ABSTRACT
Objective: To determine whether a 21-day milk-drinking intervention could reverse milk aversion.
Design: Participants consumed increasing amounts of cow’s milk for 21 days. Milk and dairy consumption, aversion, and likeness were assessed pre- and post-intervention and at 3 and 6 months post-intervention.
Setting: A large Midwestern university.
Participants: Twenty-seven milk-averse individuals completed the intervention, 26 completed the 3-month follow-up, and 24 completed the 6-month follow-up.
Main Outcomes Measured: Participants self-reported milk and dairy consumption, aversion, and degree to which they liked milk.
Analysis: Analysis of variance determined between-subject effects. Independent samples t test determined the effect of time. Fisher exact test determined factors affecting milk consumption.
Results: Lactose digesters and maldigesters showed a significant decrease in overall symptom scores after the milk intervention, with no significant difference between groups. Independent of digestive status, subjects demonstrated a significant decrease in aversion, an increase in the amount to which they liked milk, and an increase in milk and overall calcium consumption at 3 and 6 months post-intervention.
Conclusions and Implications: The results suggest a reversal of milk avoidance and the possibility that milk avoiders can increase likeness and incorporate milk into their diet after exposure.
Key Words: food aversion, milk, lactose digestion (J Nutr Educ Behav. 2015;47:325-330.)
Accepted February 8, 2015. Published online April 4, 2015.

INTRODUCTION
Aversion to certain tastes and/or foods appears to be common in humans. In a population of 517 undergraduate students, 65% reported ≥ 1 food aversions, 1 of which was milk. In a different population of 1,495 undergraduate students, 57% reported at least 1 food aversion and 5% of all aversions reported were related to dairy products. Of the dairy products listed, milk and butter accounted for 78%. The Merriam-Webster dictionary defines aversion to be a strong dislike that leads to avoidance. However, the research literature defines aversion as a strong dislike associated with food illness or gastrointestinal discomfort. Milk and dairy aversion could occur for numerous reasons. Some milk aversions may result from lactose malabsorption and lactose intolerance owing to low levels of intestinal lactase that limit the digestion of lactose. The undigested lactose moves to the large intestine where it is fermented, producing a variety of gases including hydrogen. Lactose malabsorption may cause symptoms including flatulence, abdominal pain, cramps, and diarrhea. Measurement of hydrogen gas in alveolar air (breath) is a useful clinical tool to assess malabsorption. Lactose malabsorption has been shown to be asymptomatic in multiple populations. Symptoms of lactose intolerance are dose- and situation-dependent. Furthermore, some people may incorrectly perceive themselves to be lactose intolerant as a result of irritable bowel syndrome or other intestinal disorders. This self-reported or unconfirmed diagnosis of perceived lactose intolerance may lead to dislike and avoidance of dairy products.

Although milk aversion could have multiple origins, it is likely a learned trait caused by experiencing unpleasant side effects such as gastrointestinal illness after consuming a particular food. Food aversions can be recognized as a combination of instrumental (avoidance) learning and classical (Pavlovian) conditioning, and therefore the aversion may be reversed. Therefore, it was hypothesized that milk aversion may be reversed by continual exposure. Along with reversal of the psychological aspect of food aversions, the human digestive system is capable of...
adapting to increasing amounts of lactose even if individuals are lactose intolerant or perceive themselves to be.\textsuperscript{8,16} It is difficult for adults to achieve the Dietary Reference Intake (nutrient intake recommendations made by the Institute of Medicine and the National Academy of Sciences) for calcium without consuming dairy products\textsuperscript{17} because dairy foods contribute to three-fourths of calcium in the US diet.\textsuperscript{18} Males aged 18–55 years consume about 700–900 mg/d dietary calcium without supplementation and females in the same age category consume < 700 mg/d\textsuperscript{19}; both genders do not reach the recommended intake of 1,000–1,200 mg/d.\textsuperscript{20} Low calcium intake can increase the risk for osteoporosis,\textsuperscript{21} hypertension,\textsuperscript{22,23} and some cancers.\textsuperscript{24,25} The primary published approach to reversing or lessening food aversions in humans is repeat exposure to the adverse agent.\textsuperscript{5–7} Therefore, the purpose of this study was to determine the efficacy of a repeat-exposure intervention to ameliorate milk aversion and increase calcium consumption.

**METHODS**

Potential participants were recruited via advertisements seeking persons who avoided drinking liquid cow’s milk. Advertisements were placed in a weekly electronic campus newsletter, posted as flyers in various locations around campus, and included as a 1-time advertisement placed in the back-to-school issue of the campus newspaper. The Biomedical Institutional Review Board of Purdue University approved the study protocol and advertisements. Each participant provided written informed consent.

This study included participants who met the following inclusion criteria: aged 18–55 years, reported aversion to liquid cow’s milk for at least 1 year, and consumption of only incidental (occasional use in coffee or cereal) amounts of milk (in liquid form) for 6 months before screening. Potential participants who were allergic to milk; experienced chronic gastrointestinal illness such as chronic diarrhea, chronic heartburn, stomach ulcers, colon cancer, or gastroesophageal reflux disease; were pregnant and/or lactating; used tobacco products; or had used antibiotics within the past 2 months were excluded owing to potential confounding of symptom and breath hydrogen results.

During a screening visit, participants were asked about their general health status and medication use, and completed an aversion assessment regarding the ingestion of milk to determine eligibility. The researchers calculated dietary calcium intake using a food frequency questionnaire.\textsuperscript{11} Eligible participants gave consent and scheduled a baseline hydrogen breath test (day 0). Figure 1 shows the intervention timeline.

Both lactose-intolerant (maldigesters) and tolerant (digesters) milk avoiders learned to add milk to their diets.

After the breath test, participants were instructed to consume liquid cow’s milk for 21 days in increasing amounts (days 1–7, one-half cup with a meal, twice per day; days 8–14, two-thirds cup with a meal, twice per day; days 15–21, 1 cup with a meal, twice per day). Participants were given an honorarium to defray the cost of the milk, and a diary to document adherence. After the 21-day milk intervention, participants returned for a second and final breath hydrogen test (day 22). The milk aversion assessment and food frequency questionnaire were again completed at this visit (see Supplementary Data). Participants were contacted at 3 and 6 months afterward to complete the milk aversion assessment and food frequency questionnaire, and were queried for medication use.

**Dietary Assessment**

The researchers assessed dietary calcium intake and specifically milk intake via a food frequency questionnaire (Brief Calcium Assessment Tool [BCAT]).\textsuperscript{31} The BCAT is a 15-item assessment tool that targets consumption over the preceding month. The frequency options are never or less than once per month, 1–3 times/mo, once per week, 2–6 times/wk, once per day, 2–3 times/d, and ≥ 4 times/d. Each food item is given a specific score based on the consumption frequency and associated amount of calcium. The total score is grouped into 1 of 4 calcium intake groups: excellent (> 1,300 mg calcium/d), good (1,000–1,300 mg calcium/d), fair (700–1,000 mg calcium/d), and poor (< 700 mg calcium/d). Milk consumption was calculated from the frequency reported on the BCAT during the preceding month.

**Aversion Assessment**

Participants chose from a range of behaviors regarding milk consumption, ranging from ingestion of a small cup of ice cream to a cup of milk. Difficulty scores were assigned to each action, with a higher score indicating the most difficult action to perform if milk-averse: ie, a small cup of ice cream (score = 15) vs a cup of milk (score = 100). Therefore, a higher score indicated a less adverse reaction to consuming milk. The method was adapted from de Silva.\textsuperscript{26} The Supplementary Data shows the assessment instrument.

**Assessment of Degree of Liking**

Participants also used a Likert-type scale to assess their likes and dislikes about consuming liquid cow’s milk, ranging from dislike extremely to like extremely (Supplementary Data).

**Hydrogen Breath Test**

A baseline hydrogen breath test was performed to determine lactose digestion status. Participants were asked to consume a meal of ground meat and white rice the night before the test, followed by a 12-hour fast to reduce baseline hydrogen levels. Breath samples were collected at 15 minutes before the study began, at baseline, 30 minutes after lactose ingestion, and hourly for a 5-hour period.\textsuperscript{16} Each subject consumed 20 g of lactose dissolved in water at baseline. Symptoms were recorded at the same time points as the sampling schedule. Gas samples were analyzed by chromatography (Model SC
Symptom Records

Participants rated symptoms using a Likert-type scale ranging from 0 (none) to 5 (severe) during both the hydrogen breath test and the 21-day milk intervention. Symptoms of abdominal pain, bloating, flatulence (gas), diarrhea, and headache were self-assessed. An other category was included to capture any additional symptoms.

Statistical Methods

Repeated-measure ANOVA model using the GLM repeated-measure command in SPSS (version 22, IBM Corporation, Armonk, NY, 2013) was used to analyze differences in symptom scores across status and day. Status was considered a covariate. The change in symptoms was calculated by subtracting day 1 mean symptom scores from day 22 mean symptom scores. Independent samples t test was used with digestive status as the grouping factor to determine the difference between the total change in mean scores for each group, to determine where differences occurred within each test.

The follow-up phase analysis was completed using SPSS (mixed model command) to compare aversion, degree to which the participant liked milk, milk consumption, and total BCAT score at baseline and 3 and 6 months. Time was entered as a repeated covariate. One model included status as a categorical covariate. As a post hoc analysis, a Bonferroni pairwise comparison test was used to measure when changes occurred over time. Furthermore, Fisher exact test was used to evaluate possible reasons why some subjects drank more milk than others.13

RESULTS

Participants

A total of 445 subjects contacted the researchers with interest in the study and were sent information regarding participation; of that number, 82 were screened for the study (Figure 2). One subject withdrew from the intervention because of adverse symptoms. Twenty-seven participants (15 lactose digesters and 12 lactose maldigesters) completed the milk-drinking intervention, 26 completed the 3-month follow-up, and 24 completed the 6-month follow-up. Of the 24 participants who completed the entire protocol, 14 were digesters and 10 were maldigesters. Of the participants who completed the 21-day milk drinking intervention, the average age of the subjects was 28 ± 8 years; 20 subjects were female and 7 were male. Twenty subjects reported being Caucasian, 4 were Asian, 3 were African American, and all reported being non-Hispanic.

Adaptations During Intervention

Both digesters and maldigesters showed a significant decrease in overall mean symptoms scores between the first hydrogen breath test and the second hydrogen breath test after 21 days of drinking milk (Figure 3A, B). Digestion status was a significant between-subject effect for overall mean symptom score and flatulence; day was not a significant factor. Therefore, all participants had a decrease in overall mean symptom scores (P = .035) including abdominal pain, bloating, flatulence, diarrhea, and headache. However, maldigesters had a greater decrease compared with digesters.

Adding milk to the diets of these milk avoders reduced aversion, increased the amount subjects liked milk, and improved diet quality.

Three- and 6-Month Follow-Up

The researchers hypothesized that repeated exposure to milk would result in an overall decrease in aversion (indicated by an increase in aversion assessment score) and an increase in how much subjects liked milk, as well as total BCAT score and milk consumption. Aversion score of all participants, independent of digestive status, increased from baseline to 3 months (P = .001) and reached a plateau at 3–6 months. (Aversion score is inversely correlated with aversion; a higher aversion score indicates a less adverse reaction to milk consumption.) However, the aversion score at 6 months remained higher than baseline (P = .034). Overall score for degree of liking milk for all participants increased from baseline to 3 months (P = .001) and then reached a plateau at 3–6 months, still remaining higher than baseline (P = .001). Status as a covariate had no effect in either assessment. Milk consumption and total BCAT score for all participants also increased from baseline to 3 months (P = .001) and reached a
plateau at 6 months but still remained higher than baseline ($P = .001$). Table 1 shows results. On average, subjects increased milk consumption by about 10 servings/mo at the 3-month follow-up and increased their calcium intake category from poor ($< 700$ mg/d) to fair ($700–1,000$ mg/d) ($P = .001$). At 6 months, milk consumption decreased to an average of 6 times/mo ($P = .001$) but subjects’ behaviors and feelings toward milk became more consistent.

**Post Hoc Analysis**

At the 3-month follow-up, subjects were divided into top milk drinkers ($n = 18$) and bottom milk drinkers ($n = 8$); top milk drinkers drank milk more than once per week and bottom milk drinkers drank milk once per week or less (Table 2). Malabsorption status, race, age, ethnicity, and gender were not significant factors in the grouping. Significant factors that affected whether someone was a top or bottom milk drinker were the degree to which they liked ($P < .015$) or had a aversion to milk ($P < .018$). These results were not repeated at the 6-month follow-up because dropouts caused a decrease in statistical power.

**DISCUSSION**

The majority of Americans have less than optimal calcium intake. Aversion to milk is problematic because liquid cow’s milk is an important source of dietary calcium and other nutrients. Overcoming this aversion could allow increased milk consumption, with an accompanying increase in nutrient quality of the diet. This study provided exposure to increasing amounts of milk, following

---

**Figure 2.** Recruitment information. HBT indicates hydrogen breath testing.

---

**Figure 3.** (A) Symptom scores among lactose digesters after a lactose challenge on days 0 and 22, after 21 days of milk consumption. Symptom scores were based on a Likert scale from 0 (no symptoms) to 5 (severe symptoms). There was a significant difference between mean symptom scores during hydrogen breath testing (HBT) before and after the milk-drinking intervention. This analysis used an independent samples $t$ test using the change value of overall symptom scores. (B) Symptom scores among lactose malabsorbers after a lactose challenge on days 0 and 22, after 21 days of milk consumption. Symptom scores were based on a Likert scale from 0 (no symptoms) to 5 (severe symptoms). There was a significant difference between mean symptom scores during the HBT before and after the milk-drinking intervention. This analysis employed an independent samples $t$ test using the change value of overall symptom scores.
the hypothesis that once incorporated into the diet, milk consumption would persist and aversion would decrease. The degree to which subjects liked milk and the consumption assessment scores increased significantly from baseline to 3- and 6-month follow-up, indicating decreased aversion to milk. Taste adaptation and colonic adaptation support the potential for reduced aversion. The data reported here suggest a reversal of food aversion by increasing the amount a food is liked and incorporating a food into diet after regular exposure. In this study, a decrease in aversion and an increase in how much milk was liked were associated with greater milk consumption, as shown by Fisher exact test. These changes in milk consumption were independent of other variables such as demographics and digestive status.

The average American aged > 2 years consumes three-quarters cup of milk per day, equivalent to about 22.5 servings of dairy per month. Because 3 servings of milk and/or milk products are recommended per day, the average US intake of fluid milk is not even one third of the recommendation for overall dairy intake. No age group > 12 years meets the Dietary Reference Intake for calcium. Furthermore, calcium intake and fluid milk consumption decrease with age. The subjects in this study increased milk consumption to an average of 10 times/mo for the first 3 months, with a decrease to 6 servings/mo after 6 months, equivalent to an increase of approximately 3,000 and 1,800 mg of calcium per month, respectively (60–100 mg more per day or approximately one third of a serving per day). The 15 digesters and 12 maldigesters (including the 1 maldigester who did not complete the follow-up phase) all demonstrated milk aversion at the beginning of the intervention. Because there was a similar increase in milk consumption between the 2 groups, the authors concluded that the physiological component of maldigestion was not a significant factor when reversing milk aversion. Although maldigesters’ symptom scores remained slightly elevated above the digesters, mean symptom scores for all subjects remained minimal.

By definition, aversion is a dislike that leads to avoidance and intolerance is a physiological response. Dislike of milk may result from intolerance or other factors. Both digesters and maldigesters reported fewer symptoms from a lactose challenge on day 22 after the milk intervention period. Hence, the amelioration of aversion could be caused by improved tolerance. However, intolerance was minimal in both groups. The study was not able to distinguish between improved tolerance and other unknown factors in reducing aversion.

### IMPLICATIONS FOR RESEARCH AND PRACTICE

There were several limitations to this study. The convenience sample for this study was free-living and self-reported dairy food intake and symptoms. Therefore, there is risk for over-reporting adherence and/or under-reporting based on lack of knowledge regarding serving sizes or differences in perception, subjective feelings, or opinions. Subjects were instructed regarding the type of milk to drink during the intervention period (no lactose-free milk was allowed) and the composition of the meal and fasting requirements before baseline and day 22 hydrogen breath tests. Milk was not provided. A variation of milk types and meals could have been consumed, which might have caused variation in digestive symptoms, but symptoms were minimal during the study. The sample size was too small to assess whether age, race, or gender was a significant factor in ameliorating milk aversion. The sample size also proved to be too small when dividing the total subjects into digesters and maldigesters; significance was lost, especially in aversion scores. Additional studies addressing these limitations could provide important information aimed at increasing milk consumption and therefore calcium intake among those with milk aversion.

### SUPPLEMENTARY DATA

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.jneb.2015.02.006.

### REFERENCES

CONFLICT OF INTEREST

Dennis Savaiano is on the Dannon Yogurt Advisory Board and the Ritter Pharma Medical Advisory Board. The other authors have not stated any conflicts of interest.