Original Article

Milk Consumption and Lactose Intolerance in Adults*

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Abstract

Objective To investigate relations between milk consumption and lactose intolerance (LI) in adults and to explore the effect of milk consumption on lactase activity.

Methods Total of 182 subjects aged 20-70 years were recruited and interviewed by questionnaires, and their accumulative cow's milk intake (AMI) was calculated. LI was evaluated by hydrogen breath test (HBT).

Results A negative correlation was found between AMI and severity of observed LI symptom (r=–0.2884; P<0.05). Binary logistic regression analysis showed a negative correlation between LI and duration and frequency of milk consumption (OR, 0.317 and 0.465, respectively; both P<0.05) and a positive correlation between LI and amount of milk consumed per sitting (OR, 6.337; P<0.05).

Conclusion LI is related to various milk consumption behaviors. Most Chinese adults with LI may tolerate moderate milk consumption <160 mL.

Key words: Lactose intolerance; Accumulative cow's milk intake (AMI); Milk consumption behavior

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INTRODUCTION

Lactose intolerance (LI) is present in individuals with lactase deficiency (LD). People with LI often experience gastrointestinal symptoms such as abdominal distension, cramps, flatulence, and watery stools following lactose consumption. For this reason, milk and dairy products are eliminated from the diet of many subjects with LI, which may lead to nutrition-related diseases such as rickets, osteoporosis, and osteomalacia, which are all related to calcium deficiency. Therefore increasing milk consumption via ameliorating LI symptoms is one of important measures to improve calcium nutritional status. Some studies showed that chronic lactulose feeding decreased severity of LI symptoms[1-2]. Long-term milk consumption may cause colonic adaptation to LI[3]. This study aimed to investigate relations between milk consumption behaviors and LI in adults, and to explore the effects of milk consumption behavior on lactase activities.

SUBJECTS AND METHODS

Subjects

A total of 182 subjects aged 20-70 years were recruited in the study from an urban and a rural areas in Sichuan by means of cluster random sampling method. All the subjects had neither milk protein allergies nor gastrointestinal/pulmonary diseases, and had received no antibiotic treatment within 15 days prior to the study.

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Questionnaires

All subjects were investigated for their milk consumption behaviors by questionnaires. Questionnaires were developed through repeated group discussions and were pretested. The questions in the questionnaires were designed as simple, clear, exact, and quantitative as possible. Questionnaires covered the general status of milk consumption such as duration and frequency of milk consumption, the amount of milk consumed per sitting, varieties of milk, and any symptoms that the subject experienced after drinking milk. The accumulative cow's milk intake (AMI) was calculated based on the following formula:

$$AMI = 365ATY$$

where A=amount (L) of milk consumed per sitting; T=frequency of milk consumption per day; and Y=time duration of milk consumption.

In the questionnaire, subjects were divided into non-milk drinking (i.e. they did not drink milk or drank milk less than once per month), drinking milk every day, every week, and every month groups. The frequency of milk drinking could be converted to "times per day" as follows: times of drinking milk every week be converted to 1/7×times; times of drinking milk every month be converted to 1/30×times.

Identification of Subjects with Lactose Intolerance

Lactase activities were measured by hydrogen breath test (HBT) in all subjects to identify LI conditions. The last part of the first stool was collected at 24 h after each subject had consumed a challenge dose of lactose, which contained 25 g lactose in 200 mL aqueous solution. Fecal samples were frozen at –20 °C and lactose in stools was analyzed by the method of lead acetate with aqueous ammonia[4]. End expiratory gas was collected hourly during HBT in 20-mL plastic syringes. The hydrogen concentrations of the samples were analyzed by Type60HP Hydrogen Monitor (Germany). The changes in hydrogen values (ΔH) were calculated by subtracting fasting hydrogen values from subsequent values after a challenge dose of lactose. Subjects were classified as having LD if ΔH >1.786 mg/m^3 (equivalent to 20 ppm) or fecal lactose was positive according to the method of Yao et al.[5]. Subjects with LD were defined as having LI when they were observed to have any of the symptoms shown in Table 2 after the challenge dose during HBT. The intolerance symptoms and their severity were recorded hourly for 6 h after the challenge dose using the criteria of quantification of LI symptom score (Table 1)[4].

Table 1. Criteria of Quantification of Lactose Intolerance Symptom Score

Symptoms	Symptom Factors	Severity		
Non-symptoms	0	0		
Flatulence	1	1 (Light)	2 (Moderate)	3 (Severe)
Abdominal Pain	2	1 (Light)	2 (Moderate)	3 (Severe)
Diarrhea	4	0 (Normal in Shape)	1 (Loose)	2 (Watery)

Statistical Analysis

All statistical analysis was conducted using SPSS version 13.0 for Windows. Data are expressed as $x \pm s$ or proportion. Differences in categorical data of LI in adults between subjects with milk drinking habit and those without milk drinking habit were examined by χ^2 test. Correlation between severity of LI symptoms and AMI was examined by rank correlation analysis. Odds ratio (OR) of LI was estimated by binary regression model. Statistical significance was defined as $P<0.05$.

RESULTS

Milk Drinking Behavior and Prevalence of Lactose Intolerance in Adults

The prevalence of LI in adults with non-milk drinking habit was significantly higher than that in those who drank milk every day ($\chi^2=21.452$; $P<0.05$; Table 2).

Severity of LI Symptoms and AMI in Adults

Subjects who underwent HBT were divided into 4 ranks based on the severity score of LI symptom: LT, lactose tolerance; LD, lactase deficiency; LI-0, LI without diarrhea; LI-1, LI with diarrhea (Table 3). A significant negative correlation was found between AMI and severity of observed LI symptoms ($r=-0.2884$; $P<0.05$).

Effects of Milk Drinking Behaviors on Lactose Intolerance in Adults

Nine variables related to milk consumption behaviors in all subjects were analyzed by single factor analysis (Table 4). Educational background, duration and frequency of milk consumption, and

Table 2. Adults with Different Milk Consumption Behaviors and the Prevalence of LI

Group	No of LI [*n*(%)]	No. of LT[*n*(%)]	χ^2 Values[a]	*P*
Non-Milk Drinking	82(74.5)	28(25.5)		
Drinking Milk Every Month	11(84.6)	2(15.4)	0.001[b]	
Drinking Milk Every Week	24(68.6)	11(31.4)	0.039	
Drinking Milk Everyday	6(25.0)	18(75.0)	21.452	<0.05

Note. Figures in parentheses are proportion of LI subjects or LT subjects with different milk-consumption behaviors. [a]Non-milk drinking group compared with groups drinking milk every day, every week, and every month. [b] χ^2 Fisher's exact test. LI, lactose intolerance; LT, lactose tolerance.

AMI were statistically significant variables (P<0.05); amount of milk consumed per sitting was highly significant (P<0.1). These variables were probably important in the development of LI.

Binary logistic regression analysis was used to evaluate relations between the above five variables and risk of LI, as shown in Table 5.

Table 3. Severity of LI Symptom and AMI

Rank	No. of Subjects (*n* [%])	Average AMI
LT	58 (31.87)	436.68±391.03
LD	6 (3.29)	260.00±143.39
LI-0	18 (21.95)	127.20±178.36
LI-1	42 (23.07)	24.57±48.85
Total	182 (100.00)	150.22±233.20

Note. Figures in parentheses are proportion of subjects with different scores of severity of LI symptoms. LT, lactose tolerance; LD, lactase deficiency; LI-0, lactose intolerance without diarrhea; LI-1 lactose intolerance with diarrhea.

Table 4. Nine Variables Related to Milk Consumption Behaviors in Adults[6-7]

Variable	Variable Type	No. LI Group (*n* [%] or mean)	No. LT Group (*n* [%] or mean)	χ^2 Values or T Values	*P*
Sex	Binary Variable			0.001	0.979
Male		43 (34.7)	20 (34.5)		
Female		81 (65.3)	38 (65.5)		
Time Duration of Milk Consumption	Ordered Categorical Variable			34.764	0.000
0 Year		82 (66.1)	25 (43.1)		
<5 Year		8 (6.5)	0		
5 Year ~		29 (23.4)	13 (22.4)		
10 Year~		4 (3.2)	11 (19.0)		
>15 Year		1 (0.8)	9 (15.5)		
Frequency of Milk Consumption	Ordered Categorical Variable			31.213	0.000
0 or <12 Times per Year		82 (66.1)	28 (48.3)		
At Least 1 Time per Month		10 (8.1)	0		
At Least 1 Time per Week		24 (19.3)	8(13.8)		
At Least 1 Time per Day		8 (6.5)	22 (37.9)		
Amount of Milk Consumed per Sitting	Ordered Categorical Variable			7.414	0.060
0 mL per Sitting		82 (66.1)	28 (48.3)		
<250 mL per Sitting		6 (4.8)	6 (10.3)		
250~500 mL per Sitting		36 (29.0)	23 (39.7)		
>500 mL per Sitting		0	1 (1.7)		
Educational background	Ordered Categorical Variable			23.927	0.000
Illiteracy or Elementary School		20 (16.1)	8 (13.8)		
Junior High School		31 (25)	10 (17.2)		

(Continued)

Variable	Variable Type	No. LI Group (*n* [%] or mean)	No. LT Group (*n* [%] or mean)	χ^2 Values or T Values	*P*
Senior High School Or Technical Secondary School		38 (30.6)	12 (20.7)		
College/University Undergraduate or Graduate		28 (22.7)	9 (15.5)		
Master of Science and above		7 (5.6)	19 (32.8)		
Varieties of milk	Unordered categorical variable			7.659	0.105
Non-Milk Drinking		83 (66.9)	28 (48.3)		
Fresh Milk		29 (23.4)	21 (36.2)		
Yogurt		4 (3.2)	1 (1.7)		
Milk Power		4 (3.2)	5 (8.6)		
Formula Milk Power		4 (3.2)	3 (5.2)		
Age	Continuous	124 (47.9)	58 (49.3)	0.655	0.513
BMI	Continuous	124 (22.9)	58 (23.8)	1.582	0.115
AMI	Continuous	124 (20)	58 (77.5)	6.38	0.000

Note. Figures in parentheses are proportion or mean of LI subjects or LT subjects with different variables. LI, lactose intolerance; LT, lactose tolerance.

Table 5. Variables of Binary Logistic Regression

Variable	Value
Educational Background[a]	1:Illiteracy or Elementary School 2:Junior High School 3:Senior High School or Technical Secondary School 4:College/University Undergraduate or Graduates 5:Master of Science and above
Time Duration of Milk Consumption[a]	1:0 year 2:<5 year 3:5year ~ 4:10 year ~ 5:>15 year
Frequency of Milk Consumption[a]	1:0 or <12 Times Per Year 2: At Least 1 Time Per Month 3: At Least 1 Time Per Week 4: At Least 1 Time Per Day
Amount of Milk Consumed Per Sitting[a]	1:0 mL Per Time 2:<250 mL Per Time 3: <500 mL Per Time 4:>500 mL Per Time
AMI[a]	AMI=[365χAmount of Milk Consumed per sittingχFrequency of Milk Consumption Per DayχTime Duration of Milk Consumption]/1 000

Note. [a]Variable was entered in equation as continuous and dummy variable and fit two models, which were compared by likelihood ratio test; this variable was defined as continuous variable if *P* value was >0.05.

LI (value 1; non-LI, value 0) was dependent variable and educational background, duration and frequency of milk consumption, amount of milk consumed per sitting, and AMI were independent variables. Binary logistic regression showed that determinates of LI in adults included duration and frequency of milk consumption and amount of milk consumed per sitting ($P<0.05$). There was a negative correlation between LI and duration and frequency of milk consumption (OR, 0.317 and 0.465, respectively). Duration and frequency of milk consumption served as protective factors, whereas the amount of milk consumed per sitting was a risk factor for LI (OR, 6.337) (Table 6).

Table 6. Binary Logistic Regression Analysis

Factor	*β*	Std Err	*P*	OR	95% CI
Duration of Milk Consumption	-1.150	0.321	0.000	0.317	0.169-0.594
Frequency of Milk Consumption	-0.765	0.384	0.046	0.465	0.219-0.987
Amount of Milk Consumed Per Sitting	1.846	0.538	0.001	6.337	2.210-18.172
Constant	1.330	0.378	0.000	3.782	

Note. OR, odds ratio; CI, confidence interval.

DISCUSSION

The prevalence of LI in non-milk drinking adults (74.5%) was significantly higher than in those drinking milk every day (25%; χ^2=21.452; P<0.05; Table 2). The LI prevalence was related to milk consumption behaviors. The above conclusion is consistent with other studies[8-9], which indicated that the prevalence of LI in non-milk drinking individuals was significantly higher than in those who consumed less than one cup of milk every day. Some epidemiological surveys[10-11] also showed that the prevalence of LI was significantly lower in those who consumed one glass of milk daily than in those who had non-milk drinking habit.

The correlation between severity of LI symptom and AMI was negative (r=–0.2884; P<0.05). In our survey the amount of milk consumed per sitting by each individual was relatively similar among subjects who had milk drinking habit (Table 4); consequently the duration and frequency of milk consumption may influence LI symptoms. Furthermore, binary logistic regression analysis showed that correlations between LI and duration and frequency of milk consumption were negative (OR, 0.317 and 0.465, respectively; both P<0.05), indicating that higher frequencies and long-term milk drinking behavior might alleviate LI symptoms. These results support the hypothesis that some lactose mal-digesters began to be adapted to or to tolerate lactose, and that with long-term milk consumption their metabolic products of colonic microflora changed; as a result metabolic adaptations occurred[8-12]. Such adaptations can decrease flatulence and diarrhea. Our findings are consistent with the above studies[13]. Because severity of LI symptom in adults was related to their milk consumption behaviors, daily milk consumption might alleviate LI symptoms.

Pervious researchers[1,8] have indicated that Chinese people have high prevalence of LD (approximately 75%-100%); for this reason, milk and dairy products are eliminated from the diet of many LI people. However, milk is an important source of protein, energy, calcium, potassium, phosphorus, and riboflavin. Can LI subjects drink milk? ^{13}C-lactose/H_2-glucose challenge test from our previous experiment suggested that although intestinal lactase activity in LI subjects is low, LI subjects still have residual lactase activity and can digest some amount of lactose[14], similar to the findings of Vonk's group[15]. Therefore subjects with LI can ingest a certain amount of milk. How much milk could they accept? In this study we found a positive correlation between LI and amount of milk consumed per sitting (OR, 6.337). The risk of LI is elevated when the amount of milk consumed per sitting increases. Most subjects (81.9%) in our study ingested >250-500 mL milk per sitting (Table 4); therefore it is suggested that the acceptable intake of milk per sitting should be less than <250 mL. Our previous study demonstrated that most healthy adults (80.3%) could tolerate 25 g cow's milk powder containing 6.3 g lactose to produce 200 mL of milk solution. Based on the actual situation in China, it is suggested that 20 g cow's milk powder (5 g lactose; 160 mL of milk solution) is the lowest acceptable intake for healthy adults in China[4]. Further studies should be done to determine the lowest acceptable intake of milk for Chinese LI adults.

In this study it was considered that LI in Chinese adults is related to various milk consumption behaviors. Most Chinese adults with LI might tolerate moderate milk consumption (possibly <160 mL) and thereby gain valuable source of nutrients.

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