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ORIGINAL CONTRIBUTION

Dairy products intake and the risk of incident cataracts surgery in an elderly Mediterranean population: results from the PREDIMED study

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Abstract

Proposal The aim of this study was to examine the association between the consumption of total and specific types of dairy products and the risk of incident cataracts in an elderly Mediterranean population at high cardiovascular risk.

Methods We prospectively analyzed 5860 subjects from the PREvención con DIeta MEDiterránea (PREDIMED) Study. The time to cataract surgery was calculated as the time between recruitment and the date of the surgery, last visit of the follow-up, date of death, or until the end of the study. Dairy products intake was assessed using validated food frequency questionnaires. We used Cox proportional hazard regression to assess the risk of cataract surgery according to average dietary energy-adjusted total dairy products, milk, yogurt and cheese consumption.

Results We documented a total of 768 new cataract events after a median of 5.6 years of follow-up. Subjects in the second [hazard ratio (HR) 0.62; 95% CI 0.52, 0.74] and third tertile (HR: 0.71; 95% CI 0.60, 0.85) of skimmed yogurt intake had a significantly lower risk of cataracts after adjusting for potential confounders. No significant associations were observed for total dairy products, whole and skimmed milk, whole yogurt and cheese consumption.

Conclusion The intake of skimmed yogurt was associated with a reduced risk of cataracts in an elderly Mediterranean population with high cardiovascular risk. No significant associations were observed for other type of dairy product.

Clinical Trial registration International Standard Randomized Controlled Trial Number (ISRCTN): 35739639. Registration date: 5 October 2005.

Keywords Cataracts · Dairy · Yogurt · Epidemiology · PREDIMED

Abbreviations

ANOVA	Analysis of variance
BMI	Body mass index
CIs	Confidence intervals
CVD	Cardiovascular disease
FFQ	Food-frequency questionnaire
HRs	Hazard ratios
SDs	Standard deviations
T2D	Type 2 diabetes

Introduction

Cataract affects a total of about 20 million people in the world and, when untreated, is one of the main causes of blindness [1]. According to a systematic review of US, Australian and European population-based studies, the prevalence of cataract reaches 40% in individuals by the age of 70 [2].

Surgical removal of the cataract lens and replacement with a synthetic one is the only definitive treatment, although it is not free of risk [3]. Aging is considered to be

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the strongest predictor of cataract development, but other factors such as obesity, diabetes, family history of cataracts, diet, smoking, alcohol and lower socioeconomic status are also recognized as risk factors [3–6].

The exact mechanisms underlying cataract formation are still unclear but growing evidence suggests that inflammatory and oxidative processes may have a role. As diet can modulate inflammation and oxidation, several studies have prospectively assessed the relationship between the consumption of some food or specific dietary components and the process of cataractogenesis. In this regard, three different meta-analyses of cohort studies have shown that higher intakes of vitamin E [7], vitamin C [8] and vitamin A [9] are associated with a reduced risk of cataracts. Similarly, high intakes of fruit and vegetables have been associated with a lower prevalence of cataract or cataract surgery in a cohort of elderly individuals [10].

Dairy products are naturally rich sources of protein and micronutrients that are important for health, including calcium, magnesium, phosphorus, potassium and vitamins A and B12. Furthermore, they have a particular carbohydrate and lipid profile. Including these products in a healthy dietary pattern has led to various improvements in people's well-being. A high intake of dairy products, especially yogurt, can have a protective effect against type 2 diabetes (T2D) in the elderly [11]. Also yogurt, low-fat milk and other low-fat dairy products have been associated with lower risk of metabolic syndrome [12]. Although the association between total dairy products consumption and cataracts was not found significant in a recent case-control study [13], two previous epidemiological studies have suggested a relation between milk consumption and cataract formation in an elderly population [14, 15]. Furthermore, an experimental study in rats demonstrated that an excessive intake of milk could aggravate cataract development probably through oxidative damage caused by increased ROS [16]. Yogurt consumption seems not to be cataractogenic and has even shown a protective effect in a small French adult population [17].

With this evidence and since, to our knowledge, there are no studies that relate the different types of dairy products to cataractogenesis, we hypothesized that milk intake is associated with an increased risk of cataract incidence while the consumption of fermented products is associated with a decreased risk of incident cataracts in an elderly Mediterranean population.

Materials and methods

Design

The PREDIMED study was a large, multicenter and parallel-group controlled clinical trial that aimed to assess the effect of the Mediterranean diet on the primary prevention of cardiovascular disease. The intervention took place between 2003 and 2010 and the outcomes were followed up until 30 December 2014. Subjects were allocated either to a Mediterranean Diet supplemented with extra-virgin olive oil, a Mediterranean Diet supplemented with nuts; or a low-fat diet group. The present study is part of this trial (http://www.predimed.es).

Study population, recruitment and randomization

The study population included men aged between 55 and 80 and women between 60 and 80, all free of cardiovascular disease (CVD) on enrolment, but at high cardiovascular risk since they had T2D or three or more of the following cardiovascular risk factors: hypertension, smoking, high LDL-cholesterol, hypertriglyceridemia, low HDL-cholesterol ($\leq$ 40 mg/dL), overweight [body mass index (BMI) 25–29.9 kg/m^2/obesity (BMI 30–39.9 kg/m^2)] or family history of premature cardiovascular disease. Exclusion criteria were the presence of severe medical conditions impairing the ability to participate in a nutritional intervention study, alcohol or drug abuse, BMI $\geq$ 40 kg/m^2, and allergy or intolerance to olive oil or nuts. All participants included in the study provided written informed consent according to a protocol approved by the institutional review boards of all the recruiting centers.

Anthropometrical and biochemical records

Fasting blood samples were collected and processed for biochemical analysis. Blood pressure was measured in triplicate using a validated semiautomatic oscillometer (Omron HEM-705CP; Omron Healthcare, Hoofddorp, The Netherlands) and the mean was recorded. Anthropometric measures were determined by trained personnel with calibrated equipment at baseline and at each annual visit during the follow-up. The validated Spanish version of the Minnesota Leisure-Time Physical Activity questionnaire was administered at each visit [18].

Dietary assessments

Dietary intake was measured at baseline and at each annual visit using a 137-item semi-quantitative validated food-frequency questionnaire (FFQ), completed onsite at baseline and yearly thereafter by a trained registered nutritionist [19]. Detailed information about the development, reproducibility and validity of the questionnaire in the PREDIMED cohort has been previously reported [20]. Total energy and nutrient intake were estimated using Spanish food composition tables [21, 22]. Data on different types of dairy products were collected and classified into several groups: milk, yogurt, cheese, custard, cream, butter and ice cream. Milk and yogurt groups were subdivided according to fat content into: whole and skimmed milk, and whole and skimmed yogurt. Likewise, all the different dairy products consumptions were combined and categorized into total dairy products consumption.

Cataract events

Cataract event, a pre-specified secondary outcome of the PREDIMED trial, was defined as the occurrence of cataract surgery at any time during the study. The occurrence of cataract surgery was confirmed by an annual review of the computer-based records of general practitioners. The cataract outcome was externally confirmed by an independent adjudication committee whose members were blinded to the dietary intervention and to the participants' dietary behaviors. Cases of traumatic cataracts and those that emerged after intraocular surgery, such as vitrectomy or glaucoma surgery, were excluded. In cases of bilateral surgery in the same patient, only the first event was considered in our time-to-event analyses.

Statistical analysis

Baseline descriptive data are presented as means ± standard deviations (SDs) for continuous variables and as numbers and percentages (%) for categorical variables using one-way ANOVA and the χ^2 test for comparisons between groups. Participants who were outside the predefined values for total energy intake (> 4000 or < 800 kcal/day in men and > 3500 or < 500 kcal/day in women) were excluded from the analysis. Dietary variables were adjusted for total energy intake using the residuals method [23]. We averaged food consumption from the baseline to the end of the follow-up or to the last follow-up FFQ before the occurrence of cataract surgery. Multivariable Cox proportional hazard models were fitted to assess the association between total dairy products, milk (total, whole and skimmed), yogurt (total, whole and skimmed) and cheese intake and the risk of cataract. Follow-up time was calculated as the time between recruitment and the date of the event, death, end of follow-up or end of the study, whichever came first. Hazard ratios (HRs) and 95% confidence intervals (CIs) were calculated using the first tertile as reference. Interaction for gender, T2D and intervention group were not statistically significant. The different models were adjusted for potential confounders. Model 1 was adjusted for gender, age, BMI, intervention group, smoking, leisure time activity and education level and stratified by recruiting center. Model 2 was additionally adjusted for cataracts, diabetes, hypertension and hypercholesterolemia at baseline. The final model was also adjusted for dietary energy-adjusted baseline food groups variables. Supplemental material includes an analysis with the final model adjusted for dietary baseline variables in the form of macronutrients, fibre and energy intake. All the statistical tests were 2-tailed and the level of significance was $P < 0.05$. Statistical analyses were carried out using SPSS v. 20.0 (SPSS Inc., Chicago, IL, USA).

Results

The entire PREDIMED sample was 7447 participants. We excluded the subjects with bilateral cataract at baseline and those in whom it formed during the first year, the participants with incomplete dietary data at baseline and those with extremes of total energy intake. Of the total of 5680 subjects finally included in the present analysis, a total of 768 new cataract surgeries emerged after a median of 5.6 years of follow-up. The baseline characteristics of the participants by tertiles of energy-adjusted total dairy products intake are shown in Table 1. Individuals in the highest tertile of total dairy products consumption had a lower prevalence of hypercholesterolemia and hypertension but presented a higher prevalence of T2D and incidence of cataracts. Most subjects were women, with a low waist circumference and were less likely to smoke. The baseline information according to tertiles of energy-adjusted total milk, total yogurt, skimmed yogurt and cheese is presented in Supplemental Tables 1, 2, 3 and 4.

Adjusted HRs of cataract events according to tertiles of cumulative total dairy products, total milk, whole milk and skimmed milk, total yogurt, whole yogurt and skimmed yogurt and cheese are shown in Table 2. No significant association was observed with either total dairy products consumption or with total or different types of milk. However, in contrast, subjects in the second and third tertile of skimmed yogurt intake had a significantly lower risk of cataract surgery after adjusting for potential confounders (HR 0.62; 95% CI 0.52, 0.74; (HR: 0.71; 95% CI 0.60, 0.85, respectively; P trend = 0.001). This association was not statistically significant in the case of whole yogurt, although the consumption of total yogurt in the second tertile showed the same significant protective trend (HR 0.75; 95% CI 0.62, 0.90) (P trend = 0.008). No significantly lower risk was found between total dairy products and the other dairy products analyzed. No changes were shown when we analyzed the risks in a full-adjusted model including the macronutrients, fiber and total energy instead of food groups (Supplemental Table 5).

Figure 1 shows the risk of incident cataract surgery assessed with Cox Proportional Hazard models by tertiles of cumulative energy-adjusted skimmed yogurt intake stratified by gender, presence of T2D, BMI and age categories. The inverse association between risk of cataract surgery

Table 1 Baseline characteristics of the 5860 subjects by tertiles of baseline total dairy products intake

Variable[a]	Energy-adjusted baseline total dairy products (g/day)			P^b
	T1	T2	T3	
Total dairy products intake (g/day), median (IQR)[2]	185.1 (112.1, 230.2)	328.5 (296.3, 366.8)	596.1 (524.5, 665.1)	
Women, *n* (%)	804 (41.2)	1194 (61.1)	1271 (65.1)	< 0.001
Age, years	65.6 ± 6.2	66.5 ± 6.1	66.7 ± 5.8	< 0.001
BMI, kg/m^2	29.9 ± 3.7	30.0 ± 3.9	30.1 ± 4.0	0.070
Waist circumference, cm	101.4 ± 10.2	100.3 ± 10.5	99.7 ± 10.6	< 0.001
Leisure-time physical activity, MET-min/day	245.8 ± 253.3	220.0 ± 219.9	227.9 ± 239.3	0.002
Glucose, mg/dl	118.3 ± 36.6	120.3 ± 41.7	124.4 ± 42.7	< 0.001
Cholesterol, mg/dl	217.0 ± 39.7	215.3 ± 40.3	214.0 ± 42.3	0.378
Triglycerides, mg/dl	152.3 ± 95.9	145.8 ± 88.8	141.9 ± 85.6	0.132
HDL cholesterol, mg/dl	52.4 ± 13.1	53.5 ± 15.0	53.1 ± 13.1	0.318
Diabetes, *n* (%)	824 (42.2)	921 (47.1)	1030 (52.7)	< 0.001
Hypertension, *n* (%)	1637 (83.8)	1635 (83.7)	1583 (81.1)	0.036
Hypercholesterolemia, *n* (%)	1433 (73.4)	1430 (73.2)	1374 (70.4)	0.061
Smoking status, *n* (%)				< 0.001
Never	931 (47.7)	1273 (65.2)	1318 (67.5)	
Current	400 (20.5)	219 (11.2)	262 (13.4)	
Former	622 (31.8)	462 (23.6)	373 (19.1)	
Education, *n* (%)				< 0.001
Primary education	1394 (71.4)	1521 (77.8)	1565 (80.1)	
Secondary education	371 (19.0)	307 (15.7)	265 (13.6)	
Higher education	188 (9.6)	126 (6.5)	123 (6.3)	
Intervention group, *n* (%)				0.380
Mediterranean diet with EVOO	663 (33.9)	663 (33.9)	686 (35.1)	
Mediterranean diet with nuts	669 (34.3)	623 (31.9)	637 (32.6)	
Control diet	621 (31.8)	668 (34.2)	630 (32.3)	
Cataract incidence, *n* (%)	220 (11.3)	244 (12.5)	304 (15.6)	< 0.001

EVOO extra virgin olive oil, *MET* metabolic equivalent of task, *T* tertile

[a]Means ± SDs or *n* (%), unless otherwise indicated. $n = 1953$ in T1, $n = 1954$ in T2 and $n = 1953$ in T3

[b]*P* values are based on the difference between tertiles of basal energy-adjusted total dairy products intake (ANOVA for the continuous variables and χ^2 test for categorical variables)

incidence and skimmed yogurt remained significant in all groups except for men and those subjects younger than 70. In subjects with a BMI over 30, skimmed yogurt consumption had a lower association with cataract incidence than in those with a lower BMI, whereas non-significant differences were observed with the presence of T2D.

Discussion

This is the first study to examine the association between the risk of incident cataract surgery and the consumption of total and different subtypes of dairy products. The results of the present study suggest that skimmed yogurt consumption was associated with a lower risk of cataract incidence in adult Mediterranean subjects at high cardiovascular risk. No significant associations were observed for other type of dairy product.

In recent years, evidence linking saturated fat with an increased risk of chronic metabolic disorders has led to the assumption that consuming saturated fat from all sources, including dairy products, has an equally deleterious effect on human health. However, it is well known that the food matrix affects digestion and absorption, thereby altering the properties of specific nutrients [24]. This may explain why emerging evidence shows that the increased consumption of dairy products, despite their richness in saturated fat, is associated with a lower risk of several chronic diseases [25–27].

Some studies have also reported a detrimental effect of fat consumption on the incidence of cataract. Two different case–control studies showed that total fat and cholesterol consumption was associated with a higher risk of cataract [13, 28]. In a similar way, dietary cholesterol intake

Table 2 Adjusted HRs of cataract incidence according to tertiles of total dairy products, total milk, whole and skimmed milk, total yogurt, whole and skimmed yogurt and cheese consumption

	T1 ($n=1953$)	T2 ($n=1954$)	T3 ($n=1953$)	*P* trend
Energy-adjusted average total dairy products intake				
Cataract incidence, *n*	229	229	310	
Dairy products intake (g/day), median (IQR)[a]	209.5 (146.8, 250.2)	348.2 (317.6, 382.9)	537.7 (477.2, 613.6)	
Cases/person-years	10,855	11,081	10,891	
Crude model	1 (Ref.)	0.97 (0.81, 1.17)	1.35 (1.13, 1.59)	< 0.001
Model 1[b]	1 (Ref.)	0.86 (0.71, 1.04)	1.07 (0.89, 1.28)	0.049
Model 2[c]	1 (Ref.)	0.84 (0.70, 1.01)	0.93 (0.77, 1.11)	0.187
Model 3[d]	1 (Ref.)	0.82 (0.67, 1.00)	0.88 (0.70, 1.11)	0.148
Energy-adjusted average total milk intake				
Cataract incidence, *n*	200	266	302	
Total milk (g/day), median (IQR)[a]	118.6 (43.8, 161.1)	222.3 (204.8, 249.1)	402.9 (344.1, 484.6)	
Cases/Person-years	10,996	10,881	10,949	
Crude model	1 (Ref.)	1.35 (1.12, 1.62)	1.52 (1.27, 1.81)	< 0.001
Model 1[b]	1 (Ref.)	1.18 (0.98, 1.43)	1.22 (1.01, 1.45)	0.090
Model 2[c]	1 (Ref.)	1.07 (0.89, 1.30)	0.99 (0.82, 1.20)	0.607
Model 3[d]	1 (Ref.)	1.05 (0.86, 1.28)	0.93 (0.72, 1.21)	0.501
Energy-adjusted average whole milk intake				
Cataract incidence, *n*	263	245	260	
Skimmed milk (g/day), median (IQR)[a]	− 6.7 (− 12.18, − 2.9)	5.9 (3.1, 9.1)	52.9 (20.2, 155.0)	
Cases/Person-years	11,183	10,866	10,777	
Crude model	1 (Ref.)	0.97 (0.81, 1.15)	1.04 (0.87, 1.23)	0.739
Model 1[b]	1 (Ref.)	0.86 (0.72, 1.03)	0.91 (0.76, 1.08)	0.262
Model 2[c]	1 (Ref.)	0.99 (0.82, 1.19)	0.99 (0.83, 1.19)	0.992
Model 3[d]	1 (Ref.)	0.97 (0.81, 1.17)	0.98 (0.81, 1.18)	0.956
Energy-adjusted average skimmed milk intake				
Cataract incidence, *n*	225	257	286	
Skimmed milk (g/day), median (IQR)[a]	37.2 (2.3, 101.1)	202.1 (185.3, 215.2)	376.9 (315.0, 484.4)	
Cases/Person-years	10,869	10,869	11,088	
Crude model	1 (Ref.)	1.14 (0.95, 1.36)	1.24 (1.04, 1.47)	0.058
Model 1[b]	1 (Ref.)	1.10 (0.92, 1.32)	1.09 (0.91, 1.30)	0.521
Model 2[c]	1 (Ref.)	1.06 (0.88, 1.27)	0.92 (0.76, 1.11)	0.295
Model 3[d]	1 (Ref.)	1.03 (0.85, 1.24)	0.85 (0.68, 1.06)	0.142
Energy-adjusted average total yogurt intake				
Cataract incidence, *n*	277	215	276	
Total yogurt intake (g/day), median (IQR)[a]	12.7 (2.6–28.5)	68.7 (56.2, 85.6)	128.9 (120.1, 177.9)	
Cases/Person-years	10,891	11,201	10,734	
Crude model	1 (Ref.)	0.75 (0.63, 0.89)	1.02 (0.86, 1.20)	0.001
Model 1[b]	1 (Ref.)	0.72 (0.60, 0.86)	0.88 (0.74, 1.04)	0.002
Model 2[c]	1 (Ref.)	0.76 (0.63, 0.91)	0.93 (0.78, 1.10)	0.010
Model 3[d]	1 (Ref.)	0.75 (0.62, 0.90)	0.92 (0.77, 1.09)	0.008
Energy-adjusted average whole yogurt intake				
Cataract incidence, *n*	270	262	236	
Whole Yogurt intake (g/day), median (IQR)[a]	− 1.9 (− 5.5, 0.5)	7.1 (4.8, 10.0)	41.3 (25.7, 68.0)	
Cases/Person-years	11,001	10,839	10,987	
Crude model	1 (Ref.)	0.99 (0.84, 1.17)	0.88 (0.74, 1.04)	0.271
Model 1[b]	1 (Ref.)	0.94 (0.79, 1.12)	0.84 (0.70, 1.00)	0.143
Model 2[c]	1 (Ref.)	0.98 (0.82, 1.17)	0.95 (0.79, 1.14)	0.865
Model 3[d]	1 (Ref.)	0.96 (0.81, 1.15)	0.94 (0.79, 1.13)	0.829

Table 2 (continued)

	T1 ($n = 1953$)	T2 ($n = 1954$)	T3 ($n = 1953$)	*P* trend
Energy-adjusted average skimmed yogurt intake				
Cataract incidence, *n*	299	207	262	
Skimmed yogurt intake (g/day), median (IQR)[a]	1.7 (– 0.8, 6.1)	44.6 (29.8, 57.9)	121.7 (95.7, 153.5)	
Cases/Person-years	10,591	11,380	10,856	
Crude model	1 (Ref.)	0.63 (0.53, 0.75)	0.85 (0.72, 1.00)	< 0.001
Model 1[b]	1 (Ref.)	0.61 (0.51, 0.73)	0.75 (0.63, 0.89)	< 0.001
Model 2[c]	1 (Ref.)	0.62 (0.52, 0.75)	0.73 (0.61, 0.87)	0.001
Model 3[d]	1 (Ref.)	0.62 (0.52, 0.74)	0.71 (0.60, 0.85)	0.001
Energy-adjusted average cheese intake				
Cataract incidence, *n*	268	241	259	
Skimmed yogurt intake (g/day), median (IQR)[a]	11.6 (7.0, 15.9)	28.6 (22.7, 30.6)	41.6 (36.3, 50.3)	
Cases/Person-years	11,179	10,962	10,686	
Crude model	1 (Ref.)	0.92 (0.78, 1.10)	1.03 (0.86, 1.22)	0.483
Model 1[b]	1 (Ref.)	0.94 (0.80, 1.13)	1.05 (0.88, 1.26)	0.480
Model 2[c]	1 (Ref.)	0.97 (0.81, 1.17)	1.03 (0.86, 1.23)	0.811
Model 3[d]	1 (Ref.)	0.97 (0.81, 1.16)	1.04 (0.87, 1.25)	0.741

Cox regression was used to evaluate the risk of cataracts according to tertiles of average dietary energy-adjusted total dairy products, total milk, whole milk, skimmed milk, total yogurt, whole yogurt, skimmed yogurt and cheese intake

[a]Total intakes are expressed as median and interquartile ranges (IQR)

[b]Model 1 was adjusted for gender, age, BMI, intervention group, smoking (never, current, past), leisure time activity (MET-min/day) and education (primary education, secondary education, higher education) and stratified by recruiting center

[c]Model 2 was additionally adjusted for cataracts, diabetes, hypertension and hypercholesterolemia at baseline

[d]Model 3 was additionally adjusted for dietary energy-adjusted baseline variables (vegetables, fruits, legumes, cereals, meat, fish, olive oil and nuts), alcohol and alcohol squared in grams per day

increased cataract risk in a large population of the EPIC-Oxford study [29]. On the other hand, among the 12,308 participants from the SUN cohort study, initially free of cataract and followed up for 6 years, a high intake of omega-6 fatty acids prospectively showed an inverse association with cataract risk whereas no significant associations were observed for other types of dietary fats [30]. Only two studies have prospectively assessed the relation between dairy products consumption and cataract risk. In a case-control study conducted in 314 cases and 314 frequency-matched controls aged 45–85, total dairy products consumption was not associated with the risk of cataract [13]. However, in another case–control analysis conducted in an Italian population, a 30% reduction in risk of cataract was associated with cheese consumption whereas risk increased in the upper tertile of butter consumption, and a non-significant trend-risk for milk and margarine consumption [28]. These previous findings suggest that the risk of cataract depends on the type of dairy products consumed. In our study, we did not found any association between milk nor cheese and the risk of cataract surgery incidence. Only participants with a higher consumption of skimmed yogurt showed a significant lower risk of cataract surgery incidence. Since inflammation is nowadays well accepted as one of the possible cataractogenic mechanisms [3, 31, 32], yogurt may play a protective role by taking part in anti-inflammatory processes. However, clinical trials have provided little evidence on the effect of yogurt consumption on peripheral inflammation and the little that exists is controversial. In this regard, a parallel randomized controlled trial conducted in obese subjects on an energy-restricted diet including yogurt for 12 weeks found a significant reduction in plasma CRP levels and increased adiponectin concentrations compared to the control group [33]. However, only probiotic yogurt showed a downregulation of CRP levels but no effect on TNF-α compared to conventional yogurt, in pregnant women who consumed 200 gr of probiotic or conventional yogurt for 9 weeks [34].

High galactose diets also induce lens opacification and cataract formation in rats probably through increased protein glycation and free radical damage [17]. These findings in animals suggest that, because yogurt contains galactose, its consumption should be associated with a high risk of cataract formation. However, two previous studies conducted in humans found that yogurt protects against cataract risk. There may be two different explanations for this finding: first, intestinal galactokinase activity is activated in the intestine by the free galactose contained in yogurt and, second, the rate of galactose and glucose activity is increased by insulin secretion after yogurt consumption compared to milk [17, 35]. These mechanisms may help

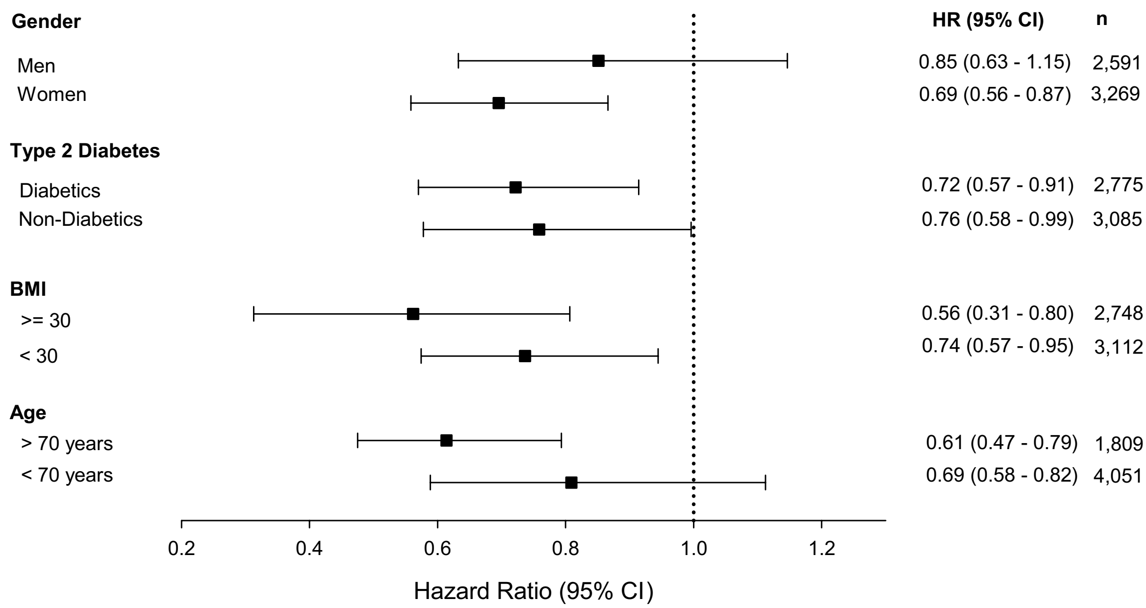

Fig. 1 HR of cataract risk in third tertile of skimmed yogurt intake compared to the first tertile, according to gender, type 2 diabetes, BMI and age. The risk of incident cataract was assessed using Cox Proportional Hazard models by tertiles of energy adjusted average skimmed yogurt intake. The model was adjusted for gender, age, BMI, intervention group, smoking (never, current, past), leisure time activity (MET s/day), education (primary education, secondary education, higher education); cataracts, diabetes, hypertension and hypercholesterolemia at baseline; dietary energy-adjusted baseline variables (vegetables, fruits, legumes, cereals, meat, fish, olive oil and nuts), alcohol, alcohol squared in grams per day and stratified by recruiting center. Gender, type 2 diabetes, BMI and age were removed in each model in which they were the dependent variable. *BMI* body mass index, *CI* confidence interval, *HR* hazard ratio, *T2D* type 2 diabetes, *MET* metabolic equivalent task

to explain the reduced risk of cataract we observed in skimmed yogurt consumers, not in milk consumers, but does not explain the differences between types of yogurt. We suggest that the protective effect observed after the intake of skimmed yogurt could be due to the combination of the benefits of free galactose plus the lower content of fat. However, we cannot discount that whole yogurt does not have a protective effect because intake in our population was lower than that of skimmed yoghurt.

The major strength of this work, besides the long follow-up period and the large sample, lies in the analysis of dairy products types and their fat content. Moreover, we used repeated dietary measurements to reduce the random measurement error produced by within-person variation and the inclusion of sensitivity analysis to support the main findings. Among its limitations are that our results cannot be generalized to other populations, that there may be errors in the estimation of the consumption of dairy products and different food groups from a FFQ, even a validated one, and we cannot completely discard a potential residual confounding of other variables although we controlled for several clinical, biochemical and nutritional parameters.

In conclusion, the results of the present study suggest that skimmed yogurt is associated with a lower incidence of cataract surgery in an adult Mediterranean population at high cardiovascular risk, whereas no associations were found for other types of dairy products. Further research is needed to confirm our results and provide further insight into the potential mechanisms explaining these findings.

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Authors' contributions. MB had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. MB, MAMG, DC, RE, MF, EGG, FA, MF, JMSL, LSM, XP, JB, ET, MAM, VZM, JSS: contributed to the conception, design, and implementation of the project; AGL: was a member of the outcome adjudication committee; LCB, MB, JFGG contributed to data collection and analytical procedures; LCB and MB: conducted the statistical analysis, interpreted data, and wrote the manuscript; and all authors: read and approved the final version of the manuscript. We

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Compliance with ethical standards

Conflict of interest JS-S reports personal fees from Nuts for Life, other from Nut and Dried Fruit Foundation, other from Nut and Dried Fruit Foundation, during the conduct of the study; personal fees from Danone S.A., personal fees from Font Vella Lanjaron, personal fees from Eroski Distributors and personal fees from Instituto Danone, outside the submitted work. None of the other authors had a personal or financial conflict of interest.

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