Distributions and Incidences of Elementary School Children with Lactose Intolerance Symptoms after Drinking Milk in Korea

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Abstract

Milk contains a number of nutrients required for human growth and development, such as disaccharide lactose which is significantly contained in milk and dairy products. About two thirds of world populations are reportedly suffering from lactose intolerance after drinking milk. Lactose intolerance is defined as a maldigestion of lactose in the human intestine with typical symptoms of abdominal pains, bloating, and diarrhea. In this study, incidence of lactose intolerance has been investigated for the elementary school children for 1 year from July, 2010 to June, 2011. It is found that about 70% of the total elementary students have joined the school milk program. Out of 636 total students that participated in this study, 449 were from the metropolis, 85 from middle-sized city, and 102 from the small town including rural areas (small town/rural areas). For distributions of lactose intolerance, 154 students (24.2%) were found to be positive among the total 636 subjects. Based on the size of the city, the symptoms were the most prevalent for the students in the small town/rural areas at 31.4% (32/102), followed by 30.6% (26/85) in middle-sized city, and 21.4% (96/449) in the metropolis. On the other hand, gender had no significant effect on the incidence of lactose intolerance, shown those for boys and girls were 24.8% (77/310), 23.6% (77/326), respectively. Further research is needed to confirm the correct incidence of lactose intolerance symptoms as the frequency is significantly affected by subject's digestive functions including irritable bowel syndrome.

Key words: lactose intolerance, incidence rate, fresh milk, school children, breath hydrogen test

Introduction

Milk and dairy products are referred to as an almost complete food to human because protein, calcium, potassium, phosphorus, vitamin B₂ (riboflavin), and many other nutrients are contained evenly. Especially, milk is recommended as the ideal food for young children. Lactose, a sort of disaccharide, is a source of energy contained in milk. It is hydrolyzed into glucose and galactose by lactase (β -galactosidase) in the small intestine prior to absorption. Once lactose is absorbed in mucosa of small intestine, it is then in turn utilized to synthesize non-digestible galactooligosaccharides which promote growth of few probiotic bacteria and to improve gut microbiota by inhibiting the growth of harmful organisms in the intestine, promoting digestion and improving the health of the body. Lactose intolerance is clinically diagnosed with the breath hydrogen production test as well as intestinal biopsy in clinical practice (Maffei *et al.*, 1977).

About 75% of the world's population genetically lacks innate ability to digest lactose. For the adults, phenotype of lactase persistence, which is able to hydrolyze lactose, is more common in the northern Europeans, but lactase non-persistence or adult-type hypolactasia is prevalent in the other areas (Arola, 1994). From the clinical point of view, physiological condition called lactase non-persistence is known as the lactose intolerance. Lactose intolerance is a congenital disorder of carbohydrate metabolism, caused by unabsorbed lactose in small intestine after when ingesting milk or dairy products containing lactose via osmosis caused by unabsorbed lactose in small intestine. As for the mechanism (Fig. 1), body fluids and electrolytes flow into the lumen and stimulate the nervous system of the small intestine due to hydrogen and methane, carbon dioxide, and others, finally leading to clinical symptoms such as diarrhea, flatulence, abdominal swelling, abdominal pain, and so on. It is commonly known to occur in adults more than children (Bedine and Bayless, 1973; Holsinger, 1978; McCracken, 1971; Paige and Bayless, 1975; Rosensweig, 1969; Savaiano and Leritt, 1987). As for the primary cause of lactose intolerance, an

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Fig. 1. Hydrogen gas generation process in the intestines (Lomer *et al.*, 2008)

enzyme lactase produced naturally decreases with age. Lactase activity is usually highest in infancy, and then gradually decreases to, finally it reaches for adult to 5-10% of that level for adults in infancy (Hertzler and Savaiano, 1996; 1997). Based on the earlier studies (Sahi, 1994; Scrimshaw and Murray, 1988), incidence of lactose intolerance in all of the world was reported to exceed 50% in Africa (Tsega, 1989), and almost 100% in several Asian countries (Andersen and Barfoed, 1978; Simoons, 1978; Tadesse, 1992). In the U.S., the difference in incidence rate by its racial difference was observed across racial groups. 15% of whites, 53% of Mexicans, and 80-90% of blacks were positive in lactose intolerance test. In Europe, 2% in Northern Europe and Scandinavia, -70% in Italy and Sicily were reported to be lactose intolerant, showing significant difference across geographical locations. Many methods have been developed to diagnose lactose intolerance in an objective and scientific way, none is perfect but the hydrogen breath test (or breath hydrogen test), has been the current method of choice in many countries (Maffei *et al.*, 1977).

This study was conducted to obtain basic information about distributions and incidence of lactose maldigestion or lactose intolerance symptoms for elementary school children in Korea.

Materials and Methods

Selection of subjects

Elementary school children (10-13 years old) were chosen as subjects who have with no medical history, especially family history of gastrointestinal disease. It was also excluded students with diabetes, use of antibiotics (within 3 wk), and abdominal surgery. This study has been conducted for 1 year from July, 2010 to June, 2011. Each student was allowed to take participate in this

experiment by parents' consent. We are fully understand the experimental ethics guidelines for human subject under KFDA, Korea.

Determination of lactose intolerance

After fasting at least 12 h before the test, all of the subjects were given 400 mL of a full-fat fresh milk product (200 mL×2, Maeil Dairy Co., Korea) adjusted to 20-25°C and consumed in 30 min. Lactose intolerance was judged by two methods as described below.

1) Lactose intolerance by questionnaire

Questionnaire sheet (Appendix) was given to the subject to answer the 20 itemized questions about symptoms which he or she had before and after drinking fresh whole milk: "Not at all" was worth 1 point, "No" 2 points, "I'm not sure" 3 points, "Ordinary" 4 points, "A little" is 5 points, and "Extremely" 6 points (Matthews *et al.*, 2005). Points of each answer were added and recorded to use statistical analysis. If the total score was above 60 points over the all of questions, then the result was recorded positive for the lactose intolerance test.

2) Test for breath hydrogen concentration (H_2 breath test)

Hydrogen concentration was measured in the expiration gas before and after drinking milk (2 h interval) using Gastrolyzer (Gastro⁺, England). Lactose intolerance test was diagnosed positive when the scores obtained by two individual measurements increased by more than 15 ppm (Fig. 2).

Statistical analysis

The standard *t*- and χ -square-tests were used to test differences between experimental groups (Lovelace and Barr, 2005). The effects of certain background factors

Fig. 2. Gastrolyzer (Gastro⁺, Bedfont, England) for breath hydrogen concentration test

(sex, age, city size, and milk consumption) were taken into account, when the each groups were compared. Statistical analyses were performed with the SPSS package program (<http://www.ibm.com>) was used for statistical processing, analysis, and frequency of non-continuous variables, such as general information. A difference was considered to be statistically significant if p -value was less than 0.05. For convenience, we made all of the data were graphed.

Results

For 636 elementary school students, lactose intolerance was examined according to the test method using the questionnaire (Fig. 3A), the incidence rate was resulted in 20.0% in the metropolis, 14.1% in middle-sized city, and 20.6% in the small town/rural areas (Fig. 3B). In addition, the breath hydrogen test (Fig. 4) produced the incidence rate of 10.5% in the metropolis, 20.0% in the middle-sized city, and 12.2% in the small town/rural areas (Fig. 4A). Lactose intolerance from breath hydrogen test were not existed at the middle-sized city A and the metropolis

C, because there was no different each other. When the results by the questionnaire are combined with those by the breath hydrogen test, overall positive percentage of lactose intolerance was 21.4% in the metropolis, 30.6% in the middle-sized city, and 31.4% in the small town/rural area (Fig. 5). This result is almost consistent with the earlier publication by Kim (1994). There is no significant difference between the middle-sized city and the small town/rural areas. However, the overall frequency in the metropolis was approximately 10% less than those at the middle-sized city and the small town/rural areas (Fig. 5A). Fig. 5B showed the fluctuations of lactose intolerance rate according to the elementary school students in the three different geographical locations.

On the other hands, gender slightly affected the frequency: a 24.8% for boys and a 23.6% for girls (Fig. 6). This result was significantly lower than the previous study (Kim, 1994), which showed incidence rate of male at 65.1%, female at 67.5%, and average at 66.3%. As for the incidence changes across geographical locations, the probable reasons include diversification of food cultures according to increases per capita income ranges. The p -

Fig. 3. The results of lactose intolerance rate by a questionnaire: The comprehensive of each result (A), The results of each test group (B). *A, B, C are individual area according to city size.

Fig. 4. The results of lactose intolerance with a breath hydrogen test: The overall results of each test (A), The results of each test group (B). *A, B, C are individual area according to city size.

Fig. 5. Distributions of lactose intolerance in different geographical locations: The comprehensive of each result (5), The results of each test group (5). *A, B, C are individual area according to city size.

Fig. 6. Incidence rate of lactose intolerance according to the gender.

value obtained for gender was 0.986 and was not statistically significant at the 5% significance level ($p < 0.05$). Furthermore, the result based on city size was also not statistically significant at 5% significant level with the p -value of 0.135 at significance level ($p < 0.05$).

Discussion

Lactose in foods needs to be hydrolyzed prior to intestinal absorption. The hydrolytic enzyme responsible for splitting lactose into its monomeric forms, glucose and galactose, is called as lactase or β -galactosidase (Kretschmer, 1972). The former is primarily used as blood sugar and energy source and the latter used in glycolipid synthesis of brain tissues in infants. Genetic analysis of human lactase gene continued that lactase persistence was closely related to the *err* site of C/T-13910 single nucleotide polymorphism from the 5'-end (Kuchay *et al.*, 2011). Frequency of lactose intolerance with conventional diagnosis is thought to be overestimated mainly because the subjects are exposed too much lactose of 50 g rather than a single serving quantity (Kim, 1994). Thus, simple and accurate diagnostic methods for lactose intolerance need to be established. It is admitted that frequency discrepancy between the two independent tests is present just because the difference could be present between the self-diagnosed symptoms and those caused by lactose intolerance, and also account for the degree of symptoms felt by individual subject. The incidence changes in geographical locations include diversification of food cultures according to increases per capita income ranges, which provides ample opportunity to drink the milk and the expansion of school milk feeding. These results were similar to those from the earlier study (Johnson, 1987) of lactose intolerance that showed are regional differences among the Chinese in Taiwan and Hawaii, and also from the study (Cavalli-Sforza *et al.*, 1987) of the variation of regional of lactose digestion in central, northern, and southern regions of Italy.

On the other hand, the incidence of lactose intolerance was not significantly different by gender. The typical symptoms were more severe in girls than boys when controlled for as for the same amount of milk-borne lactose. Reportedly, lactose maldigesters are defined as the person who suffers from clinical symptoms at 80-100% when consumed 50 g of lactose at once, and 1/3-1/2 of them has same symptoms appeared after drinking 200-250 mL of milk (Arola, 1994). Scrimshaw and Murray (1988) claimed that experimental incidence of lactose intolerance is more or less exaggerated than true incidence rate just because the popular protocol provides excessive amount of lactose (50 g), which is much higher amount of lactose than that (approximately 12 g) contained in fresh milk usually consumed in daily life. According to the study about lactose intake and diarrhea in Japan,

2006, incidence of diarrhea by daily increase of lactose intake from 30 to 60 g (by 10 g increment) for healthy people, who are free of the symptoms such as diarrhea, constipation, and gastrointestinal disorder, was not observed until 30 g. However, the incidence rate increased from 11% at 40 g, 39% at 50 g, and 55% at 60 g. As most of Koreans usually drinks fresh milk less than 500 mL daily, which is equivalent to 25 g of lactose. It is reasonable to conclude that lactose in milk is not directly related to frequent incidence of diarrhea, especially for elementary school children in Korea.

Acknowledgement

This work was supported by the Korean Dairy Farmers' Pick-Off Fund Commission in Korea, 2010.

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(Received 2011.11.1/Revised 2011.12.8/Accepted 2011.12.8)

Appendix

Questionnaire form used in this study

No	Questions	Score					
		Not at all (1 point)	No (2 points)	I am not sure (3 points)	Ordinary (4 points)	A little (5 points)	Extremely (6 points)
1	I have experienced diarrhea or stomachache after drinking milk						
2	feel stomachache						
3	feel nausea						
4	fluttered heart						
5	dried mouth						
6	acidic belching						
7	muscular pain						
8	headache						
9	feel fatigue						
10	lack of concentration						
11	vomit						
12	feel motion sickness						
13	have constipation						
14	loose bowels						
15	gas in stomach						
16	borborygmus						
17	feel bloated						
18	break gas						
19	frequently urinate						
20	be convulsed						
21	describe other abnormalities						

This form is filled out by individual subject at 2 h after drinking a 400 mL of fresh milk.