Comparative tolerance of adolescents of differing ethnic backgrounds to lactose-containing and lactose-free dairy drinks

I. Initial experience with a double-blind procedure[1, 2]

Linda Haverberg,[3] Ph.D., Peter H. Kwon,[4] B.S., and Nevin S. Scrimshaw,[5] M.D., Ph.D.

ABSTRACT A lactose-free (LF) chocolate dairy drink and one containing 4.5% lactose (LC) were administered randomly in 240- and 480-ml volumes on 4 consecutive mornings under double-blind conditions to 110 healthy teenagers (14 to 19 years old) of differing ethnic backgrounds. Capillary blood glucose analysis after 50 g of oral lactose identified 67 of them as lactose malabsorbers. Neither absorbers nor malabsorbers reported significantly different gastrointestinal symptoms after 240 ml of LC compared with the same amount of LF. However, 17 absorbers and 21 malabsorbers reported symptoms inconsistent with intolerance due to lactose. These subjects had symptoms after LF only, after both LF and LC, or after 240 ml but not 480 ml of LC. After 480 ml of LC, 26 malabsorbers had symptoms, compared to 15 after 480 ml of LF. The prevalence of symptoms after 480 ml of LC, but not after 480 ml of LF, was 7% for absorbers and 24% for malabsorbers. The results indicate that most of the individuals who reported gastrointestinal symptoms after ingestion of the two beverages did so for reasons other than their lactose content. *Am. J. Clin. Nutr.* 33:17–21, 1980.

Evidence has been accumulating that low intestinal lactase activity and intolerance to a standard test dose of lactose are highly prevalent among adult populations in Asia, Africa, and much of Latin America, and among blacks, Latin Americans, and Asian Americans in North America (1). Considerable differences have been reported among different regions and various ethnic and racial groups (2–7). In most mammals and in 60 to 90% of non-Caucasian races examined in prevalence studies, lactase activity is high in the neonate and decreases to low levels after weaning. In contrast, only 5 to 15% of Caucasian adults show low levels of lactase activity (8).

Most of the studies that have demonstrated a high incidence of lactose intolerance in human subjects among various age and population groups have been based on direct measurements of intestinal lactase activity and/or determination of lactose absorption after a single oral test dose of lactose approximately equivalent to that in four glasses of

[1] From the Department of Nutrition and Food Science, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139.

[2] Supported by a grant from the National Dairy Council.

[3] Present address: Development Resources, Latin American Bureau, Room 2252, Agency for International Development, Washington, D.C. [4] Present address: Columbia Medical School, New York, New York. [5] Author to whom reprint requests should be addressed.

milk. Diagnosis of lactose intolerance from reactions to such large, experimentally administered doses of lactose, however, is not necessarily an indication of intolerance to moderate amounts of milk. Several studies have examined the relationship between milk intake and lactose intolerance as determined by the standard lactose tolerance test (9–13). Determining whether clinical symptoms are associated with milk consumption would seem to be a more direct, practical approach.

Papers on the prevalence and significance of milk intolerance secondary to lactose malabsorption are conflicting and do not satisfactorily identify the nature and extent of the causal relationship between lactose malabsorption and milk intolerance. In a study of 32 healthy black teenagers, Mitchell et al. (10) found that, of 13 lactose-intolerant subjects, seven (54%) experienced "abdominal bloating and/or cramps after drinking 8 ounces of milk." In a study of 166 adult black and white hospital patients, Bayless et al. (9) found that, of 44 lactose-intolerant black subjects, 26 (59%) had symptoms within 24 hr after consuming about 8 ounces of low-fat milk. In contrast, Stephenson and Latham (12) found that most of their lactose-intolerant subjects were able to consume moderate amounts of milk without experiencing any serious symptoms. Garza and Scrimshaw (13) found no intolerance to one glass of whole milk (240 ml) in a group of children (6 to 9 years old), most of whom were black, although 33% were lactose malabsorbers as determined by the standard test; however, 21% of the malabsorber subjects reported symptoms after one and one-half glasses, and 40% after two glasses, of whole milk.

We now extend these studies *1*) to determine the extent to which moderate amounts of milk may or may not produce symptoms in older children identified as lactose malabsorbers, and *2*) to determine the extent to which the symptoms produced are directly and unequivocably attributable to the presence of lactose in the milk and not to other chemical, physiological, or psychological factors. We examined the relationship between lactose malabsorption, as determined by oral administration of lactose, and clinical symptoms of intolerance to consumption of one and two glasses of a lactose-containing and a lactose-free synthetic chocolate dairy drink, administered on a double-blind basis.

Methods

Subjects

The subjects were 110 healthy adolescent volunteers, ranging in age from 14 to 19 years, attending Cathedral High School, Boston, Mass. Of these, 58 were black, 44 were white, and eight were of Latin-American descent. Informed consent was obtained from each volunteer.

Lactose absorption test

A standard lactose absorption test was administered to each subject. In the morning after an overnight fast, all subjects received an oral dose of 50 g of lactose dissolved in 250 ml of water. At 0, 20, and 40 min, microcapillary blood samples (0.1 ml) were obtained from the fingertip directly into EDTA-coated capillary tubes. Glucose was determined by the orthotoluidine method (14), as reported in the Sigma Technical Bulletin no. 635 (Sigma Chemical Co., St. Louis, Mo.). An increase in blood glucose of less than 26 mg/100 ml was considered indicative of lactose malabsorption. Symptoms were not recorded during the test because our classification was based on the biochemical index of malabsorption rather than on the subjective symptomatic response to lactose (intolerance).

"Milk" tolerance study

All subjects were studied for tolerance to one glass (240 ml) and two glasses (480 ml) of a lactose-free chocolate dairy drink (LF) and one containing 4.5% lactose (LC) given in random order on 4 consecutive days. The chocolate drinks were used to ensure a double-blind study in which lactose was the only ingredient variable between the two preparations (compositions given in Table 1). Chocolate and sweeteners masked the difference in flavor between the LF and LC formulas. The LC formula is marketed in New England as a chocolate dairy drink by H. P. Hood, Inc., Boston, Mass. Osmolality of LF was 582 ± 15; that of LC was 668 ± 34. Subjects were informed that they might or might not receive both types of drink during the 4-day study period; in fact, all subjects were given both types.

Subjects were asked to omit milk and dairy products from breakfast during the entire 4-day period, if they could not omit this meal completely. The beverages were distributed at 8:00 AM on each day of the study, and nothing further was consumed until lunchtime, at least 4 hr later. They were advised of the possibility of symptoms and were required to report them within 24 hr after drinking the formula.

Questionnaires were distributed at 8:00 AM each day following beverage intake. These were divided into two sections: part I (8:00 AM to noon) and part II (noon to 8:00 AM), and contained yes/no and multiple choice questions on the presence or absence, severity and duration of diarrhea, abdominal pain, flatulence, or bloating. The occurrence of diarrhea, two or more mild gastrointestinal symptoms, or one or more symptoms of moderate or severe degree was taken as evidence of a positive response of intolerance to the drink served on

that day. A negative response required no symptoms or only one mild symptom other than diarrhea.

Results

Lactose absorption test

Biochemical results of the standard lactose absorption test showed 83% of the black subjects, 62% of the Hispanic subjects, and 32% of the white subjects to be lactose malabsorbers (Table 2). The prevalence rate of 32% in the white subjects is higher than those previously reported for Caucasians in North America; this may be due to a higher percentage of persons from southern Europe in our sample.

Milk tolerance test

The frequency with which symptoms were reported by lactose absorbers and malabsorbers combined was 17% after 240 ml and 26% after 480 ml of LF (Table 3). The rates for lactose absorbers responding to LC were 16% after 240 ml and 19% after 480 ml; of the lactose malabsorbers, 28% and 39% reported symptoms after 240 and 480 ml, respectively, of LC (Table 3).

Relationship between lactose malabsorption and symptoms (Table 4)

Of the 67 subjects found to be lactose malabsorbers by the lactose tolerance test, 30 (45%) responded negatively on all 4 days. Of the 37 lactose malabsorbers who reported symptoms, four did so after LF only, 10 after both LF and LC, and seven after 240 ml but not 480 ml of LC. These responses could not be explained by the lactose content of the beverages. The remaining 16 subjects were potential examples of milk intolerance due to lactose malabsorption. Of these, however, only three reported symptoms on days on which 240 or 480 ml of LC were given, with-

TABLE 1
Composition of beverages[a]

Ingredient	Percentage composition	
	LF	LC
Coconut fat[b]	1.00	1.00
Sodium and calcium caseinate[c]	3.00	3.00
24 DE corn sugar[d]	5.44	
Cane sugar[d]	8.00	7.79
42DE corn sugar[d]		1.14
Salt (NaCl)[e]	0.18	0.18
Cocoa[f]	1.20	1.20
Carrageenan[g]	0.05	0.05
Polysorbate, monoglycerides and diglycerides[h]	0.10	0.10
Water	81.03	81.04
Lactose[i]		4.50

[a] Manufactured and supplied by H. P. Hood, Inc., Boston, Mass. [b]Used as a substitute for milk fat, which, in the form of cream, would introduce lactose in the lactose-free product. [c]Provides the same amount of protein normally found in "low-fat chocolate milk" but with a lower protein efficiency ratio than the equivalent total protein or whole milk protein found in milk. [d]Contributes sweetness and extra solids to enhance taste and texture. [e]Added to enhance flavor. [f]18% fat Dutch process cocoa. [g]Provides body and suspends cocoa fiber. [h]Added as emulsifiers for fat suspension. [i]Added to provide the equivalent of lactose normally found in "low-fat chocolate milk."

TABLE 2
Results of lactose tolerance test

Group	No. of subjects	Lactose-absorbing[a]	Lactose-malabsorbing[b]
		%	%
White	44	30 (68)	14 (32)
Black	58	10 (17)	48 (83)
Latin-American	8	3 (38)	5 (62)
All	110	43 (39)	67 (61)

[a] Maximum increase in blood glucose ≥26 mg/100 ml over fasting level. [b]Maximum increase in blood glucose <26 mg/100 ml over fasting level.

TABLE 3
Response to graded amounts of LF and LC drinks

Group	No. of subjects	Subjects reporting symptoms			
		LF		LC	
		240 ml	480 ml	240 ml	480 ml
		%	%	%	%
Lactose malabsorber[a]	67	12 (18)	15 (22)	19 (28)	26 (39)
Lactose absorber[a]	43	7 (16)	14 (32)	7 (16)	8 (19)
Both groups	110	19 (17)	29 (26)	26 (24)	34 (31)

[a] As determined by the standard lactose tolerance test (see Table 2).

TABLE 4
Classification of subjects by response to graded amounts of LF and LC dairy drinks

Group	Symptom response				No. of subjects	
	240 ml		480 ml		Lactose absorber[a]	Lactose malabsorber[a]
	LC	LF	LC	LF		
Tolerant to 480 ml of LC	0[b]	0	0	0	23	30
	0	0	0	+[c]	2	2
	0	+	0	0	2	1
	0	+	0	+	3	1
	+	0	0	0	1	5
	+	0	0	+	3	1
	+	+	0	0	0	0
	+	+	0	+	1	1
	0	0	+	+	4	2
	0	+	+	+	0	2
	+	0	+	+	0	4
	+	+	+	+	1	2
Intolerant to 480 ml of LC	0	0	+	0	2	8
	0	+	+	0	0	2
	+	+	+	0	0	3
Intolerant to 240 ml of LC	+	0	+	0	1	3
Total					43	67

[a] As determined by standard lactose tolerance test (see Table 2). [b]No symptoms or one mild symptom other than diarrhea. [c]Symptoms present.

out reporting symptoms on days on which LF was given. The remaining 13 reported symptoms on the day that 480 ml of LC were consumed without reporting symptoms on the day on which 480 ml of LF were given. In this study sample, therefore, the apparent prevalence of milk intolerance secondary to lactose malabsorption would be 5% (3/67) after 240 ml and 24% (16/67) after 480 ml of LC.

Of the 43 subjects found to be lactose absorbers, 20 (46%) also reported symptoms. Of these, 17 did so after LF only, after both LF and LC, or after 240 ml and not 480 ml of LC. Of the remaining three, one subject reported symptoms after both levels of LC, and two after 480 ml of LC. Unless these three subjects represent false-negative results of the lactose tolerance test, it must be assumed that the symptoms reported by these individuals were due to factors other than lactose and were possibly of psychosomatic origin.

Discussion

The results of this study of 110 healthy teenagers suggest that a significant number of lactose malabsorbers reporting symptoms after drinking the chocolate formulas were not really reacting to lactose. Although 39% of the lactose malabsorbers reported symptoms after 480 ml of LC, 22% also responded to 480 ml of LF. In comparison, 19% of the lactose absorbers reported symptoms after 480 ml of LC, and 32% responded to 480 ml of the LF. At the 240 ml level of intake, the differences between the rates of lactose absorbers and malabsorbers reporting symptoms were even smaller.

Under the conditions of the present study, the risk of gastrointestinal upset after consumption of 240 ml of LC appears to be relatively small for the teen-age lactose malabsorber, and not significantly different statistically from the response to LF. The reasons for the symptoms reported by both lactose absorbers and malabsorbers after ingestion of LF are unknown, but may have been due to other ingredients or to responses of a subjective nature. Other age groups may differ in their sensitivity to these formulas and should be studied in a similar manner.

The most important conclusion of the present study is that the symptoms after ingestion of milk or milk-based beverages may be largely due to factors other than lactose, even for lactose malabsorbers, and that this can be

detected effectively only by double-blind procedures using a placebo preparation. Further studies using this method must be conducted to understand the nature and extent of the causal relationship between lactose malabsorption and clinical symptoms due to lactose ingestion in milk and milk-based products.

Welsh and Hall (15) found that less chocolate milk (614 mOsm/kg) than plain (2% fat) milk (283 mOsm/kg) was emptied from the stomach during a 30-min period by both lactose absorbers and malabsorbers. However, the volume used in that study was 750 ml, compared with 240 and 480 ml in the present study. In addition, the osmolality of the LF was slightly less and that of the LC slightly greater than the osmolality of the chocolate milk used by Welsh and Hall (15). The practical effect on symptoms of the higher osmolality of the dairy drinks compared with plain milk is unknown and is difficult to determine because of the need for a double-blind study. The chocolate flavoring and sweeteners were needed to mask the difference in flavor between the two preparations; hence, without using a flavored milk formula or a milk- or lactose-containing formulated food, the requirement of double-blind test conditions could not have been met.

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