lactose was spread throughout the day. Lactose content of the diet was estimated from food composition tables (18,19). Calcium content of the diet was determined by direct analysis by atomic absorption spectroscopy on daily composites (20).

Intolerance Symptoms

During the lactose challenge, symptoms were self-reported hourly using a record sheet (8). The subjects were instructed to rate the degree to which they experienced each symptom (abdominal pain, bloating, flatulence, diarrhea/loose stools, and headache) by placing an "X" anywhere on the 5-cm line

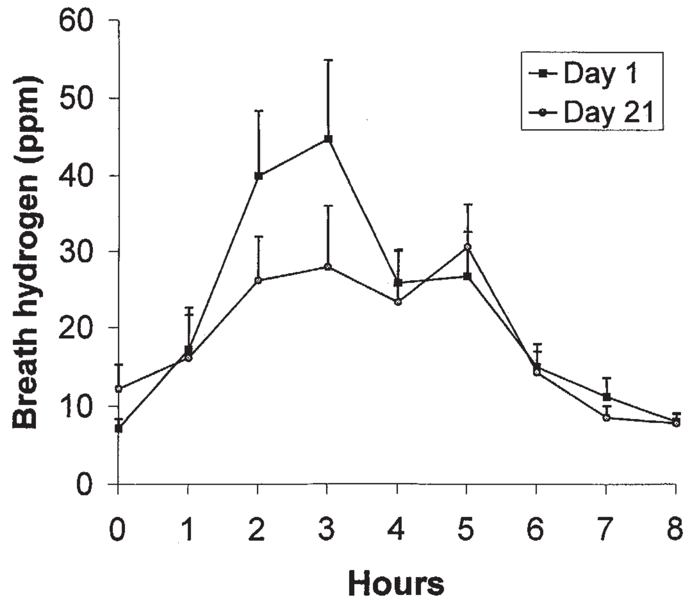

*FIG. A comparison of the amount of total hydrogen produced over 8 hours at the time of experiment 1 and experiment 2, after the subjects had been on a controlled high-lactose diet for 21 days. Hydrogen production was measured in parts per million (ppm). Data points represent the mean hydrogen production per hour+SEM, n=14. *P<.03.*

numbered 0 to 5. The severity of symptoms was described on the line as follows: 0=none, 1=slight, 2=mild, 3=moderate, 4=moderately severe, and 5=severe. Data are reported as the mean sum of hours 1 to 8. Thus, the maximum possible score for any individual symptom would be 40 (a "5" rating each hour for 8 hours). In addition, subjects self-reported symptoms once per day (evening) during the feeding period using the same scale.

Breath Gas Analysis

End-alveolar air samples were collected hourly during the breath hydrogen tests in 60 mL plastic syringes fitted with 3-way stop clocks. The samples were analyzed for carbon dioxide and hydrogen concentrations using the Quintron Model SC hydrogen analyzer (Quintron Instruments, Milwaukee, Wisc). Hydrogen values were corrected for atmospheric contamination of alveolar air by normalization to a Pco_2 of 5.33 kPa (40 torr), the partial pressure of carbon dioxide in alveolar air (21). For breath hydrogen, an area under the curve (AUC) was developed for each subject using a method adapted from Wolever et al (22). The AUC was determined by adding all areas above the baseline fasting value. If a subject experienced a rise in breath hydrogen of >20 parts per million (ppm) (0.9 μmol hydrogen/L air) after a challenge dose of lactose (0.35 g lactose/kg body weight) administered after an overnight fast, the subject was classified as having lactose maldigestion (12).

Statistical Analysis

The AUC for hydrogen production and the levels of intolerance symptoms for the 2 breath hydrogen tests were compared using the Wilcoxon signed ranks test (23), using SYSTAT for the MacIntosh software (version 5.2, 1992, Systat Inc, Evanston, Ill) (24). To test for evidence of a trend toward either improvement or worsening of the symptoms that were recorded on a daily basis over the feeding period, Spearman's ρ test for trend was used (23). All statistical tests were 2-tailed and an $\alpha<.05$ was considered significant.

RESULTS

Of the 17 subjects who participated in the study, 14 were classified as having lactose maldigestion based on a breath hydrogen increase of more than 20 parts per million (ppm) above baseline. Data from 3 subjects who had breath hydrogen increases of less than 20 ppm were not included in the results. One of the excluded subjects was a methane producer (at least 1 breath methane >5 ppm) and might also be considered a maldigester. However, there are no criteria regarding the rise in methane sufficient for detecting lactose maldigestion. Hence, the subject was excluded. Of the 14 hydrogen producers, there was a significant decrease in the amount of hydrogen produced on day 21 (100.7±19.3 ppm×hours) as compared to day 1 (148.3±27.0 ppm×hours) (*P*<.03, Figure).

During both lactose challenges, both the lactose digesting and lactose maldigesting subjects reported minimal or no gastrointestinal symptoms. However, in the subjects with lactose maldigestion, there was a significant decrease in the severity of bloating (0.8 vs 0.0, *P*<.04) and flatulence (1.3 vs 0.0, *P*<.05) after adaptation to the diet. In addition, there was a nonsignificant decrease in the degree of headache (control symptom) reported (3.1 vs 0.8, *P*<.10) after adaptation to the diet. Finally, there was a nonsignificant increase in abdominal pain (0.9 vs 1.8, *P*<.85) from day 1 to day 21. The average reported symptoms on day 1 and day 21 are shown in the Table. Although the decrease in symptoms is statistically significant, a score of 1.3 on a 40-point scale is not biologically relevant. During the 21-day calcium metabolism study, the daily symptoms reported were nonexistent for all subjects, except one individual who reported minimal symptoms.

DISCUSSION

Although only subjects who agreed to drink milk were included in Camp Calcium, the majority of these African-American girls had a negative attitude toward the consumption of milk at the beginning of the study. On day 1, some subjects stated that they didn't like milk, others claimed that they would get sick if they drank the milk. However, on day 21, all subjects consumed the milk without complaint, although they did not necessarily look forward to the milk challenge. This change in attitude could be a result of behavioral conditioning that resulted from the rigorous protocol that the subjects adhered to during the calcium balance study. Subjects were required to collect all biological fluids, all dietary intake was strictly controlled, and subjects were under 24-hour supervision. Conversely, the change in attitude toward milk could be attributed to the recognition by the subjects that a high-calcium, milk-based diet was readily tolerated. Subjects were not blinded to the milk or dairy products consumed during this protocol. Thus, perhaps for the first time in their dietary experience, subjects learned that the consumption of relatively large amounts of milk does not necessarily lead to intestinal symptoms. The rise in breath hydrogen production above baseline after consumption of the challenge on day 1 (52.7±9.2 ppm, mean±SE) is consistent with the increase in breath hydrogen production after challenge in other studies (4,24). Furthermore, the decrease in breath hydrogen production and decrease in symptoms is presumably a result of an adaptation to the habitual lactose intake and not a random variation in the breath hydrogen procedure or subject anxiety, as these techniques are highly reliable (1).

Although the subjects initially complained about drinking the milk, almost all subjects expressed a preference for milk over yogurt when given the choice at the beginning of the study. Thus, the original diet protocol that included yogurt (due to its recognized tolerance by persons with lactose maldigestion) was reformulated to provide most of the calcium as fluid milk with some cheese and frozen yogurt. There was concern that this milk-based diet would cause substantial intolerance, but subjects tolerated the milk-based diet extremely well. This finding is consistent with previous studies reporting adaptation (10).

Camp Calcium was a unique opportunity to study lactose digestion and tolerance among African-American adolescent girls. Based on our past experience, it seemed necessary to have 24-hour supervision as well as careful oversight of the lactose challenges and sample collections in order to conduct this study (15,20); Camp Calcium provided such supervision and oversight. Primary caretakers need to provide this supervision and oversight at home to more consistently alter diet patterns.

The results from this study extend our understanding of lactose tolerance to an important population. Some adolescent populations may be avoiding dairy foods because of perceived lactose intolerance. Young women are particularly likely to consume inadequate calcium. In African-American girls aged 6 to 11 and 12 to 19 years, the average calcium intake is 755 mg/day and 730 mg/day, respectively, whereas adequate intake for 4- to 8-year-olds and 9- to 13-year olds is 800 mg/day and 1,300 mg/day, respectively (14,25). These results demonstrate that this lactose maldigesting adolescent population is able to tolerate the lactose in the amount of daily products needed to meet calcium intake recommendations. Research findings in adults provide evidence of lactose tolerance and colon adaptation to ongoing milk consumption (12,13). Supplementing the diet with 1,300 mg of calcium per day via dairy products does not cause appreciable symptoms in lactose maldigesting women (26). It appears that similar tolerance and adaptation are present in African-American adolescent girls. However, demonstrating tolerance does not necessarily evoke behavioral change. Culture and habit are difficult to change and may require long-term behavioral interventions.

Table
Mean symptoms ratings after lactose challenges[a]

Symptoms	Day 1	Day 21
Abdominal pain	0.9±0.5	1.5±0.9
Bloating	0.8±0.4	0.0±0.0*
Flatulence	1.3±0.6	0.0±0.0*
Diarrhea	0.0±0.0	0.1±0.1
Headache	3.1±1.3	0.8±0.5

[a]Intolerance symptom ratings during the 2 breath hydrogen tests (mean±SEM, n=14). Subjects rated symptoms by placing an "X" on a 5-cm line, numbered 0 to 5. The severity of symptoms was described on the line as follows: 0=none, 1=slight, 2=mild, 3=moderate, 4=moderately severe, and 5=severe. The maximum score would be 40 (a "5" rating each hour for 8 hours).
*$P<.05$ significantly different from day 1 for corresponding symptoms.

APPLICATIONS/CONCLUSIONS

For adolescent girls who have an especially critical need for calcium, this study demonstrates that lactose intolerance is not a limiting factor in consumption of adequate calcium. Dietetic practitioners can advise lactose-intolerant clients to include dairy foods with meals at levels that result in sufficient calcium to meet the Recommended Dietary Intakes.

■ Recommendations may include up to 1 cup of milk, yogurt, and cheese with a meal. Such recommendations do not result in symptoms of intolerance.

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PRACTICE POINTS

The benefits of drinking milk, even if you are lactose intolerent

Most people would agree that if you are lactose intolerant, you should not drink regular milk. After reading the preceding article, however, **Georgia Clark-Albert**, MS, RD, has changed her thinking. Clark-Albert is the director of nutrition service at the Redington-Fairview General Hospital in Skowaggan, Maine. She said her "recommendations would change after reading 'Lactose digestion and tolerance among African-American adolescent girls fed a dairy-rich diet.'"

Journal: How have your views changed on people with a lactose intolerance drinking milk after reading this article?

Clark-Albert: I agree that a lot of people do have some intolerance to lactose; however, now I would recommend that a patient try a little milk with dinner. Having the milk with a meal will help the body digest the lactose. I also think dietetics professionals need to really evaluate the symptoms of the patient. I would not suggest that someone with a high lactose intolerance sit down and drink a big glass of milk, but I would not completely rule out having a drink of milk with a meal or two. It will vary from case to case.

Journal: Why is drinking milk so important?

Clark-Albert: Milk is important because of the calcium, of course, but also because of the vitamin D. Vitamin D will also help the body utilize the calcium. If I have a client who absolutely cannot drink cow's milk, I would suggest he or she try a vitamin D-fortified lactaid milk. I also recommend that people who cannot drink milk look to other dairy products, like cheese, to get their calcium, but again, cheeses do not have all the benefits of milk, because they are lacking vitamin D.

Journal: How much calcium do adult men and women need?

Clark-Albert: According to the dietary reference intakes (DRI), men and women aged 19 to 50 should have 1,000 mg of calcium a day. For men and women age 51 or over, the amount is 1,200 mg. The DRIs are adequate intakes, and I recommend adult women have 1,500 mg of calcium a day. I use the DRIs as a guide, and having the extra 500 mg a day for women is not going to cause any harm. Because the amount of calcium intake in children and pregnant women varies, consult your dietetics professional on what is the proper amount for you or your child.

Journal: How do you counsel a patient who refuses to drink milk?

Clark-Albert: Most of the clients I have who refuse to drink milk are teenage girls and young children. Most of the time with the teenage girls, I explain all the things milk contains that are good for them. I also tell them that they can get all these benefits without getting any fat if they drink skim milk. Most kids who don't want to drink milk don't realize how important it is for them. After I give them my milk lecture, most kids will at least try it. Another suggestion I always offer is chocolate syrup. Even though it adds calories, it is worth it so the kids get the calcium.

*This article was written by **Julie Swartz**, a member of the Professional Development Team at ADA headquarters in Chicago, Ill.*