Original Article

Association between dairy consumption and prevalence of obesity in adult population of northeast China: An internet-based cross-sectional study

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Background and Objectives: Dairy has been shown to reduce the risk of obesity in many epidemiological studies. However, few studies have been fully conducted in China in this respect. We aimed to investigate the association between dairy consumption and prevalence of obesity in an adult Chinese population. **Methods and Study Design:** A cross-sectional study was performed in an adult population of 5598 in northeast China, aged ≥18. Intakes of dairy products were obtained by internet-based dietary questionnaire for the Chinese (IDQC). The associations between total and individual dairy consumption and prevalence of overall and abdominal obesity were examined by logistic regression. Sex stratification was performed. **Results:** A total of 3871 participants, including 1700 men and 2171 women, were eligible for analysis. Men who consumed ≥100 g/day of yogurt had lower risks of abdominal obesity (multivariate-adjusted OR=0.41; 95% CI: 0.24-0.70) than men who did not consume yogurt. Women who consumed ≥200 g/day of milk had lower risks of overall obesity (multivariate-adjusted OR=0.47; 95% CI: 0.24-0.91) than women who did not consume milk. **Conclusions:** Increased dairy consumption was associated with lower risk of obesity in adult population in northeast China. Further studies are needed to confirm these observational findings and explain the observed gender-specific difference.

Key Words: dairy product, milk, yogurt, obesity, abdominal obesity

INTRODUCTION

The prevalence of obesity has dramatically increased in China in recent decades. Specifically, the prevalence of overweight and obesity of Chinese adult increased from 25.1% in 1997 to 39.6% in 2009.[1] Overweight and obesity are strongly correlated with increased risks of diabetes, cardiovascular diseases, chronic kidney disease, and certain cancer,[2-6] which poses a serious health threat to the population.

Dairy product is an important source of calcium, high-quality protein and many other nutrients which play a potential role in the metabolic pathways of obesity. The effect of dairy product on obesity has been widely investigated in the US and European countries. Many cross-sectional[7-10] and prospective[11-14] studies have shown negative relationship between dairy consumption and overweight or obesity, while some studies have reported no association[15] or even positive association.[16] On the other hand, meta-analyses of randomized controlled trials[17,18] support the beneficial effect of increased dairy intake on body weight loss only when energy is restricted in diets.

Traditionally, dairy products are not frequently included in the Chinese diet. According to the data from Chinese Health and Nutrition Surveys, the intake of dairy products in China has been increasing rapidly from 1991 to 2012, but still remained at a quite low level compared with that of Western countries.[19] Considering the obesity epidemic in China and the inconsistent evidence regarding the association between dairy intake and obesity in Western countries, it is necessary to examine the effect of dairy product on obesity in Chinese population.

Some previous studies[20-23] conducted in Chinese population have shown beneficial effect of dairy product on obesity. However, dairy intake or obesity was not the focus in all these studies, so that some details such as dairy food type were not considered. Besides, there is

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limited evidence in the previous studies regarding the difference between genders in the effects of dairy consumption on obesity. Therefore, in the present study, we aimed to examine the association between the consumption of different types of dairy food and the prevalence of obesity in an adult population in northeast China. We focused on the 3 most commonly consumed dairy products (milk, yogurt, milk powder) in order to assess association between these dairy products and overall and abdominal obesity. Besides, gender difference was also explored.

METHODS

Subjects and exclusion criteria

From 2014 to 2016, a population-based cross-sectional survey was conducted in Dalian, a sub-provincial city located in northeast China, with a population of 5.96 million, to gather information on the dietary intake and the prevalence of obesity. The sample size (n) was calculated as $n = z_\alpha^2 \times p \times (1-p) / d^2$, where p is the prevalence of the study outcome, d is the accepted margin of error (set at $0.1 \times p$), and z_α=1.96 (95% confidence level). Based on previous study conducted in China,[1] a prevalence of overall obesity of 30% was used to calculate the estimated sample size. Besides, a complex sampling design effect of 3 and a non response rate of 20% were considered. Therefore, the final estimated sample size was 3480.

Participants were recruited using multistage random sampling method. This cross-sectional study covered 11 administrative regions of the city each year. Two subdistricts were randomly selected from each region, and two communities were randomly sampled from each of the selected sub-district. In every community, twenty households were randomly sampled, and household members who had lived in Dalian for at least 5 years were invited to participant. Finally, a total of 5598 residents participated in this survey over the three years. Data obtained from participants aged 18 and above in this survey were used to examine the association between dairy intake and risk of obesity as a representative adult population of northeast China.

Dietary data was obtained by internet-based dietary questionnaire for the Chinese (IDQC), a convenient web-based tool for dietary data collection and dietary nutritional education for Chinese population designed and validated at Harbin Medical University previously by experts of nutrition, epidemiology and bio-statistics. Detailed information about the development, content and validation of IDQC can be found in our previous published manuscript.[24] Briefly, each of the 5598 participants firstly registered an account and finished the online demographic questionnaires. Then all participants were asked to complete the IDQC for the past 1 year. After finishing the IDQC, a concise dietary assessment report was automatically generated online for nutritional education purpose.

The final sample subjected to statistical analysis included 3871 participants (1700 men and 2171 women). The exclusion criteria included (1) participants under 18 years old or women who were during the period of gestation (n=117); (2) participants with extreme daily energy intake (<800 kcal or >5000 kcal for males; <600 kcal or >4000 kcal for females) (n=612); (3) participants who had missing data for anthropometric measurements (n=163) and dietary intake (n=195); (4) participants who have had definite diagnosis of at least one of the following diseases from any hospital at the time of participation (n=640). The diseases included diabetes, hypertension, hyperlipidaemia, fatty liver, cardiovascular disease, and cancer, all of which could lead to dietary change of participants in response to these health issues.

The study was reviewed by the Institutional Review Boards of the participating institutions, approved by the ethics committee of Dalian Center for Disease Control and Prevention and conducted in accordance with the Declaration of Helsinki. Informed consents were obtained from all participants. The privacy rights of human subjects were observed.

Dietary assessment and dairy product consumption

Dietary intake was assessed using IDQC through self-administered method, in which a validated food-frequency questionnaire was used to collect information on usual dietary intake over the previous 4 months for each participant. The questionnaire included 3 dairy food items (i.e., milk, yogurt, and milk powder). Participants were asked how frequently they consumed each dairy item and the amount of intake in each time. The frequency of food intake in IDQC included 8 categories: never (less than once/month), 1-3 times/month, once/week, 2-3 times/week, 4-5 times/week, once/day, twice/day, and three times or more/day. The portion size for each eating occasion for milk and yogurt had 6 options: <100 ml (g), 100-150 ml (g), 200-250 ml (g), 300-350 ml (g), 400-450 ml (g), and ≥500 ml (g)), and another 6 options for milk powder: <25 g, 25-50 g, 50-75 g, 75-80 g, 80-100 g, and ≥100 g. Images of commercial serving units of dairy products (i.e., 200 ml/250 ml of milk, 100 g/250 g/450 g of yogurt) were illustrated in IDQC to aid in intake amount estimation. To facilitate comparison between different dairy foods, milk intake expressed in terms of milliliter per day were calculated into grams per day by multiplying the relative density of raw milk of 1.027 g/ml according to National Food Safety Standard of Raw milk of Peoples Republic of China (GB19301-2010).[25] To facilitate aggregation of different dairy foods, we converted milk powder intake into its equivalent amount of fluid milk by taking into account the protein contents between the two dairy products according to the China Food Composition Table.[26]

In this study, we estimated total dairy consumption by summing up the gram per day of milk, yogurt and milk powder (fluid milk equivalent). The 2016 Chinese Dietary Guidelines[27] recommends 300 g per day of fluid milk or its equivalent dairy products for adults. Therefore, we created four cutting points for dairy consumption for statistical analysis: 0 g/day, 100 g/day (1/3 recommendation intake level), 200 g/day (2/3 recommendation intake level) and 300 g/day (recommendation intake level). Finally, for the overall participants, dairy consumption was categorized into five groups (0 g, 0<to<100 g, 100≤to<200 g, 200≤to<300 g, ≥300 g) for total dairy consumption and four groups (0 g, 0<to<100 g, 100≤to<200 g, ≥200 g) for milk consumption and three groups(0g, 0<to<100 g, ≥100

g) for yogurt consumption given that the number of participants consuming milk ≥300 g and yogurt ≥200 g were small. When gender-stratified analysis was done, total dairy consumption was categorized into four groups (0g, 0<to<100 g, 100≤to<200 g, ≥200 g) because the number of participants whose total dairy consumption was ≥300 g per day got smaller when stratified by gender.

We also calculated average daily intakes of other food groups and nutrients according to the China Food Composition Table.[26] The food groups were categorized as grains, potatoes, soy food, vegetables, fungi, fruits, seeds and nuts, meats, dairy foods, eggs, seafood, sweets, and beverages. We calculated all the study participants' total daily energy intake (kcal), the intake of carbohydrate (g), protein (g), fat (g), dietary fiber (g), cholesterol (g), potassium (mg), phosphorus (mg), sodium (mg), calcium (mg) and vitamin C (mg).

The validation study of the IDQC has been published.[24] Briefly, in a random sample of 292 participants enrolled in IDQC investigation, the estimates of dietary intake derived from the food-frequency questionnaire were compared with those derived from a 3-day diet diary. The Pearson correlation coefficient for total dairy products was 0.61. The coefficients for nutrient intakes ranged from 0.37 to 0.96.

Anthropometric measurements

All anthropometric measurements of the participants were conducted by trained personnel in community health centers in the 11 districts. Weight and height were measured by an anthropometer while participants were wearing light cloths and were without shoes and recorded to the nearest 0.1 kg and 0.1 cm. Waist circumference was measured using a flexible anthropometric tape on the horizontal plane between the lowest rib and the iliac crest over light clothing, to the nearest 0.1 cm.

BMI was defined as weight in kilograms divided by the square of height in meters (kg/m^2). As this study was performed in Chinese population, the BMI cut-off points of Chinese subjects (overweight: 24.0–27.9 kg/m^2; obesity ≥28.0 kg/m^2) were used.[28] Abdominal obesity was defined as waist circumference ≥85 cm in men and waist circumference ≥80 cm in women, according to the 2013 Criteria of Weight for Chinese Adults.28

Demographic, socioeconomic and health-related data were obtained from IDQC: investigation year (2014, 2015, 2016), gender (men and women), age (18-29, 30-44, 45-59, ≥60), income (<2000 yuan/month, 2000-3000 yuan/month, 3000-4000 yuan/month, ≥4000 yuan/month), education level (primary school graduates or less, junior middle school graduates, high school graduates, bachelor or above), residential location (downtown, county, countryside), smoking status (non-smoker, former smoker, current smoker), alcohol consumption (non-drinker, drink 1~12 times per month, drink ≥12 times per month), labor intensity (light, medium, heavy), physical activity (0 h/week, 1 ~10 h/week, ≥10 h/week).

Statistical analysis

Baseline characteristics of participants across total dairy consumption categories were analyzed. The proportions of each covariate and the prevalence of obesity in each dairy intake category were calculated. *p* value was calculated by using Pearson chi-square test for categorical variables.

General Linear Model were applied to investigate the association between total dairy consumption with intakes of energy, nutrients, and food groups. These models were controlled for covariates including age, education, residential region, income, smoking, wine-drinking, labor intensity, physical activities and total energy intake (continuous).

Binary logistic regression analyses were conducted to calculate the odds ratio (OR) and 95% confidence interval (CI) of overall obesity and abdominal obesity across total dairy intake categories, and across consumption categories of milk and yogurt respectively. To examine the trend of odds ratios across quartiles of dairy intake, the median value of dairy intake in each quartile was assigned as a continuous variable and then used in the analysis. Logistic regression analysis stratified by gender was conducted to examine gender differences. The multivariable model was adjusted for investigation year, gender, age, income, education level, residential location, smoking status, alcohol consumption, labor intensity, physical activity and total energy (continuous variable).

Statistical analyses were carried out using the SPSS software (version 18.0; Beijing Stats Data Mining Co. Ltd, Beijing, China). *p*-values of 0.05 (two-sided) were considered statistically significant.

RESULTS

In our study, 14.5% of the participants did not consume dairy product. The average total dairy consumption was 94.04 g/day (data not shown) for all participants who consume dairy food (Table 1). Those consuming higher total dairy product per day were more likely to be women, younger, highly educated, living in urban area, with middle to high monthly income, lighter labor intensity, physically active, non-smokers and non alcohol drinkers compared with those who consumed no dairy product (all $p<0.001$). Besides, the prevalence of overall obesity ($p=0.02$) and abdominal obesity ($p<0.001$) in population with higher total dairy intake was significantly lower than those who consumed no dairy product.

Dietary and nutrient intakes by total dairy consumption are shown in Table 2. Higher total dairy consumption was associated with a greater intake of fruits ($p<0.05$) and sweet ($p<0.001$) and a lower intake of grains ($p<0.001$) in both men and women compared with their counterparts who did not consume dairy product. Differences in food group intake between men and women were found in vegetable, soy food, and seafood. Men who consumed ≥200 g total dairy products per day eat more vegetables than men who did not consume dairy food. Women who consumed ≥200 g total dairy products per day eat more seafood ($p<0.001$) and less soy food ($p=0.02$) than women who did not consume dairy product.

In both genders, total dairy product consumption was positively related with the intake of energy, protein, fat, cholesterol, dietary calcium, potassium, phosphorous, and vitamin C, but negatively related with the carbohydrates (all $p<0.001$). Total dairy consumption was positively related with dietary fiber intake in men, while the differ-

Table 1. Characteristics and lifestyle of participants according to total dairy consumption

	Total, n (%)	Total dairy consumption (g/day), n (%)†					*p* value‡
		0	0<to<100	100≤to<200	200≤to<300	≥300	
Total	3871 (1000)	560 (14.5)	1779 (46.0)	735 (19.0)	531 (13.7)	266 (6.9)	
Gender							<0.001
Men	1700 (43.9)	331 (59.1)	769 (43.2)	277 (37.7)	214 (40.3)	109 (41.0)	
Women	2171 (56.1)	229 (40.9)	1010 (56.8)	458 (62.3)	317 (59.7)	157 (59.0)	
Age, year							
18-29	706 (18.2)	58 (10.4)	326 (18.3)	155 (21.1)	100 (18.8)	67 (25.2)	<0.001
30-44	1434 (37.0)	166 (29.6)	659 (37.0)	304 (41.4)	209 (39.4)	96 (36.1)	
45-59	1075 (27.8)	212 (37.9)	511 (28.7)	180 (24.5)	124 (23.4)	48 (18.0)	
≥60	656 (16.9)	124 (22.1)	283 (15.9)	96 (13.1)	98 (18.5)	55 (20.7)	
Income per month							<0.001
< 2000 yuan	1186 (30.6)	262 (46.8)	533 (30.0)	171 (23.3)	131 (24.7)	89 (33.5)	
2000-3000 yuan	1300 (33.6)	163 (29.1)	622 (35.0)	258 (35.1)	189 (35.6)	68 (25.6)	
3000-4000 yuan	757 (19.6)	70 (12.5)	346 (19.4)	169 (23.0)	117 (22.0)	55 (20.7)	
≥4000 yuan	628 (16.2)	65 (11.6)	278 (15.6)	137 (18.6)	94 (20.3)	54 (20.3)	
Location							<0.001
Countryside	811 (21.0)	221 (39.5)	378 (21.2)	96 (13.1)	80 (15.1)	36 (13.5)	
County	892 (23.0)	114 (20.4)	484 (27.2)	147 (20.0)	102 (19.2)	45 (16.9)	
Downtown	2168 (56.0)	225 (40.2)	917 (51.5)	492 (66.9)	349 (65.7)	185 (69.5)	
Education							<0.001
Primary school and below	385 (9.9)	97 (17.3)	139 (7.8)	63 (8.6)	54 (10.2)	32 (12.0)	
Junior middle school	763 (19.7)	174 (31.1)	390 (21.9)	103 (14.0)	67 (12.6)	29 (10.9)	
High school	927 (23.9)	139 (24.8)	444 (25.0)	164 (22.3)	122 (23.0)	58 (21.8)	
Bachelor and above	1796 (46.4)	150 (26.8)	806 (45.3)	405 (55.1)	288 (54.2)	147 (55.3)	
Labor intensity							<0.001
Light	2822 (72.9)	319 (57.0)	1292 (72.6)	588 (80.0)	415 (78.2)	208 (78.2)	
Medium	574 (14.8)	90 (16.1)	261 (14.7)	103 (14.0)	81 (15.3)	39 (14.7)	
Heavy	475 (12.3)	151 (27.0)	226 (12.7)	44 (6.0)	35 (6.6)	19 (7.1)	
Physical activity, h/week							
0	2282 (59.0)	410 (73.2)	1083 (60.9)	349 (47.5)	304 (57.3)	136 (51.1)	<0.001
1~10	1477 (38.2)	133 (23.8)	655 (36.8)	358 (48.7)	209 (39.4)	122 (45.9)	
≥10	112 (2.9)	17 (3.0)	41 (2.3)	28 (3.8)	18 (3.4)	8 (3.0)	
Smoking							0.004
Non-smoker	3184 (82.3)	383 (68.4)	1496 (84.1)	627 (85.3)	454 (85.5)	224 (84.2)	
Former smoker	158 (4.1)	45 (8.0)	62 (3.5)	23 (3.1)	14 (2.6)	14 (5.3)	
Current smoker	529 (13.7)	132 (23.6)	221 (12.4)	85 (11.6)	63 (11.9)	28 (10.5)	
Alcohol drinking, times per month							0.001
Non-drinker	3242 (83.8)	401 (71.6)	1512 (85.0)	638 (86.8)	467 (87.9)	224 (84.2)	
1~12	462 (11.9)	93 (16.6)	215 (12.1)	75 (10.2)	45 (8.5)	34 (12.8)	
≥12	167 (4.3)	66 (11.8)	52 (2.9)	22 (3.0)	19 (3.6)	8 (3.0)	

†Total dairy consumption includes milk, yogurt and milk powder. ‡*p* value was calculated by Pearson chi-square test for categorical variables.

Table 1. Characteristics and lifestyle of participants according to total dairy consumption (cont.)

	Total, n (%)	Total dairy consumption (g/day), n (%)†					p value‡
		0	0<to<100	100≤to<200	200≤to<300	≥300	
Overall obesity							0.2
Yes	302 (7.8)	57 (10.2)	152 (8.5)	42 (5.7)	34 (6.4)	17 (6.4)	
No	3569 (92.2)	503 (89.8)	1627 (91.5)	693 (94.3)	497 (93.6)	249 (93.6)	
Abdominal obesity							<0.001
Yes	1286 (33.2)	243 (43.4)	611 (34.3)	198 (26.9)	167 (31.5)	67 (25.2)	
No	2585 (66.8)	317 (56.6)	1168 (65.7)	537 (73.1)	364 (68.5)	199 (74.8)	

†Total dairy consumption includes milk, yogurt and milk powder. ‡*p* value was calculated by Pearson chi-square test for categorical variables.

Table 2. Dietary and nutrition intakes by total dairy consumption stratified by gender†

	Men (n=1700)					Women (n=2171)				
	Total dairy consumption (g/day)					Total dairy consumption (g/day)				
	0	0<to<100	100≤to<200	≥200	p value‡	0	0<to<100	100≤to<200	≥200	p value‡
	Mean±SE	Mean±SE	Mean±SE	Mean±SE		Mean±SE	Mean±SE	Mean±SE	Mean±SE	
Dietary intakes										
Grains, g/day	278.1±7.7	240.8±7.0*	231.6±9.2*	208.1±9.0*	<0.001	233.5±16.9	202.2±16.6*	187.6±17.0*	167.7±17.2*	<0.001
Potatoes, g/day	49.3±3.0	49.2±2.7	53.4±3.5	49.8±3.4	0.53	59.4±8.0	55.8±7.8	55.8±7.9	58.4±8.0	0.43
Vegetables, g/day	282.5±313.6	296.5±12.3*	320.4±16.2*	317.6±15.8*	0.04	250.6±34.6	258.2±34.0	262.6±34.7	275.4±35.2	0.28
Fruits, g/day	193.0±11.6	191.2±10.6*	204.6±13.8*	221.7±13.5*	0.04	216.6±32.6	225.4±32.0	228.2±32.7	254.9±33.1*	0.01
Meat, g/day	68.1±3.9	75.5±3.6	80.6±4.8*	64.8±4.7	0.001	58.1±8.9	66.9±8.7*	74.4±8.9*	61.4±9.1	0.01
Soy food(dry bean equivalents), g/day	21.0±2.1	26.0±1.9*	25.2±2.5	19.7±14.9	0.001	11.4±4.9	14.6±4.9	11.5±5.0	6.3±5.0*	0.02
Seafood, g/day	62.5±4.2	66.8±3.8	69.7±5.0	69.1±4.9	0.39	40.7±9.2	51.0±9.01	54.7±9.2*	53.6±9.4*	<0.001
Eggs, g/day	29.8±2.4	28.6±2.1	24.8±2.7	33.0±2.6	0.02	22.3±4.0	21.8±3.8	22.6±4.0	24.0±4.0	0.31
Nuts and seeds, g/day	27.3±3.0	38.6±2.7*	32.9±3.6	35.6±3.5	<0.001	10.8±6.5	17.5±6.4*	9.5±6.5	12.7±6.6	<0.001
Sweets, g/day	1.6±0.3	2.4±0.2*	2.6±0.3*	2.9±0.3*	<0.001	1.3±0.8	2.2±0.8*	2.3±0.8*	2.4±0.8*	0.001
Non alcohol beverages, ml/day	24.3±3.9	27.6±3.5	38.3±4.6*	25.6±4.4	0.007	21.8±7.6	25.9±7.4	35.5±7.6*	26.3±7.7	<0.001
Nutrition intakes										
Total energy, kcal/day	2775.0±66.1	2748.9±58.4	3134.7±71.9*	3157.6±69.2*	<0.001	2076.2±146.6	2199.6±142.5*	2525.1±143.9*	2667.0±145.9*	<0.001
Total protein, g/day	66.7±1.1	71.9±1.0*	74.4±1.4*	74.7±1.3*	<0.001	52.3±2.4	56.3±2.3*	58.0±2.4*	59.0±2.4*	<0.001
Total fat, g/day	60.1±1.7	66.2±1.5*	64.7±2.0*	69.6±1.9*	<0.001	47.1±3.6	51.1±3.5*	52.6±3.6*	54.4±3.6*	<0.001
Total Carbohydrate, g/day	310.0±4.3	292.6±3.8*	296.4±5.1*	285.1±4.9*	<0.001	254.0±8.8	241.7±8.7*	236.0±8.9*	231.8±9.0*	<0.001
Fiber, g/day	14.5±0.5	15.6±0.4*	15.7±0.6	15.9±0.6*	0.02	12.9±1.1	13.3±1.1	12.5±1.1	13.2±1.1	0.1
cholesterol, g/day	464.5±22.2	484.5±19.8	507.2±25.5	565.2±24.8*	<0.001	353.3±41.8	375.2±41.0	418.4±41.9*	445.9±42.5*	<0.001
Calcium, mg/day	408.7±17.7	533.7±16.1*	613.6±21.6*	789.3±21.2*	<0.001	377.2±42.5	492.6±41.7*	584.6±42.6*	753.2±43.2*	<0.001
potassium, mg/day	1969.4±49.4	2188.0±44.7*	2341.4±59.4*	2487.9±58.1*	<0.001	1782.9±117.2	1944.3±115.2*	2012.0±117.8*	2259.6±119.5*	<0.001
phosphorus, mg/day	1034.8±19.0	1132.6±17.2*	1178.7±22.7*	1210.3±22.2*	<0.001	829.1±42.2	902.8±41.5*	939.0±42.4*	983.8±43.0*	<0.001
Sodium, mg/day	3359.3±117.2	3456.8±105.0	3471.9±136.2	3349.2±132.4	0.6	3211.2±263.1	3341.5±257.2	3303.4±262.0	3282.7±266.0	0.51
Vitamin C, mg/day	87.9±5.4	96.6±4.9	103.2±6.6	117.6±6.5*	<0.001	83.4±16.9	95.4±16.6	91.7±16.9	115.7±17.2*	<0.001

†The general linear model included covariates including age, education, residential region, income, smoking, wine-drinking, labor intensity, physical activities and total energy intake (continuous). ‡*p* value for comparison among categories. **p*<0.05 compared with the 1st category.

ence was not found in women.

The odds ratio of overall and abdominal obesity according to categories of dairy products in the overall participants are shown in Table 3. With adjustment for demographic and lifestyle confounding factors and total energy, participants consuming ≥300 g total dairy products per day were less likely to be at risk of abdominal obesity than those consumed no dairy product (OR=0.61; 95% CI=0.42-0.88; p for trend=0.003). Milk consumption of ≥200 g per day was inversely associated with the risk of overall obesity, compared with 0g milk consumption (OR=0.56; 95% CI=0.36-0.88; p for trend=0.005). Yogurt consumption of ≥100 g per day was inversely associated with the risk of abdominal obesity, compared with 0 g yogurt consumption (OR=0.50; 95% CI=0.34-0.72; p for trend=0.01).

The odds ratio of overall and abdominal obesity according to categories of dairy products by gender are shown in Table 4. After controlling for demographic and lifestyle confounding factors and total energy, men who consumed ≥100 g of yogurt per day had lower risk of being abdominal obesity than men who did not consume yogurt(OR=0.41; 95% CI=0.24-0.70; p for trend<0.001). Women who consumed ≥200 g of milk per day had lower risk of being overall obesity than women who did not consume milk (OR=0.47; 95% CI=0.24-0.91; p for trend=0.01).

DISCUSSION

In this study, we found that total dairy product and yogurt consumption were inversely associated with prevalence of abdominal obesity, and milk consumption was inversely associated with overall obesity in adult population of northeast China. In gender-stratified analysis, higher yogurt consumption was associated with less risk of abdominal obesity in men, while higher milk consumption was associated with less risk of overall obesity in women.

With respect to the type of dairy products, previous

Table 3. Multivariate adjusted odds ratio (OR) and 95% confidence interval (CI) of overall and abdominal obesity by category of dairy consumption for overall participants

Dairy consumption categories (g/day)	Participant (n, %)	OR (95% CI)	
		Crude model†	Multivariate adjusted model‡
Overall obesity			
Total dairy food			
0	560 (14.5)	1	1
0<to<100	1779 (46.0)	0.82 (0.60-1.14)	0.95 (0.681-1.33)
100≤to<200	735 (19.0)	0.54 (0.35-0.81)**	0.61 (0.39-0.95)*
200≤to<300	531 (13.7)	0.60 (0.39-0.94)*	0.67 (0.42-1.06)
≥300	266 (6.9)	0.60 (0.34-1.06)	0.60 (0.34-1.08)
p for trend		0.01	0.01
Milk			
0	915 (23.6)	1	1
0<to<100	2083 (53.8)	0.87 (0.66-1.14)	0.91 (0.68-1.21)
100≤to<200	337 (8.7)	0.66 (0.40-1.08)	0.67 (0.40-1.12)
≥200	536 (13.8)	0.57 (0.37-0.88)*	0.56 (0.36-0.88)*
p for trend		0.01	0.005
Yogurt			
0	1373 (35.5)	1	1
0<to<100	2212 (57.1)	0.60 (0.47-0.77)	0.76 (0.57-1.00)
≥100	286 (7.4)	0.44 (0.25-0.78)**	0.58 (0.32-1.06)
p for trend		0.01	0.68
Abdominal obesity			
Total dairy food			
0	560 (14.5)	1	1
0<to<100	1779 (46.0)	0.68 (0.56-0.83)**	1.20 (0.82-1.27)
100≤to<200	735 (19.0)	0.48 (0.38-0.61)**	0.81 (0.62-1.05)
200≤to<300	531 (13.7)	0.60 (0.47-0.77)**	0.93 (0.71-1.24)
≥300	266 (6.9)	0.44 (0.32-0.61)**	0.61 (0.42-0.88)**
p for trend		<0.001	0.003
Milk			
0	915 (23.6)	1	1
0<to<100	2083 (53.8)	0.89 (0.76-1.05)	1.06 (0.88-1.27)
100≤to<200	337 (8.7)	0.75 (0.57-0.98)*	0.90 (0.66-1.22)
≥200	536 (13.8)	0.84 (0.67-1.06)	1.02 (0.79-1.32)
p for trend		0.11	0.68
Yogurt			
0	1373 (35.5)	1	1
0<to<100	2212 (57.1)	0.45 (0.40-0.52)**	0.84 (0.71-1.00)
≥100	286 (7.4)	0.21 (0.15-0.29)**	0.50 (0.34-0.72)**
p for trend		<0.001	0.01

†Crude model adjusted for no potential factors.
‡Multivariate adjusted model adjusted for investigation year, age, gender, education, residential region, income, smoking, wine-drinking, labor intensity, physical activities, and total energy (continuous variable).
*p<0.05 compared with the 1st category **p<0.01 compared with the 1st category.

Table 4. Multivariate adjusted odds ratio (OR) and 95% confidence interval (CI) of overall and abdominal obesity by category of dairy consumption stratified by gender

Dairy consumption categories (g/day)	Men (n=1700)			Women (n=2171)		
	Participant (n, %)	OR (95% CI)		Participant (n, %)	OR (95% CI)	
		Crude model†	Multivariate adjusted model‡		Crude model†	Multivariate adjusted model‡
Overall obesity						
Total dairy food						
0	331 (19.5)	1	1	229 (10.5)	1	1
0<to<100	769 (45.2)	0.86 (0.56-1.34)	0.83 (0.52-1.31)	1010 (46.5)	0.79 (0.49-1.27)	1.16 (0.70-1.92)
100≤to<200	277 (16.3)	0.74 (0.42-1.31)	0.67 (0.36-1.23)	458 (21.1)	0.41 (0.22-0.75)**	0.60 (0.31-1.16)
≥200	323 (19.0)	0.93 (0.55-1.56)	0.87 (0.50-1.52)	474 (21.8)	0.40 (0.22-0.73)**	0.54 (0.28-1.04)
p for trend		0.83	0.73		<0.001	0.003
Milk						
0	441 (25.9)	1.00	1.00	474 (21.8)	1	1
0<to<100	895 (52.6)	0.95 (0.64-1.40)	0.91 (0.61-1.38)	1188 (54.7)	0.81 (0.55-1.19)	0.92 (0.61-1.38)
100≤to<200	142 (8.4)	0.88 (0.45-1.72)	0.81 (0.40-1.62)	195 (9.0)	0.50 (0.24-1.04)	0.57 (0.26-1.25)
≥200	222 (13.1)	0.74 (0.41-1.34)	0.70 (0.38-1.31)	314 (14.5)	0.44 (0.23-0.84)*	0.47 (0.24-0.91)*
p for trend		0.31	0.25		0.006	0.01
Yogurt						
0	774 (45.5)	1.00	1.00	599 (27.6)	1	1
0<to<100	845 (49.7)	0.75 (0.53-1.05)	0.65 (0.44-0.96)*	1367 (63.0)	0.51 (0.36-0.72)**	0.93 (0.62-1.39)
≥100	81 (4.8)	0.70 (0.30-1.67)	0.51 (0.21-1.26)	205 (9.4)	0.34 (0.16-0.72)**	0.74 (0.32-1.70)
p for trend		0.32	0.15		0.011	0.49
Abdominal obesity						
Total dairy food						
0	331 (19.5)	1	1	229 (10.5)	1	1
0<to<100	769 (45.2)	0.90 (0.69-1.16)	1.02 (0.77-1.34)	1010 (46.5)	0.63 (0.46-0.85)**	1.02 (0.71-1.47)
100≤to<200	277 (16.3)	0.86 (0.63-1.19)	1.02 (0.72-1.44)	458 (21.1)	0.35 (0.24-0.51)**	0.63 (0.40-0.97)*
≥200	323 (19.0)	0.85 (0.63-1.16)	0.98 (0.71-1.37)	474 (21.8)	0.43 (0.30-0.61)**	0.72 (0.47-1.11)
p for trend		0.38	0.89		<0.001	0.01
Milk						
0	441 (25.9)	1	1	474 (21.8)	1	1
0<to<100	895 (52.6)	0.96 (0.76-1.21)	1.05 (0.82-1.33)	1188 (54.7)	0.90 (0.70-1.15)	1.06 (0.79-1.41)
100≤to<200	142 (8.4)	1.20 (0.82-1.75)	1.29 (0.86-1.93)	195 (9.0)	0.45 (0.29-0.72)**	0.57 (0.34-0.97)*
≥200	222 (13.1)	1.05 (0.76-1.45)	1.13 (0.80-1.59)	314 (14.5)	0.76 (0.54-1.07)	0.90 (0.60-1.35)
p for trend		0.41	0.33		0.013	0.15
Yoghurt						
0	774 (45.5)	1	1	599 (27.6)	1	1
0<to<100	845 (49.7)	0.670 (0.56-0.82)**	0.77 (0.61-0.97)*	1367 (63.0)	0.39 (0.31-0.48)**	0.95 (0.73-1.25)
≥100	81 (4.8)	0.35 (0.21-0.58)**	0.41 (0.24-0.70)**	205 (9.4)	0.19 (0.12-0.31)**	0.65 (0.37-1.13)
p for trend		<0.001	0.001		<0.001	0.12

†Crude model adjusted for no potential factors.
‡Multivariate adjusted model adjusted for investigation year, age, gender, education, residential region, income, smoking, wine-drinking, labor intensity, physical activities, and total energy (continuous variable).
**p*<0.05 compared with the 1st category ***p*<0.01 compared with the 1st category.

studies have shown beneficial effect of milk and yogurt on both overall and abdominal obesity. Satija et al[29] did a cross-sectional analysis in adult population in India and found men and women who consumed ≥1 portions of plain milk per day had lower risk of being overall obese (men: OR=0.67, 95% CI: 0.51-0.87; women: OR=0.57, 95% CI: 0.43-0.76) and lower risk of high waist circumference (men: OR=0.71, 95% CI: 0.54-0.93; women: OR=0.79, 95% CI: 0.59-1.05) than those who do not consume any milk. Similarly, Crichton et al[7] examined the association between the consumption of different types of dairy food and the risk of obesity among adult population of Luxembourg. They found participants in the highest category of whole-fat milk and whole-fat yogurt had significantly lower odds for being global obesity (whole-fat milk: OR=0.63, 95% CI: 0.44-0.92; whole-fat yogurt: OR=0.57, 95% CI: 0.39-0.85) and abdominal obesity (whole-fat milk: OR=0.61, 95% CI: 0.44-0.86; whole-fat yogurt: OR=0.58, 95% CI: 0.41-0.83), compared with those in the lowest intake category. In longitudinal analysis of the Framingham Heart Study offspring cohort,[13] Wang et al found participants who consumed ≥3 servings/week of yogurt had a 0.10 (±0.04) kg and 0.13 (±0.05) cm smaller annualized increment of weight (*p* for trend=0.03) and waist circumstance (*p* for trend=0.008) compared with those consuming <1 serving/week. Consisting with these findings, our result showed that participants consuming higher amount of yogurt per day had lower risk of abdominal obesity compared with those who did not consume yogurt, and participants consuming higher amount of milk per day had lower risk of overall obesity compared with those who did not consume milk. However, we did not find any association between milk consumption and abdominal obesity and between yogurt consumption and overall obesity.

Some of the nutrients in milk have been shown to contribute to the weight-control effect. Calcium in milk plays its role in weight management by down-regulating lipogenesis and attenuating inflammatory cytokine production through suppressing calcitrophic hormones (1,25-(OH)2-D and or parathyroid hormone).[30] Calcium can also promote fat excretion by forming insoluble fatty acid soaps and other hydrophobic aggregations of bile acids.[31] In addition, milk protein's anti-inflammatory properties and satiety also aid in weight control.[32,33] Other components of milk, such as conjugated linoleic acids and bioactive peptides, play important roles in anti-inflammatory activities.[34] As a fermented product from milk, yogurt is more nutrient-concentrated. What's more, the traditional (*S. thermophilus* and *L. bulgaricus*) and probiotic (*L. acidophilus*, *B. bifidum*, *B. lactis*, et al) strains added in yogurt have been demonstrated to regulate intestinal barrier function[35] which is thought to have more influence on central adiposity than on overall adiposity.[36] Therefore, the inverse association between yogurt consumption and abdominal obesity might be partly attributed to yogurt's beneficial role in gut function regulation.

Our study showed the association between dairy consumption and prevalence of obesity differed between men and women. Some studies[37,38] have showed gender-difference in the protective effect of dairy products against overweight/obesity, in which dairy products were more likely to have inverse associations with obesity in women, rather than men. Women who consumed higher dairy food tended to have a more healthy eating and living habit, whilst the correlation was not obvious in men.[37] Besides, the prevalence of obesity in men was mostly higher than that in women. It is possible that the prevalence of obesity might have influenced the positive effect of dairy consumption on obesity in men.[37] In line with these results, we found an inverse association between milk consumption and risk of overall obesity only in women, no significant association between milk consumption and overall obesity were observed in men.

However, we also found an inverse association between yogurt consumption and risk of abdominal obesity only in men. No significant association was observed between yogurt consumption and abdominal obesity in women. Since yogurt are usually added probiotic strains which can help maintain a healthy gut microbiota,[35] we hypothesize that gender-specific disparities in the yogurt-microbiota correlation might explain the gender discrepancy in the yogurt-obesity association. Yoshio et al[39] recently conducted a cross-sectional study of healthy Japanese college freshmen to evaluate the role of host gender in the association between the intestinal microbiota and the frequency of yogurt consumption, in which several gender-specific disparities were detected. Specifically, they found higher yogurt consumption demonstrated an inverse association with *Lactobacillus sakei* subgroup, Enterobacteriaceae and Staphylococcus in men and a positive association with *Lactobacillus casei* subgroup and succinic acid in women. Human microbiota act as a possible mediator of visceral fat accumulation but not subcutaneous or total body fat accumulation, by regulating intestinal barrier function.[36] Therefore, the disparity in the yogurt-microbiota correlation in men and women could lead to gender discrepancy in the association between yogurt and abdominal obesity, however, further studies are needed to verify this hypothesis.

There are some limitations in this study. First, causal relationship between dairy consumption and the risk of obesity could not be evaluated in this cross-sectional designed study. Second, as in most dietary survey, all the dietary intakes were reliant upon self-report and therefore, underreporting and over reporting biases could exist. However, the FFQ has been previously validated, and images of every food item with commonly consumed portion were illustrated in the FFQ to aid the participant in amount estimation. Moreover, participants with unreasonable energy intake were excluded in the analysis to improve the accuracy of analysis. Third, because of the lack of classifications for high- and low-fat dairy products and low consumption of cheese and skimmed milk in the typical Chinese diet, the association between dairy intake and obesity requires further investigation. Fourth, although we adjusted for demographic, health-related and dietary factors, the possibility of other confounders unable to be identified in our study could not be ruled out. Finally, the participants in our study were from one city in northeast China. Extrapolation of this result to other populations should be cautious. Nonetheless, this study was valuable because it examined the association between dairy consumption and risk of obesity in an adult population in northeast China, taking dairy type, measurements of obesity, and gender into consideration. Our results coincided with previous studies, indicating that higher consumptions of dairy products was inversely associated with risk of obesity in our population. In addition, we found gender difference in this association and provide some plausible explanations. What's more, the validated web-based FFQ we used facilitated our data collection in a large population scale which increased the validity of our results.

In summary, our results indicated inverse associations between dairy consumption and obesity prevalence in a Chinese adult population. The association varied depending on type of dairy product, measurements of obesity, and gender. Further research are required to confirm the inverse associations and to explain the observed gender-specific difference.

AUTHOR DISCLOSURES

The authors declare no conflict of interest.

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