



RESEARCH ARTICLE

Association between dairy product intake and high blood pressure in Chilean adults

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Keywords

Dairy • Low fat dairy • High blood pressure • Lifestyles • Food frequency

Summary

Background. Hypertension is a major risk for cardiovascular disease. Several studies have connected dairy consumption with lower blood pressure (BP). However, these have not considered the Latin American population. The aim of this study was to examine the relationship between consumption of full-fat or low fat/free dairy products and high blood pressure in Chilean adults.

Methods. Cross-sectional study containing data from 3,807 adults between 20 and 98 years old from the National Health Survey (NHS) of Chile 2016-2017. Information on lifestyle, food frequency, and socio-demographics was collected using standardized questionnaires. Trained fieldworkers took anthropometric and blood pressure measurements. The frequency of consumption data included seven ad-hoc questions on habitual eating and frequency options, based on the Mediterranean diet (fish products, fruit and vegetable, and dairy products) and its protective effect

on cardiovascular diseases. The selection of foods was supported by expert opinion.

Results. Of the 3,807 adults, 37% were male and 63% were female. Sex, education level, frequency of dairy products and fish, smoking, and sport or physical activity had a direct relationship with consumption of dairy products ($P < 0.05$). Consumption of low fat/free dairy products was protectively associated with high blood pressure in the unadjusted model (OR: 0.76, CI 95% 0.64-0.91). However, after adjustment for confounding variables (education level modifies the effect 10.2%), this association was attenuated (OR: 0.88; CI 95% 0.71-1.08).

Conclusion. We found limited evidence that the type of dairy products consumed is associated with high blood pressure in the Chilean population.

Introduction

One of the risk factors for the development of cardiovascular disease and stroke is high blood pressure. It is expected that 29% of the adult population in the world will develop hypertension by 2025 and prevention and management are a public health priority[1]. Hypertension is defined as a blood pressure (BP) greater than 140 mmHg/90 mmHg in the United States and in Europe as 130 mmHg/80 mmHg [2, 3]. The World Health Organization (WHO) has classified hypertension as the leading cause of preventable death [4], mainly due to environmental factors, including diet and other lifestyle aspects including overweight and/or obesity, excessive drinking, smoking, poor eating habits, and reduced physical activity [5, 6]. The prevalence of high blood pressure is worrying because of its direct, independent relationship with chronic disease risk[7]. Cardiovascular disease, strokes, and high blood pressure were listed as the leading causes of death for over 17,759 Chileans and they are responsible for more than 7 million deaths worldwide each year [7, 8].

Diet is an important determinant of blood pressure. Scientific evidence has emerged supporting a beneficial relationship between the consumption of dairy products

and the control of blood pressure in adults, for example Dietary Approaches to Stop Hypertension (DASH) notes the effects of dietary patterns on blood pressure [9]. In this trial, adults diagnosed with hypertension consumed a controlled diet for 8 weeks and demonstrated that the consumption of fruit, vegetables and low-fat dairy products led to an additional reduction in both systolic blood pressure (SBP) and diastolic blood pressure (DBP) of 2.7 mmHg and 1.9 mmHg respectively [9].

Furthermore, meta-analyses of subsequent studies [10, 11] showed a lower risk (16%) of elevated blood pressure and hypertension (HTN) (3%) in adults for every 200 grams/day of total dairy intake: 0.97 (95% CI, 0.95-0.99) for total dairy, 0.96 (95% CI, 0.93-0.99) for low-fat dairy and 0.96 (95% CI, 0.94-0.98) for milk. However, subsequent randomized controlled intervention studies have shown inconsistent results on the BP lowering effects of dairy products. This may be related to the consumption of milk products with varying fat compositions and differences in study design (e.g. short trial duration and low statistical power) [12–16].

The relationship between the fat content of dairy products consumed and hypertension has been investigated previously in European or North American populations showing an inverse association [17, 18]. At

present, it is not known if this association between high blood pressure and types of dairy product consumption is found in other locations. For example, there is a lack of evidence on this association from Latin America and in particular Chile. The purpose of this study was to investigate the association between the consumption of dairy products with different fat contents and high blood pressure in a representative sample of adults in Chile. We hypothesized that the consumption of dairy products with a low-fat content is a protective factor for hypertension in this population.

Methods

STUDY DESIGN

Data for this study came from the National Health Survey (NHS) 2016-2017. A multistage stratified cluster sampling design was used. The survey is representative of the 15 regions, rural and urban strata. The sample was calculated using an absolute sampling error of 2.6% at the national level, the root of the design effect of 1.797, estimated with 95% confidence and relative error less than 30%, resulting in a final sample of 6,233 individuals ≥ 15 years old. The data was collected between August 2016 and March 2017. The methodology of the NHS has been described in detail in the report of the Chilean Ministry of Health [19]. For this study, 3,807 Chileans were selected (Fig. 1).

Chile is a country in western South America with an estimated total population of 17.5 million as of 2017 and the territory is divided into fifteen regions. The country has an ethnically mixed population of white, mestizos, indigenous Amerindians or Native people. The GINI is 44.4 and the Human Development Index (HDI) is 0.847 [20].

INCLUSION AND EXCLUSION CRITERIA

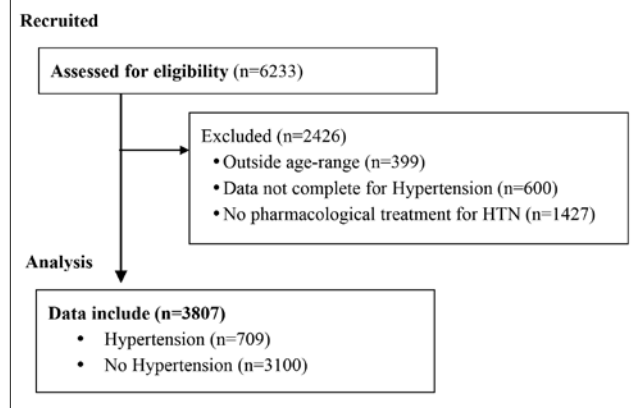
For this analysis, we excluded participants < 20 years old ($n = 399$) and those undergoing pharmacological treatment for diagnosed hypertension ($n = 1427$). All participants signed an informed consent form [19].

Measurements

ANTHROPOMETRIC AND METABOLIC MEASUREMENTS

The anthropometric measurements were performed by trained personnel and under protocols described in detail in the NHS [19]. Nutritional status was classified according to BMI based on the recommendations of WHO [21]. BP was measured using standardized methods previously described in the NHS along with their respective cut-off points (SBP ≥ 140 or DBP ≥ 90 mmHg). Three blood pressure measurements were taken prior to reading the person rested five-minute exactly by a clock, and each measurement had an interval of exactly two minutes. An automatic pressure

Fig. 1. Flowchart illustrating the recruitment and selection of the sample. Study population and area.



device (Omron HEM 742®) was used. The third blood pressure measurement was taken to evaluate individual variability [19].

FOOD FREQUENCY

Seven *ad-hoc* questions about habitual diet were included. The questions were based on the Mediterranean diet (omega fatty acids, dietary fiber, and phytonutrients) as a way to establish basic epidemiological surveillance considering its protective effect on cardiovascular risk. The selection of the foods was supported by expert opinion. Three food groups were considered [19]:

• Dairy products

To determine the consumption of the different types of dairy products, we used multiple-choice survey questions: How often do you consume milk, cheese, fresh cheese or yogurt? The answer choice options were: 2 or more times a day, less than 3 times a day, once a day, every other day, at least once a week, between one and three times a month, and less than once a month or never. What type of dairy such as milk, fresh cheese or yogurt do you prefer? The answer choice options were: *semi-fat, fat-free or low-fat* and *whole or full fat* [19].

• Fish or Shellfish

How often do you eat fish or shellfish (any type of preparation or presentation)? The answer choice options were: More than 1 time per week or once a week, less than 3 times a month, and less than once a month or never.

• Fruits and vegetables

The consumption of fruits and vegetables was included according to the WHO strategy “5 a day”. For this pictures were used with examples of servings of typical Chilean fruits and vegetables (1 serving = 80 g). We used questions to determine the consumption: How many servings of fruit do you eat on one of those days? How many servings of vegetables do you eat on one of those days?

LIFESTYLES AND OTHER VARIABLES

To determine smoking habits, a known lifestyle associated with hypertension, questions based on the Pan American Health Organization were selected [22]. Demographic variables such as age, sex, and education level were collected using questionnaires validated in the national population [19]. The levels of physical activity (PA) in the population include activities of daily living (like commuting) and activities of moderate or vigorous intensity. These activities were assessed by the “Global Physical Activity Questionnaire” [19].

STATISTICAL ANALYSIS

Descriptive statistics were used to characterize the categorical variables as frequencies and percentages (%), χ^2 test analysis for categorical variables were used with dairy products. Bivariate analyses were conducted to examine the association between the hypertension and other variables. The association between the type of dairy consumed and hypertension was examined using a Logistic Regression model. Results were presented as Odds Ratio (OR) and their respective 95% confidence intervals (95% CI). Sex, age, education, frequency of fish consumption, physical activity level, smoking and body mass index (BMI) were considered *a priori* confounders since these factors are associated with both the dependent variable (blood pressure) and the independent variables (dairy intake). Confounding was investigated using a *forward stepwise analysis* and variables were considered as confounders if the difference between the two measures of association was 10% or more. A likelihood ratio test was performed to check for interaction between dairy intake and the potential confounders. For all analyses, the complex sample analysis module of the STATA SE v15 program was used and all results were estimated using expanded samples according to the NHS 2016-2017 [19]. The significance level was defined as $p < 0.05$.

ETHICAL CONSIDERATIONS

This survey received ethics approval for the protocol that was granted by the Ethics Committee of the School of Medicine of the Pontifical Catholic University of Chile. The adults received both written and verbal information in Spanish about the survey and provided written informed consent.

Results

Table I provides a description of the population per type of dairy products consumed. It was observed that 37.2% of individuals who consume low fat / fat-free dairy were hypertensive. Sixty-five percent of men consume mostly whole dairy products, as did almost eighty percent of people with more than 8 years of education. Frequency of dairy consumption, frequency of consumption of fish, smoking, and sport or physical activity presented statistically significant differences concerning the type of dairy products consumed.

Hypertension was lower among women compared with men (15.2 vs 24.4; OR = 0.55; 95% CI 0.46-0.65), those aged 20-44 years (5.9%), and was higher among those with < 8 years of education (7.6 vs 39.9; OR = 8.07; 95% CI 6.12-10.65), morbidly obese (14.4 vs 24.6; OR = 1.93; 95% CI 1.23-3.01), and those whose consumption of fish was “*less than once a month or never*” (16.4 vs 19.9; OR = 1.27; 95% CI 1.05-1.54). Regarding lifestyles, hypertension was higher among former smokers (19.6 vs 21.4; OR = 1.11; 95% CI 0.91-1.36) and those who did not engage in sports or physical activity in the last month (9.9 vs 21.1; OR = 2.42; 95% CI 1.75-3.34) (Tab. II).

Overall, the chances of hypertension were lower among adults who consume low fat/fat free dairy products (OR = 0.76, 95% CI 0.64-0.91). After adjustment for sex, age, education level, frequency of fish consumption, physical activity, BMI and smoking history, the association became insignificant (OR = 0.88; 95%CI 0.71-1.08) (Tab. III).

The level of education of the individual was found to be a potential confounder since it modifies 10.2% the effect. Regarding the interaction analysis, no statistical significance was observed in the variables included in the model. Forty-three percent of individuals with hypertension who consume whole/full fat dairy products have a low education level (< 8 years), while 38.8% of individuals without hypertension and who consumed low-fat/fat-free dairy products had a high educational level (> 12 years) (Fig. 2).

Discussion

Our findings contribute to the literature: First, to our knowledge, this is the first nationally representative study to examine the association between hypertension and consumption of dairy products in Chilean adults. Second, educational level was shown to be a confounding variable, this being an important finding, which leads us to think of hypertension as a social problem, in which educational level plays an important role. Third, this study showed an inverse relationship between dairy consumption and hypertension.

An inverse association between dairy consumption and hypertension may be attributed to the many beneficial components of low-fat dairy foods. These may contribute to their protective effects, such as calcium [23] and peptides derived from casein [24]. In general, studies have shown a beneficial effect of low fat dairy on BP [25, 26], but when consumption is predominantly high fat dairy, the research suggests that the amount of fat consumed may negatively influence BP levels [27, 28]. Follow-up studies identified that the association between BP and dairy foods is much stronger than the association of BP with calcium intake alone. It has therefore been suggested that the components of dairy foods may play an important role. There are also studies that show a modified, high fat, DASH diet (which includes high fat dairy) that is low in carbohydrates was not associated with increased BP [29].

Tab. I. Characteristics of participants according to dairy products in Chilean adults (n=3809).

Variables	Dairy Products		p-value
	Whole of Full-Fat n (%)	Low-fat/Fat-free n (%)	
Sex			
Male	854(65.1)	454(34.9)	< 0.001
Female	1153(53.1)	1017(46.87)	
Age			
20-44 years	999(58.2)	718(41.8)	0.530
45-64 years	669(57.8)	489(42.23)	
≥ 65 years	330(55.6)	264(44.4)	
Education Level			
≥ 12 years	414(44.6)	515(55.4)	< 0.001
8-12 years	1131(60.7)	732(39.3)	
< 8 years	433(67.7)	211(32.8)	
Body Mass Index BMI			
Normal/Thin	495(58.9)	345(41.1)	0.596
Overweight	782(56.4)	605(43.62)	
Obese	643(58.0)	465(41.9)	
Morbidly Obese	70(60.34)	46(39.66)	
Frequency of dairy consumption (milk, cheese, fresh cheese or yogurt)			
More than 3 times per day	102(45.9)	120(54.1)	< 0.001
Less than 3 times per day	792(49.8)	798(50.2)	
Every other day	442(63.5)	254(36.5)	
1 time per month or never	662(68.9)	299(31.1)	
Consumption of fruits or vegetables per day			
≥ 5 servings per day	145(57.8)	106(42.2)	0.439
< 5 servings per day	1835(57.7)	1345(42.3)	
0 servings per day	18(47.4)	20(52.6)	
Frequency of consumption of fish			
More than 1 time per week or once a week	765(51.1)	731(48.9)	< 0.001
Less than 3 times a month	494(61.1)	314(38.9)	
Less than once a month or never	739(63.4)	426(36.6)	
Smoking			
No, I have never smoked	893(57.9)	648(42.1)	0.007
Yes, one or more cigarettes	532(61.4)	334(38.6)	
Yes. Less than one cigarette a day	156(56.5)	120(43.48)	
Ex-smoker	417(53.1)	369(46.9)	
Sport or Physical activity in the last month 30 minutes or more			
Yes, 3 or more times a week	194(48.1)	209(51.9)	< 0.001
Less than 3 times a week	246(56.6)	189(43.45)	
No, I did not engage in sports or physical activity in the last month	1558(59.2)	1073(40.8)	

Meta-analyses of observational studies have also shown that consumption of low fat dairy is associated with a lower risk of high BP (RR = 0.84, 95% CI 0.74, 0.95; I² = 38%) [10] and non-communicable diseases [11]. Another meta-analysis showed that dairy intake was associated with a lower risk of metabolic syndrome components, such as hyperglycemia, high blood pressure, hypertriglyceridemia and low high-density lipoproteins (HDL) cholesterol [30]. In our study only 42.4% of the participants reported consuming low fat or fat free dairy products. These dairy products included milk, cheese and yogurt.

A clinical study, in which 55 healthy men and women with high BP were randomly assigned to 3 isoenergy diets for a period of weeks (diet 1: no dairy, diet 2:

containing low fat dairy and diet 3: including high fat dairy), found no difference in BP between the three groups [31]. Another study where a group was given 30 grams of Grana Padano cheese for a period of 3 months showed a significant reduction in systolic and diastolic blood pressure at the end of the study [32]. Another crossover, randomized, controlled study that compared a Mediterranean Diet with 3 to 4 daily servings of dairy (Mediterranean Dairy) and a low fat control diet resulted in a reduction in systolic and diastolic BP and other cardiometabolic parameters [33]. Our results might have shown a greater effect on BP, however, only 5.8% of the participants consumed more than 3 servings of dairy per day. 41.7% of the participants consume 1 to 3 servings per day, but unfortunately, the NHS survey does not

Tab. II. Hypertension according to potentially associated factors products in Chilean adults (n=3809).

Variables	Total Adults	With HTN n (%)	Crude OR	95% CI
		709 (18.6)		
Sex				
Male	1299	348 (24.4)	1	-
Female	2170	361 (15.2)	0.55**	0.46; 0.65
Age				
20-44 years	1717	110(5.9)	1	-
45-64 years	1158	294 (22.8)	4.70**	3.72; 5.93
≥ 65 years	596	305(46.9)	14.12**	11.03; 18.07
Education Level				
≥ 12 years	929	72 (7.6)	1	-
8-12 years	2863	333(16.3)	2.37**	182; 3.07
< 8 years	644	293(39.9)	8.07**	6.12; 10.65
Body Mass Index BMI				
Normal/Thin	840	134 (14.4)	1	-
Overweight	1387	274(18.1)	1.30**	1.04; 1.63
Obese	1108	265(21.8)	1.64**	1.31; 2.07
Morbidly Obese	116	31(24.6)	1.93**	1.23; 3.01
Frequency of dairy consumption (milk, cheese, fresh cheese or yogurt)				
More than 3 times per day	222	33(14.9)	1	-
Less than 3 times per day	1590	276(17.4)	1.20	0.81; 1.78
Every other day	696	132(18.9)	1.34	0.88; 2.03
1 time per month or never	961	268(20.6)	1.48*	1.00; 2.20
Consumption of fruits or vegetables per day				
≥ 5 servings per day	251	52(18.9)	1	-
< 5 servings per day	3180	651(18.7)	0.98	0.72; 1.34
0 servings per day	38	6(12.0)	0.58	0.23; 1.44
Consumption of fish				
More than 1 time per week or once a week	1496	266 (16.4)	1	-
Less than 3 times a month	808	182 (20.8)	1.33*	1.08; 1.65
Less than once a month or never	1165	261 (19.9)	1.27*	1.05; 1.54
Smoking				
No, I have never smoked	1541	332(19.6)	1	-
Yes, one or more cigarettes	866	154(15.9)	0.77*	0.62; 0.95
Yes. Less than one cigarette a day	276	41(13.7)	0.65*	0.95; 0.92
Ex-smoker	786	182(21.4)	1.11	0.91; 1.36
Sport or Physical activity in the last month 30 minutes or more				
Yes, 3 or more times a week	403	44(9.9)	1	-
Less tan 3 times a week	435	52(11.4)	1.16	0.76; 1.78
No, I did not engage in sports or phsycial activity in the last month	2631	613(21.1)	2.42**	1.75; 3.34

* p-value < 0.05; ** p-value < 0.001.

Tab. III. Association between fat content of dairy (milk, fresh cheese or yogurt) products in Chilean adults (n=3809).

Type of Dairy (Milk, fresh cheese or yogurt)	Total Adults	With HTN n (%)	Model 1*	Model 2**
			OR (95%CI)	AOR (95% CI)
Whole/Full Fat	1998	400(20.02)	1	1
Low fat or Fat free	1471	237(16.11)	0.76 (0.64; 0.91)	0.88 (0.71; 1.08)

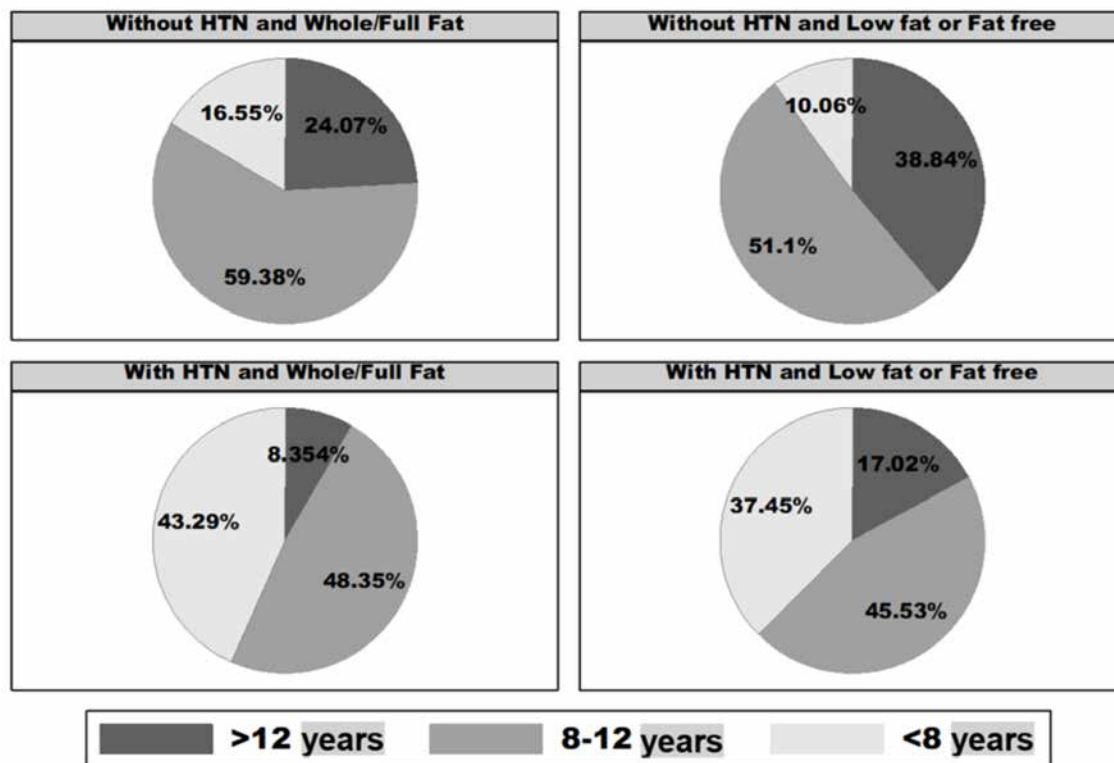
* Crude Odds Ratio; ** Adjusted Odds Ratio: sex, age, education level, frequency of fish consumption, physical activity, BMI and smoking history.

distinguish between 1, 2 or 3 servings. Therefore, we could not analyse a more refined association between dairy consumption and blood pressure.

Several agencies stress the importance of reducing saturated fats to optimize cardiometabolic health and it is recommended that saturated fats contribute <10% of total energy intake [34,35]. Another clinical study with

60 adults with high BP used a crossover trial design and randomised participants to 4 servings of high fat dairy vs no dairy (4 weeks per each dietary intervention), finding no significant effect on high BP [36].

In developing countries like Chile, low educational levels can still be observed in the population. This factor becomes crucial when thinking about the diet-

Fig. 2. Education level according to Hypertension and Type of Dairy products.

disease relationship. In a study developed by Geaney et al (2015) [37], it was observed that higher nutrition knowledge was associated with lower blood pressure, providing evidence that nutrition knowledge is significantly associated with diet quality. It is possible that people with higher levels of education have access to information that allows them to make better dietary choices. There is also an association between higher incomes and the possibility to pay for better food. Finally, people who complete higher education learn more about nutrition, generally earn higher incomes, and thus have both the knowledge and the access to eat a more varied and balanced diet.

Among the strengths of our study is that a representative sample of Chilean adults was used, but because of the type of survey, we could not analyse separately the frequency of consuming milk, cheese, yogurt, or other dairy, the portion sizes consumed and its relation with high blood pressure. Furthermore, since it is a cross-sectional study, we cannot speak of causality but only association. However, we encourage further studies to understand this relationship and especially to work with the most vulnerable populations for the prevention of comorbidities associated with uncontrolled blood pressure.

Conclusions

In our study, low fat dairy consumption was associated with lower blood pressure in the unadjusted models.

However, after adjustment for confounders (particularly education), the association between blood pressure and type of dairy products consumed was not statistically significant. It is necessary to delve deeper into the importance of education in our populations to prevent chronic non-communicable diseases.

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Conflicts of interest

The authors declare no conflicts of interest

Author contributions

The authors' contributions are as follows: Y.A.M. and S.D.A contributed to the study design, data analyses and interpretation of the findings and wrote the manuscript; R.F, L.M, and D.D contributed to the study design, subject briefings. All authors read and approved the final version of the manuscript. The authors have no financial or personal conflicts of interest to declare.

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