National Institutes of Health Consensus Development Conference: Lactose Intolerance and Health

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Lactose intolerance is the syndrome of diarrhea, abdominal pain, flatulence, or bloating occurring after lactose ingestion. These symptoms, which are produced by malabsorption of lactose, a sugar found in milk and other dairy products, often cause afflicted individuals to avoid dairy products in their diets. Lactose malabsorption is caused by a decreased ability to digest lactose that is due to a deficiency in the levels of the enzyme lactase. Lactase breaks lactose down into 2 simpler sugars, glucose and galactose, which are readily absorbed into the bloodstream. This enzyme is produced by expression of the lactase–phlorizin hydrolase gene in the cells lining the small intestine.

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All infants produce lactase and successfully digest lactose provided by human milk or by infant formulas. However, sometime after weaning, a genetically programmed decrease in lactase (lactase nonpersistence) occurs in most children worldwide.

The symptoms of lactose intolerance result from bacterial fermentation of undigested lactose in the colon. Lactose malabsorption can be diagnosed by having individuals ingest a standard dose of lactose after fasting and measuring breath hydrogen; elevated breath hydrogen levels are caused by bacterial fermentation of undigested lactose in the colon. Other diagnostic tools include measuring lactase activity in an intestinal biopsy sample or genetic testing for the common polymorphism that is linked to lactase nonpersistence. The demonstration of lactose malabsorption does not necessarily indicate that an individual will have symptoms. Many variables determine whether a person who malabsorbs lactose develops symptoms, including the dose of lactose ingested, the residual intestinal lactase activity, the ingestion of food along with lactose, the ability of the colonic flora to ferment lactose, and individual sensitivity to the products of lactose fermentation.

Current management often relies on reducing lactose exposure by avoiding milk and milk-containing products or by drinking milk in which the lactose has been prehydrolyzed with lactase. Alternatively, persons with lactase nonpersistence may tolerate moderate amounts of dairy products ingested with other foods. Many individuals, however, mistakenly ascribe symptoms of diverse intestinal disorders to lactose intolerance without undergoing testing. This misconception becomes intergenerational, when parents with self-diagnosed lactose intolerance place their children on lactose-restricted diets (even in the absence of symptoms) in the mistaken belief that the children will develop symptoms if given lactose.

The public health burden from deficiencies attributable to lactose intolerance has not been established. Many adults and children who avoid dairy products—which con-

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* Panel statement from an NIH Consensus Development Conference held on 22–24 February 2010 at the National Institutes of Health, Bethesda, Maryland. For a list of the members of the NIH Consensus Development Panel and other participants, see the **Appendix** (available at www.annals.org).

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stitute a readily accessible source of calcium, vitamin D, and other nutrients—are not ingesting adequate amounts of these essential nutrients. For example, most African-American adolescents consume inadequate amounts of calcium and vitamin D because they avoid dairy products. Deficient intakes of calcium and vitamin D are risk factors for decreased bone mineral density. This may increase the risk for fracture throughout the life cycle, especially in postmenopausal women. Very low intake of vitamin D can lead to the development of rickets, especially in children of African descent and other highly pigmented persons. Although reduced-lactose dairy and nondairy alternative products are typically fortified with calcium, vitamin D, and other nutrients, they may be more expensive and less widely available than conventional dairy products. The bioequivalence of these and other calcium supplements is uncertain.

To examine this important topic more closely, the *Eunice Kennedy Shriver* National Institute of Child Health and Human Development and the Office of Medical Applications of Research of the National Institutes of Health convened a Consensus Development Conference. This conference, which addressed several questions, was informed by a systematic review conducted by the Minnesota Evidence-based Practice Center.

Question 1

What is the prevalence of lactose intolerance, and how does this prevalence differ by race, ethnicity, and age?

The prevalence of lactose intolerance in the United States cannot be estimated from available data. The potentially relevant studies identified in the systematic review used the definition of lactose malabsorption rather than an accurate and appropriate definition of lactose intolerance and did not evaluate a representative sample of the U.S. population. Studies that assessed self-reported lactose intolerance provided limited insight because the self-diagnoses were not confirmed by testing for lactose malabsorption, and the symptoms seen in true lactose intolerance may result from several other conditions, including the irritable bowel syndrome. Some studies evaluated only the genetic predisposition to lower-than-expected lactase levels in adults (lactase nonpersistence) without assessing lactose malabsorption or intolerance directly.

Despite the limitations of available studies, several noteworthy observations emerged. First, lactose intolerance determined by self-report or nonblinded lactose challenge is less frequent across all ethnic groups than is lactose malabsorption determined by breath hydrogen tests or lactase nonpersistence determined by biopsy or genetic testing. Second, lactose intolerance, lactose malabsorption, and lactase nonpersistence vary across racial and ethnic groups, with the lowest reported occurrence in European Americans and higher (although variable) occurrence in African Americans, Hispanic Americans, Asian Americans, and Native Americans. Finally, lactose intolerance with nonblinded lactose challenge and lactose malabsorption was low in young children but increased with age. In children younger than 6 years, lactose malabsorption was low in all the studies and peaked between 10 and 16 years of age. Little evidence suggests that lactose intolerance increases in older persons. These trends need to be verified by representative population studies by using the case definition of lactose intolerance.

Question 2

What are the health outcomes of dairy-exclusion diets?

The health outcomes of dairy-exclusion diets depend on whether other sources of nutrients, such as calcium and vitamin D, occur in the diet in sufficient quantities to replace dairy products as a source of these nutrients, and to what extent other components of milk are beneficial.

Calcium is necessary for normal growth and bone development, as well as subsequent maintenance of bone density. The strongest argument for promotion of dairy ingestion is the beneficial effect of calcium (and fortified vitamin D in milk) on growth and development of the skeleton. Calcium is necessary for adequate bone accretion and optimal peak bone mass, which is a major determinant of risk for osteoporosis and fragility fractures later in adult life. Evidence suggests that certain age groups, such as children and teenagers, may be at increased risk for deficient bone acquisition if their diets are deficient in calcium or vitamin D. Weak evidence indicates that children with calcium-deficient diets have increased fracture rates. The maximal accumulation of bone mineral, and therefore the maximal calcium requirement, occurs during puberty. Although studies indicate that young children who drink milk are likely to meet or exceed the adequate intake for calcium, teenagers as a group tend not to take in enough calcium to meet recommended needs. This problem is exacerbated by dairy avoidance in individuals who consider themselves lactose intolerant, regardless of whether they have undergone objective testing for lactose intolerance.

Studies show that the presence of lactose does not necessarily affect the efficiency of calcium absorption across the intestine and that persons with lactase nonpersistence do not have substantial impairment in calcium absorption. Thus, the limiting factor in achieving optimal peak bone mass in young individuals is the intake of calcium. Similarly, in older individuals, low calcium intake rather than deficient absorption is probably a major factor contributing to loss of bone mass. Replacement of calcium using supplements or dairy products slows the rate of bone loss in older people, possibly as a result of an overall decrease in bone turnover. Across the age spectrum, the factor that limits adequate calcium accrual in many individuals probably is dairy avoidance.

Dairy-exclusion diets may decrease gastrointestinal symptoms (bloating, cramps, flatus, and diarrhea) in symp-

tomatic persons who have lactose malabsorption or intolerance. The degree of relief is probably related to the degree of expression of lactase and the quantity of lactose ingested. People who remain symptomatic on a dairy-exclusion diet may have other causes for their gastrointestinal symptoms, such as the irritable bowel syndrome, celiac disease, inflammatory bowel disease, or small-bowel bacterial overgrowth.

Question 3

What amount of daily lactose intake is tolerable in persons with diagnosed lactose intolerance?

Among persons with appropriately diagnosed lactose intolerance, differences in several factors—including lactase activity, gastric emptying rates, fecal bacterial metabolites, colonic mucosal absorptive capacity, and intestinal transit time—can greatly influence their susceptibility to development of intolerance symptoms after ingestion of foods and beverages containing lactose. Individuals differ in the intensity of symptoms of lactose intolerance because of differences in abdominal pain perception and the psychological effect of pain and social discomfort. Determining the amount of lactose that can be tolerated is necessary to develop evidence-based dietary recommendations that meet the needs of the individual.

High-quality evidence that addresses the above question is limited. Pertinent studies used different definitions of lactose intolerance, sample selection criteria, lactose administration procedures, and assessment and follow-up methods. Most studies used a single dose of lactose administered without food and evaluated short-term responses. Efforts often were not made to mask the taste difference between lactose-free milk and milk containing lactose. Only a handful of studies tested the participants in a double-blinded manner with increasing amounts of lactose administered throughout the day to determine the daily tolerable lactose dose. Most studies examined small numbers of participants, and few or no studies focused exclusively on children, pregnant women, or lactating women.

In most studies, participants were classified as malabsorbers or absorbers on the basis of breath hydrogen measurement or a blood glucose test, and symptoms of lactose intolerance were not always required for study entry. A blinded control was rarely used to define lactose intolerance at study entry; thus, it is probable that some individuals would have reported symptoms after ingestion of lactose-free solutions. Most studies investigated individuals with proven lactose malabsorption, not diagnosed lactose intolerance.

The available evidence suggests that adults and adolescents with diagnosed lactose malabsorption could ingest at least 12 g of lactose when administered in a single dose (equivalent to the lactose content in 1 cup of milk) with no or minor symptoms. Individuals with lactose malabsorption can tolerate larger amounts of lactose if ingested with meals and distributed throughout the day. However, 50 g of lactose (equivalent to the lactose content found in 1 quart of milk) usually induced symptoms in adults with lactose malabsorption when administered as a single dose without meals. For women with lactose malabsorption, tolerance to dietary lactose may improve during pregnancy but then worsen after delivery. Some data suggest that the routine ingestion of lactose increases the amount of lactose that is tolerable in both adults and adolescents. There is no scientific evidence on the tolerable dose of lactose for children with lactose malabsorption.

Question 4

What strategies are effective in managing individuals with diagnosed lactose intolerance?

Available studies about the effects of interventions, such as reduced-lactose dairy products, probiotics (a live microbial food component that benefits the recipient through improved intestinal microbial balance), and colonic adaptation, have important limitations that preclude definitive recommendations. Regardless, it is important to distinguish lactose intolerance from other causes of gastrointestinal symptoms. Targeting the specific underlying condition will probably optimize outcomes and help avoid unnecessary food restriction. Whether individuals who have diagnosed themselves as lactose intolerant will accept interventions that ask them to consume a food they believe leads to side effects is unknown. Education on lactose intolerance and appropriate evaluation of gastrointestinal symptoms may be the most productive therapeutic approach in these persons.

Even in persons with lactose intolerance, small amounts of milk, yogurt, hard cheeses, and reduced-lactose foods may be effective management approaches. As noted above, individuals with lactose malabsorption probably can tolerate 12 g of lactose without significant symptoms, particularly if ingested with other foods. Lactase-treated products may be tolerated better than nontreated products, but more research is needed.

Whether individuals with lactose intolerance have important nutritional deficiencies or long-term clinical sequelae is unknown, but skeletal health is a concern. Although dairy foods are an excellent source of calcium, protein, magnesium, potassium, riboflavin, and other nutrients and, when fortified, vitamin D, these individual nutrients are available in other foods and supplements. Data are lacking on the effects of interventions designed to increase dairy intake versus counseling affected persons on ways to meet nutrient requirements from other sources. An overall nutritional eating plan should be emphasized that focuses on nutrients potentially reduced by a dairy-free diet while maintaining appropriate caloric intake. An excellent source of overall nutritional guidance and information on nondairy dietary sources of calcium—such as calcium-fortified

soy or rice drinks, fruit juices, soy products, dried beans, and leafy greens—can be found at www.mypyramid.gov.

Such strategies as colonic adaptation, in which lactose intake is gradually increased over time, have intriguing preliminary data and may be helpful in some individuals. Although researchers continue to investigate the various treatment strategies, individual treatment approaches can be developed both for lactose-intolerant persons and for those who avoid dairy foods for other reasons. Individualized strategies could combine inclusion of small amounts of dairy foods and lactase-treated products and could provide suggestions for alternate nutrient sources, emphasizing approaches and food items that are acceptable to and accessible to each individual. The goals of treatment should be to ensure adequate intake of nutrients important for skeletal health and other clinical outcomes. There are stages of the life cycle, such as adolescence, pregnancy and lactation, and older age, when meeting these goals is particularly critical for bone accrual and maintenance.

Question 5

What are the future research needs for understanding and managing lactose intolerance?

Reliable estimates of the U.S. prevalence of lactose intolerance and lactose malabsorption are not available in a representative population of diverse ages and races or ethnicities. Therefore, we recommend that a study be conducted to determine the prevalence of lactose intolerance in the U.S. population and the differences across age and racial or ethnic groups. The study should examine a representative sample of the U.S. population and determine the prevalence of self-reported baseline symptoms, the prevalence of lactose malabsorption with or without symptoms after a blinded lactose challenge, the relationship between self-reported symptoms and the presence of lactose malabsorption, and the prevalence of lactose intolerance in persons with lactose malabsorption on the basis of the blinded challenge.

The best approach to minimize placebo effects is to conduct blinded challenges using a standardized, taste-masked dose with and without lactose and to define symptoms using a well-validated scoring system. Studies on what constitutes an optimal challenge dose of lactose also should be conducted. Dietary history of lactose consumption and symptoms associated with polymorphisms affecting lactase gene expression may obviate the need for taste-masked, blinded oral challenges with lactose and placebo. The infrastructure of the National Health and Nutrition Examination Survey or other ongoing nationally representative studies could be used, because these programs already are collecting dietary intake data that would provide additional and potentially informative evaluation of the intake of lactose-containing foods in persons with rigorously determined lactose malabsorption, with or without symptoms.

Few data are available on bone health in persons with lactose intolerance and dairy avoidance. Future studies should investigate the association between dietary calcium intake and outcomes in people with lactose intolerance on low-lactose diets. A diverse population should be evaluated, including children, elderly persons, men and women, members of ethnic or racial subgroups, and persons with susceptible genetic polymorphisms. The efficacy of dietary calcium intake from nondairy products and nutritional supplements should also be examined in relation to bone health and in terms of whether other foods influence calcium absorption from these sources.

Blinded randomized, controlled trials are needed to determine whether the quantity of lactose that lactose-intolerant persons can tolerate varies by race, ethnicity, age, or sex. Symptoms should be reported in a standardized, validated format so that clinically important differences can be appreciated.

Defining the tolerable dose of lactose in persons with lactose malabsorption is critical to determining the clinical importance of lactose malabsorption and the prevalence of lactose intolerance, and it may provide critical information for management. A stepwise approach should be developed to define the specific amount of dairy foods to introduce to a person with lactose intolerance (that is, the greatest amount of lactose that is not associated with symptoms). Studies also should be conducted to confirm whether lactose is better tolerated if distributed throughout the day or given with meals. Trials are needed to evaluate whether lactase- or lactose-hydrolyzed milk and probiotics are effective interventions for reducing symptoms.

It will be important to determine whether testing for lactose malabsorption will change the behavior of individuals who avoid dairy products, many of whom may not have lactose intolerance. Future research should use standardized interventions, blinded controls, and reporting of improvement of symptoms in a consistent, validated manner to compare the efficacy of these dietary management strategies in obtaining clinically meaningful health outcomes.

Once effective interventions have been identified, behavioral and culturally sensitive approaches to convince people to adopt recommended dietary changes should be developed and tested. Clearly, the perception of symptoms in individuals with lactose intolerance may be highly subjective and susceptible to many psychological and cultural factors. Thus, various strategies may result in very different behavioral changes, and their effectiveness should be compared rigorously.

Finally, additional work needs to be done to improve the management of patients with the irritable bowel syndrome and a hypersensitive colon who may also have lactose intolerance.

Conclusions

Lactose intolerance is a real and important clinical syndrome, but its true prevalence is not known. Most people with lactose malabsorption do not have clinical lactose intolerance. Many persons who think they are lactose intolerant do not have lactose malabsorption.

Many individuals with real or perceived lactose intolerance avoid dairy and ingest inadequate amounts of calcium and vitamin D, which may predispose them to decreased bone accrual, osteoporosis, and other adverse health outcomes. Most persons do not need to eliminate dairy consumption completely. Evidence-based dietary approaches with and without dairy foods and supplementation strategies are needed to ensure appropriate consumption of calcium and other nutrients in lactose-intolerant individuals. Educational programs and behavioral approaches for individuals and their health care providers should be developed and validated to improve the nutrition and symptoms of individuals with lactose intolerance and dairy avoidance.

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