Dairy consumption and risk of falls in 2 European cohorts of older adults

Short running head: **Dairy consumption and risk of falls in older adults**

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Main text word count: 3729

Number of data elements: 4

Number of supplemental elements: 6

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ABSTRACT

Background & aims: Some previous evidence have linked dairy products with greater muscle mass, bone mineral density and lower risk of osteoporosis. However, other authors have found a detrimental effect of milk on the risk of hip fracture. The aim of this study was to assess the prospective association between dairy consumption and risk of falls in older adults.

Methods: We used data from 2 cohorts of community-dwellers aged ≥60y: the Seniors-ENRICA cohort with 2,981 individuals, and the UK Biobank cohort with 8,927 participants. In the Seniors-ENRICA, dairy consumption was assessed with a validated diet history in 2008-10, and falls were ascertained up to 2015. In the UK Biobank study, dairy consumption was obtained with 3-5 multiple-pass 24-h food records in 2006-10, and falls were assessed up to 2016.

Results: A total of 801 individuals in the Seniors-ENRICA and 201 in the UK Biobank experienced ≥1 fall. After adjustment for potential confounders, dairy products were not associated with risk of falls in the Seniors-ENRICA [hazard ratio (95% confidence interval) per 1-serving increment in total dairy consumption: 1.02 (0.93-1.11), milk: 0.93 (0.85-1.01), yogurt: 1.05 (0.96-1.15), and cheese: 0.96 (0.88-1.05)]. Corresponding figures in the UK Biobank were: total dairy: 1.19 (1.00-1.41), milk: 1.53 (1.13-2.08), yogurt: 1.10 (0.90-1.31), and cheese: 1.02 (0.87-1.22).

Conclusions: These results suggest a null association between habitual dairy consumption and the risk of falling in older adults. Whether milk consumption may increase the risk of falls, as observed in the UK Biobank cohort, merits further study.

Keywords: older adults, epidemiology, milk, yogurt, cheese.

INTRODUCTION

Falls in older persons are a major public health problem, as they increase the risk of many adverse health outcomes and death (1). However, studies that evaluate the association between diet and risk of falling are scarce, so only a few of them have examined the role of nutrients, such as calcium (2), vitamin D (2, 3) and proteins (4), diet patterns (5) and individual foods (6, 7).

Dairy products are an important source of energy, proteins, vitamins and minerals, including calcium, potassium and vitamin D, which are important nutrients for bone and muscle health (8). Previous studies have linked dairy products with a lower risk of frailty (9), cardiovascular disease (10, 11) and type 2 diabetes (12, 13), which are also predictors of falls in older people. Furthermore, in a cross-sectional study, a higher dairy consumption was associated with lower prevalence of falls, greater lean body mass and better physical performance in women (14). Likewise, dairy products have been associated with greater muscle mass (14, 15) and greater bone mineral density (16), as well as with lower risk of osteoporosis and functional disability (17-20). These results might suggest that dairy intake could prevent falls through the improvement of the musculoskeletal system. On the other hand, some authors have hypothesized a detrimental effect of milk on the risk of hip fracture (19,21) because of its content of D-galactose; however, this hypothesis has not been confirmed in a recent study (22). Lastly, since each type of dairy product provides different amounts of nutrients and bioactive compounds, they might also have different effects on health (10).

The aim of this study was to evaluate the prospective association between dairy products consumption, specifically, total dairy, milk, yogurt and cheese, and risk of falling. We assessed this association in 2 cohorts of community-dwelling older adults from Spain and the United Kingdom (UK), to better understand the underlying role of population characteristics and to improve the external validity of the results.

MATERIAL AND METHODS

Study design and participants

The Seniors-ENRICA study

The ENRICA study (Study on Nutrition and Cardiovascular Risk in Spain) was established in 2008-2010 with 12,948 individuals representative of the non-institutionalized population of Spain aged ≥18y (23). Of them, 3,289 participants aged ≥60y comprised the Seniors-ENRICA cohort. Information about socio-demographic characteristics, lifestyle, health status and morbidity were collected at baseline through a telephone interview. Moreover, two home visits were performed to assess food consumption, conduct a physical examination and obtain blood and urine samples. Two waves of data collection were subsequently performed in 2012 and 2015 to update the information of the cohort. The Clinical Research Ethics Committee of 'La Paz' University Hospital in Madrid approved the study protocol, and the study participants gave their informed written consent.

The UK Biobank study

The UK Biobank cohort has recruited more than half a million individuals between 40-69 years (81,725 were ≥60 y) in the UK during the period 2006-2010 (24). At baseline, participants completed a touchscreen questionnaire, conducted a face-to-face interview, underwent a physical exam, and provided biological samples. Two waves of data collection (in 2012-2013 and 2014-2016) have been performed in a subsample of participants to update the information of the cohort. The UK Biobank study was conducted under generic ethical approval from the NHS National Research Ethics Service (ref 11/NW/0382, 17 June 2011).

Study variables

Dairy products and other dietary variables

In the Seniors-ENRICA, dietary information was collected through a validated electronic diet history developed from the one used in the European Prospective Investigation into Cancer and Nutrition cohort study in Spain (25). This method of diet assessment included 880 different foods and allows for taking different portion sizes and cooking methods into account, as well as weekly and seasonal variations in food consumption. The dairy products recorded were: whole milk, part-skim and skim milk, whole- and low-fat yogurt, and cheese. We transformed the quantity consumed (ml or g per day) into serving/day, by dividing the total amount of each food by the standard serving size (200 ml of milk, 125 g of yogurt and 40 g of cheese) (9, 22). In the validation study we found a moderate to good correlation between consumption of dairy products estimated from the diet history and the mean of seven 24-hour recalls during one year (r=0.68). Total energy intake and calcium, protein, and saturated fat were estimated using standard food composition tables (25) and were adjusted for energy intake using the residual method (26). Adherence to the Mediterranean diet was assessed with the Mediterranean Diet Adherence Screener (MEDAS) (27). This score includes 14 items on food consumption and food intake habits characteristic of the traditional Mediterranean diet in Spain. The MEDAS score ranges from 0 to 14, with a higher score indicating greater adherence (**Supplemental table 1)**.

In the UK Biobank, food consumption was assessed through five web-based 24-h recalls (Oxford WebQ) (28), which included more than 200 foods frequently consumed in the UK and allowed for considering seasonal variations. For the present analyses, we selected the participants who completed at least three 24-h recalls. Dairy products recorded were: whole milk, part-skim and skim milk, powdered milk, full- and low-fat yogurt, and cheese. The reported consumptions for each type of dairy were: none, 0.5, 1, 2, 3, 4, 5 and ≥6 servings/day. The mean of consumption in servings/day was calculated among the available 24-h recalls for each participant. Nutrient intakes were estimated with standard foods composition tables in the UK (29) and adjusted for energy by the residual method. Finally, adherence to the Mediterranean diet as per the MEDAS score was also assessed in this population as an indicator of diet quality. Two items in the score were excluded for not having this information in the cohort: the item on the amount of olive oil consumed, and the item related to "sofrito" (a type of cooking that uses a sauce made with fried tomato and vegetables). Thus, in the UK Biobank the MEDAS score ranged from 0 to 12 (**Supplemental table 1)**.

Falls

In the Seniors-ENRICA study, self-reported incident falls were assessed by asking the participants at the follow-up waves (2012 and 2015): "How many times have you fallen down since the last interview?" We categorized the answers into: having no falls, and ≥1 fall. In addition, participants reported if because of the fall, they had suffered a fracture. In the UK Biobank study, information about self-reported falls was obtained from the touchscreen questionnaire at baseline and the subsequent two follow-up waves by asking the participants: "In the last year have you had any falls?" The possible answers were "no falls", "only one fall", and "more than one fall". This variable was also categorized into: having no falls, and ≥1 fall.

Mortality

In the Seniors-ENRICA study, we performed a computerized search of the National Death Index to evaluate all-cause mortality (30). This information was available for 99.9% of the cohort. In the UK Biobank study, death certificates from the National

Health Service (NHS) Information Centre (England and Wales) and the NHS Central Register Scotland (Scotland) provided information about vital status (31).

Other variables

In the Seniors-ENRICA, data on age, sex, educational level (≤ primary, secondary, university), smoking status (never, former, current smoker) and alcohol intake (abstainer: <0.1 g/d, moderate drinker: 0.1-39 g/d in men and 0.1-23 g/d in women, and heavy drinker: ≥40 g/d in men and ≥24 g/d in women) (32) were collected at baseline. Weight and height were measured in each participant under standardized conditions. Body mass index (BMI) was calculated as weight (kg) divided by the squared height (m). Physical activity during leisure time (metabolic equivalent tasks-h/week) was evaluated with the EPIC-cohort questionnaire, validated in Spain (33). Self-reported sleep duration (h/d) was also recorded. Blood pressure (BP) was measured with a validated sphygmomanometer using standardized procedures, and hypertension was defined as systolic BP ≥ 140 mm Hg, diastolic BP ≥ 90 mm Hg, or being under hypertensive drug treatment. Twelve-hour-fasting serum glucose was measured, and type 2 diabetes was defined as glucose ≥ 126 mg/dl or being on oral antidiabetic drugs or insulin. Participants were considered frail when they met three or more of the following five self-reported criteria proposed by Morley et al. (34): fatigue, reduced resistance, reduced aerobic capacity, having several illnesses and a significant weight loss during the previous. Participants also reported if they had been diagnosed with osteo-muscular disease (osteo-arthritis or arthritis) by a physician. Finally, use of sleeping pills was assessed.

In 2013, several other measurements were performed to assess sarcopenia in this population. Percentage of body fat (%BF) was measured by bioelectrical impedanciometry and skeletal muscle mass (SMM) with the equation developed by

Janssen (35). Skeletal muscle mass index (SMI) was obtained by dividing SMM by height squared. Muscle strength was approached through grip strength, considering the highest value of two consecutive measures on the dominant hand using a Jamar dynamometer. Physical performance was measured using the Short Physical Performance Battery (SPPB), following the protocols of the National Institute on Aging (36).

In the UK Biobank study, most of the variables were collected and categorized as in Seniors-ENRICA study. However, physical activity was ascertained with questions from the short International Physical Activity Questionnaire (IPAQ) (37) and the presence of diabetes, hypertension or osteo-muscular disease was self-reported by the participants.

Statistical analyses

In the Seniors-ENRICA, we excluded 308 participants: 4 with missing data on dairy consumption, 13 with implausible values of energy intake (outside the range of 800-5,000 kcal/d for men and 500-4,000 kcal/d for women), and 291 who were frail or lacked data on this variable at baseline (because frailty is a strong predictor of falls) (38) In the UK Biobank, among those ≥60 y, we excluded 72,798 participants: 69,476 with <3 web-based 24-h diet recalls, 137 with missing data on dairy, 939 with implausible high or low energy intake, and 2,246 who reported falls or lacked data on falls at baseline. This resulted in an analytical sample of 2,981 individuals in the Seniors-ENRICA and 8,927 in the UK Biobank study (**Supplemental figure 1**).

We categorized dairy products consumption into tertiles of servings/day, except for milk in the UK Biobank study, which was categorized in two groups (yes vs no consumption), due to the very low consumption reported. We used the lowest tertile as reference for the analyses. Person-years of follow-up were calculated from the date of the baseline questionnaire until the date of the outcome (falling), death, loss to follow-up, or the end of the study, whichever came first. To assess the association between categories of dairy consumption and the incidence of falls, we used Cox regression models to estimate hazard ratios (HR) with 95% confidence intervals (CI) for each category of dairy consumption. We built several models: the first one adjusted for age and sex; the second one additionally adjusted for other potential confounders, including education, smoking, alcohol intake, BMI, physical activity, sleep duration, energy intake, MEDAS score, hypertension, diabetes and use of sleeping pills; and a third model further adjusted for osteo-muscular disease, to explore its role in the studied relationship. Moreover, when we assessed the specific association for milk, yogurt, and cheese, we built a fourth model additionally adjusted for the other types of dairy products. To investigate the linear dose-response relation, we modeled the categories of dairy products consumption as continuous variables. Likewise, we calculated the risk of falls associated with a 1-serving/d increment for the different types of dairy. We also performed some sensitivity analyses by excluding participants with cardiovascular disease, hip fracture and those who were heavy alcohol drinkers at baseline since they had higher risk of falling than other population subgroups. This analysis was not possible to be done for milk consumption and risk of falling in UK Biobank due to the low number of cases among milk consumers. We also adjusted our main analyses by markers of sarcopenia status (percentage of lean mass, handgrip strength and gait speed) to explore the implication of sarcopenia in the studied association in the Seniors-ENRICA cohort, which had these measurements done. Moreover, we analyzed the relationship between the different dairy products and the risk of falls with fracture in the Seniors-ENRICA study. We did not use data on falls with fractures in the UK Biobank cohort due to the very small number found (n= 19). Finally, in order to account for changes in dairy consumption during follow-up, we estimated the cumulative consumption by using dietary information available in Seniors-ENRICA at baseline and in the first follow-up wave, 2 years later (in the UK Biobank study, repeated diet measurement was not available).

The main analyses were stratified by sex, hypertension, type 2 diabetes, osteo-muscular disease, sleep duration, protein intake and physical activity; also, likelihood-ratio tests comparing models with and without interactions terms were used to assess if results varied across strata. These analyses were performed only in the Seniors-ENRICA since in the UK Biobank the number of falls was too low.

Finally, to test the non-linear trends of risk of falls according to total dairy products consumption, we used restricted cubic-splines with three knots. We conducted the analyses separately in each cohort using Stata (version 15.0; Stata Corp., College Station).

RESULTS

Characteristics of the participants in each cohort according to tertiles of total dairy consumption are presented in **Table 1**. In the Seniors-ENRICA, participants in the highest vs. lowest tertile were less frequently men and less often current smokers or heavy drinkers. Also, they had a higher BMI, a higher intake of energy, calcium, protein, and saturated fat, and a lower adherence to the Mediterranean diet. The distribution of dairy consumption was similar in the UK Biobank, with the exception that those with higher consumption also had higher education and adherence to the Mediterranean diet.

The intake of both total dairy and each type of dairy products was higher in Spain than in the UK, except for low fat yogurt (**Table 2**). Average total dairy intake was 2.28 (standard deviation: 1.36) servings/d among participants in the Seniors-ENRICA, and 0.92 (0.64) servings/d in those in the UK Biobank. Milk accounted for a large part of this consumption in Spain (45%) but not in UK (19%). In addition, part-skim milk was the most consumed type of milk in both cohorts (40% and 67%, respectively).

In the Seniors-ENRICA study, over 7.2 years of follow-up (median follow-up, 5.4 y), 801 individuals reported ≥1 falls (**Table 3**). No association was found between the consumption of total dairy or any type of dairy products and the risk of falls, neither in the crude- nor in the fully-adjusted analyses [fully-adjusted hazard ratio (95% confidence interval) per 1-serving/d increment in total dairy consumption: 1.02 (0.93-1.11), milk: 0.93 (0.85-1.01), yogurt: 1.05 (0.96-1.15), and cheese: 0.96 (0.88- 1.05)]. Neither we found any difference in this association by categories of sex, morbidity, sleep duration, protein intake and physical activity level (p for interaction >0.05 in all cases) (**Supplemental table 2**). Moreover, we did not find any association between dairy products and the risk of falls with fracture (**Supplemental table 3**). Also, when cumulative dairy consumption was used as exposure, we still observed a null association with falls risk (**Supplemental table 4**). Similar results were also obtained when we excluded participants with cardiovascular disease, hip fracture and those who were heavy alcohol drinkers at baseline, or when we adjusted our analyses by markers of sarcopenia status (**Supplemental tables 5 y 6**).

Over 10.2 years of follow-up in the UK Biobank study (median follow-up, 3.2 y), 201 people reported ≥1 falls (**Table 4**). Participants in the highest tertile of total dairy consumption showed a higher risk of falls in the crude model [HR: 1.51 (95% CI: 1.07, 2.13), p-trend 0.02], compared to those of the lowest tertile. However, in the fully-adjusted model, this association became non-significant [1.41, (0.99, 2.01) p-trend 0.06]. As regards milk consumption, participants who consumed any amount had a higher risk of falls [fully-adjusted HR 1.53 (1.13, 2.08)] compared to non-consumers. We did not find any statistically significant association between the consumption of yogurt or cheese and the risk of falls by comparing the highest vs. the lowest tertile. Also, when we excluded participants with cardiovascular disease, hip fracture and those who were heavy alcohol drinkers at baseline, we found a null association between the consumption of total dairy and the risk of falls; of note, the positive association between milk consumption and the risk of falls found in the total population disappeared in this subsample (**Supplemental table 7**).

Finally, when analyzing the relation between total dairy and the risk of falls using non-parametric techniques, some differences between the two cohorts were observed. Whereas in the Seniors-ENRICA cohort there was no suggestion of a trend, in the UK Biobank, a statistically significant increased risk of falls in those participants who consumed >1.5 servings/day was observed (**Supplemental figure 2**).

DISCUSSION

In this study using data from two European cohorts, we generally did not find an association between the different types of dairy products and the risk of falls, independently of population characteristics or among subgroups of participants. There was a suggestion of an increased risk of falls among those who consumed milk in the UK Biobank; however, this result has to be confirmed in future studies.

In the scientific literature, we have only identified one study that examined the association between the consumption of dairy products and the risk of falling (14). In this cross-sectional study, no effect of dairy on falls was observed (14). However, authors found a protective association when results were adjusted for non-dairy proteins. Moreover, in a recent systematic review and meta-analysis including 18 observational studies, Bian et al. (21) found that individuals with higher consumption of yogurt and cheese had a lower risk of hip fracture, a serious consequence of falls. Nevertheless, as in our results from the UK Biobank cohort, the authors found a nonlinear positive dose-response association between milk intake and the risk of hip fracture across a range of milk consumption from 0 to 600 g/day (21). Therefore, our results in the UK Biobank cohort might be driven by those with very high milk intake, although we could not test this hypothesis due to the low number of study participants with such a high consumption.

On the other hand, in the largest study examining the association between milk intake and the risk of mortality and fractures, Michaëlsson et al. (19) found an increased risk of fractures among women who consumed ≥3 glasses/d of milk. Among the possible explanations for this finding was the D-galactose present in milk, but not in fermented dairy products. In animal studies, D-galactose has been associated with chronic inflammation, increased oxidative stress and accelerated aging (39-41), which are also factors that might influence falls risk (42,43). Moreover, milk consumption has been positively associated with biomarkers of inflammation and oxidative stress in men and women (19). However, an alternative explanation for this positive association could be the nutritional quality of the background diet. For example, older adults with dentition problems often have diets with poorer nutritional status and inadequate protein intake (44), so for these people dairy could be an important source of protein. In this case, the results found in the UK Biobank cohort might be explained by reverse causation. This explanation is reinforced by the fact that the sensitivity analyses done after eliminating those participants who had a high baseline risk of falls (participants with CVD, previous hip fracture and heavy alcohol drinkers), showed no association. In addition, Ding et al. (45) suggest that the health effect of replacing dairy products depends on the nature of the food for which it is replaced. In our study, we adjusted the analyses for the overall quality of the diet, but we did not have information about changes in the consumption of dairy products among these participants to examine its impact on health.

The divergences in the results found in both cohorts may also be driven for the characteristics of the participants. In the Seniors-ENRICA, mean age was higher and the prevalence of chronic conditions was more elevated than in the UK Biobank study, which may explain the larger number of incident falls. In addition, the UK Biobank study is not a representative sample of the UK population, so the participants in this study could be considered healthier across several health parameters. In the same way, we can also speculate that social and environmental conditions may play a role in the studied association by modulating both, the likelihood of falling because of inadequate urban conditions for the older people and the social support available to avoid situations of high risk in this population.

One of the strengths of this study was the use of two prospective cohorts from countries with different amount and proportion of consumption of dairy products, as well as different socioeconomic characteristics and lifestyle. Additional strengths were the long follow-up period and the large number of potential confounders that were accounted for in the analyses. Specifically, the adjustment for a diet quality score allowed examining the effect of dairy independently from the diet pattern where this food group was consumed, since it has been suggested that dairy products are nutrient-dense foods that may simply reflect a better diet, as in the UK Biobank (46).

This study also has some limitations. Measurement of dairy consumption relied only on the baseline measurements since dietary information in the UK Biobank study has not been updated during follow-up; therefore, possible changes that may have occurred in participants' diets were not taken into account. However, sensitivity analyses performed in the Seniors-ENRICA cohort showed that results using cumulative consumption of dairy products were quite similar than those performed with the baseline measure of diet. Also the relatively low consumption of skim-fat milk and yogurt did not allow for additional analyses for these categories of dairy products; however, current evidence on high-fat vs. low-fat dairy does not conclusively suggest that any of these groups has a beneficial effect on health compared to the other group (10). The measurement of falls was self-reported and some events could have been missed because of the recall bias. Since dietary information was collected when participants already had 60 years old, this null association may not reflect the effect of dairy consumption throughout the life on the development of long-term diseases with an impact on the risk of falls, such as osteoporosis. Finally, as in any observational study, some residual confounding may persist despite relatively exhaustive adjustment.

CONCLUSIONS

In conclusion, our results suggest that habitual dairy consumption in the advanced age is not associated with the risk of falling in older adults and therefore, its consumption does not pose a risk for falls in this population. Whether milk consumption might increase the risk of falls, as observed in the UK Biobank cohort, merits further study.

ACKNOWLEDGEMENTS

This research has been conducted with the use of the UK Biobank Resource under application number 29009. UK Biobank is an open access resource. Bona fide researchers can apply to use the UK Biobank data by registering and applying (http://www.ukbiobank.ac.uk/register-apply/).

STATEMENT OF AUTOSHIP

The authors' contributions were as follows: MMF, EAS and ELG: designed the research; MMF: performed the statistical analyses; all authors: contributed to interpretation of the results; MMF, EAS and ELG: drafted the manuscript; ELG: supervised the conduct of research and had primary responsibility for final content; and all authors reviewed the manuscript for important intellectual content, and read and approved the final manuscript.

CONFLICT OF INTEREST STATEMENT

The authors declare that they have no competing interests.

FUNDING SOURCES

This work was supported by FIS grants 16/609 and 16/1512 (Instituto de Salud Carlos III, State Secretary of R+D+I, and FEDER/FSE), the ATHLOS project (EU H2020-Project ID: 635316) and the JPI HDHL (SALAMANDER project).

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Table 1. Baseline characteristics of participants across tertiles of dairy consumption in the Seniors-ENRICA and in the UK Biobank study.

	Seniors-ENRICA study (N=2,981)			UK Biobank study (N=8,927)		
	Total dairy consumption, servings/d[b]			Total dairy consumption, servings/d[c]		
	Tertile 1 (0-1.62)	Tertile 2 (1.63-2.62)	Tertile 3 (2.63-12.0)	Tertile 1 (0-0.60)	Tertile 2 (0.61-1.12)	Tertile 3 (1.13-6.50)
Participants, n	994	994	993	3224	2728	2975
Age, y	68.7 (6.5)	69.1 (6.5)	69.4 (6.7)	63.7 (2.7)	63.7 (2.7)	63.7 (2.5)
Men, %	49.7	45.5	43.7[*]	58.6	50.0	49.9[**]
Educational level, %						
≤ Primary	55.9	58.5	57.2	11.7	9.5	7.1
Secondary	23.9	22.6	24.4	30.6	28.8	28.3
University	20.2	18.9	18.4	57.7	61.7	64.6[5]
Current smoker, %	14.7	13.1	8.2[5]	5.9	5.2	3.8[5]
Heavy drinker[a], %	10.5	7.6	5.9[4]	19.1	16.6	15.7[4]
BMI, kg/m^2	28.4 (4.4)	28.4 (4.3)	28.9 (4.6)[*]	26.7 (4.2)	26.4 (3.9)	26.7 (4.4)
Physical activity, METs-h/wk	22.0 (15.8)	21.7 (14.8)	21.1 (15.0)	43.3 (50.2)	42.6 (50.7)	43.7 (45.5)
Sleep duration, h/d	6.9 (1.4)	6.9 (1.4)	6.8 (1.4)	7.3 (1.0)	7.3 (0.9)	7.3 (0.9)
Energy intake, kcal/d	1900 (562)	2049 (673)	2109 (749)[**]	2043 (479)	2088 (464)	2206 (499)[**]
Intake of calcium, mg/dl	615 (167)	843 (158)	1182 (342)[**]	848 (261)	970 (245)	1141 (292)[**]
Intake of protein, g/d	84.1 (25.0)	90.2 (24.7)	98.6 (28.0)[**]	78.4 (18.2)	81.4 (17.8)	87.9 (19.6)[**]
Intake of saturated fat, g/d	20.6 (8.9)	24.1 (9.9)	28.4 (12.9)[**]	28.6 (10.1)	29.4 (10.2)	31.8 (10.8)[*]
MEDAS score	7.0 (1.7)	6.7 (1.9)	6.8 (1.7)[*]	4.3 (1.5)	4.4 (1.6)	4.6 (1.6)[**]
Diagnosed diseases, %						
Hypertension	63.2	64.6	65.3	35.3	33.8	33.2
Diabetes	17.0	16.4	15.7	5.2	4.1	4.4
Osteomuscular disease	48.2	49.8	49.9	22.1	21.7	23.0
Use of sleeping pills, %	13.6	14.1	16.3	0.5	0.4	0.5
Muscle mass in %, year 2013	49.4 (8.9)	49.0 (9.2)	48.8 (9.0)	-	-	-
Exhaustion, %, year 2013	4.5	5.9	5.3	-	-	-
Slow walking speed, %, year 2013	9.8	10.1	10.2	-	-	-

Note: MET: Metabolic Equivalent. BMI: Body Mass Index.

For continuous variables, the mean (standard deviation) is reported.

[a] Heavy drinker: ≥40 g/d of alcohol in men and ≥24 g/d in women.

[b]Serving sizes in Seniors-ENRICA study (1 serving): 200 ml of milk, 125 g of yogurt, and 40 g of cheese.

[c]Serving sizes in UK Biobank study (1 serving): 250 ml of milk, 125 g of yogurt, and 40 g of cheese.

[*]p<0.05; [**]p<0.001.

Table 2. Dairy consumption in the Seniors-ENRICA and UK Biobank study.

	Seniors-ENRICA study (N=2,981)	UK Biobank study (N=8,927)
	Mean (SD) servings/d	Mean (SD) servings/d
Total dairy products	2.28 (1.36)	0.92 (0.64)
Milk	1.03 (0.80)	0.18 (0.30)
Whole milk	0.23 (0.53)	0.01 (0.09)
Part-skim milk	0.41 (0.65)	0.12 (0.26)
Skim milk	0.39 (0.72)	0.05 (0.16)
Yogurt	0.59 (0.66)	0.41 (0.45)
Full-fat yogurt	0.25 (0.49)	0.08 (0.23)
Low-fat yogurt	0.34 (0.57)	0.33 (0.43)
Cheese	0.66 (0.87)	0.33 (0.31)

Table 3. Hazard ratios (95% confidence interval) for the association between dairy consumption and the risk of ≥1 falls in the Seniors-ENRICA study (N=2,981).

	Dairy consumption, servings/d				Continuous per 1 serving/d increment
	Tertile 1	Tertile 2	Tertile 3	P-trend	
Total dairy					
Tertile range	0-1.62	1.63-2.62	2.63-12.01		
Person-years	5014	4961	4952		
Cases, n	261	257	283		
Age- and sex-adjusted model	1.00	0.99 (0.83-1.17)	1.09 (0.92-1.29)	0.32	1.04 (0.96-1.14)
Multivariable[1]	1.00	0.99 (0.83-1.17)	1.03 (0.86-1.22)	0.75	1.01 (0.93-1.11)
Multivariable[2]	1.00	0.99 (0.83-1.18)	1.03 (0.87-1.23)	0.72	1.02 (0.93-1.11)
Milk					
Tertile range	0-0.68	0.69-1.21	1.22-7.84		
Person-years	4932	5115	4880		
Cases, n	275	279	247		
Age- and sex-adjusted model	1.00	0.88 (0.75-1.04)	0.89 (0.75-1.06)	0.19	0.94 (0.86-1.03)
Multivariable[1]	1.00	0.86 (0.72-1.01)	0.84 (0.71-1.01)	0.06	0.92 (0.84-1.00)
Multivariable[2]	1.00	0.85 (0.72-1.01)	0.85 (0.71-1.02)	0.08	0.92 (0.84-1.01)
Multivariable[3]	1.00	0.86 (0.73-1.02)	0.86 (0.72-1.03)	0.10	0.93 (0.85-1.01)
Yogurt					
Tertile range	0	0.01-0.92	0.93-7.00		
Person-years	5390	4916	4621		
Cases, n	274	256	271		
Age- and sex-adjusted model	1.00	0.96 (0.81-1.14)	1.11 (0.94-1.32)	0.22	1.06 (0.97-1.15)
Multivariable[1]	1.00	0.97 (0.82-1.16)	1.09 (0.92-1.30)	0.32	1.05 (0.96-1.14)
Multivariable[2]	1.00	0.96 (0.81-1.14)	1.09 (0.92-1.30)	0.34	1.04 (0.96-1.14)
Multivariable[3]	1.00	0.97 (0.81-1.16)	1.10 (0.92-1.31)	0.29	1.05 (0.96-1.15)
Cheese					
Tertile range	0-0.15	0.16-0.68	0.69-9.43		
Person-years	5002	4904	5021		
Cases, n	277	255	269		
Age- and sex-adjusted model	1.00	0.93 (0.78-1.10)	0.97 (0.82-1.15)	0.74	0.99 (0.91-1.07)
Multivariable[1]	1.00	0.93 (0.78-1.11)	0.93 (0.78-1.11)	0.41	0.96 (0.88-1.05)
Multivariable[2]	1.00	0.92 (0.78-1.10)	0.92 (0.77-1.10)	0.36	0.96 (0.88-1.05)
Multivariable[3]	1.00	0.93 (0.78-1.11)	0.93 (0.78-1.11)	0.42	0.96 (0.88-1.05)

[1] Cox model adjusted for age, sex, educational level (≤primary, secondary, university), smoking status (never smoker, former smoker, current smoker), alcohol consumption (abstainer, moderate, heavy drinker), BMI (tertiles of kg/m^2), physical activity (tertiles of MET-h/wk), sleep duration (tertiles of h/d), energy intake (tertiles of kcal/d), MEDAS score (tertiles), hypertension, diabetes, and use of sleeping pills.

[2] Cox model additionally adjusted for osteomuscular disease.

[3] Cox model additionally adjusted for the other types of dairy products.

Table 4. Hazard ratios (95% confidence interval) for the association between dairy consumption and the risk of ≥1 falls in the UK Biobank study (N=8,927).

	Dairy consumption, servings/d				Continuous per 1 serving/d increment
	Tertile 1	Tertile 2	Tertile 3	P-trend	
Total dairy					
Tertile range	0-0.60	0.61-1.12	1.13-6.50		
Person-years	12168	9920	10184		
Cases, n	64	68	69		
Age- and sex-adjusted model	1.00	1.32 (0.93-1.86)	1.51 (1.07-2.13)	0.02	1.23 (1.04- 1.45)
Multivariable[1]	1.00	1.31 (0.93-1.86)	1.44 (1.01-2.06)	0.04	1.20 (1.01-1.43)
Multivariable[2]	1.00	1.31 (0.93-1.85)	1.41 (0.99-2.01)	0.06	1.19 (1.00-1.41)
Milk					
Consumption (yes vs no)	No		Yes		
Person-years	22581		9692		
Cases, n	135		66		
Age- and sex-adjusted model	1.00	-	1.57 (1.16-2.11)		
Multivariable[1]	1.00	-	1.57 (1.16-2.13)		
Multivariable[2]	1.00	-	1.54 (1.14-2.09)		
Multivariable[3]	1.00	-	1.53 (1.13-2.08)		
Yogurt					
Tertile range	0	0.25-0.50	0.60-3.00		
Person-years	13942	8434	9896		
Cases, n	69	68	64		
Age- and sex-adjusted model	1.00	1.47 (1.04-2.06)	1.22 (0.87-1.73)	0.23	1.11 (0.94-1.31)
Multivariable[1]	1.00	1.49 (1.05-2.10)	1.22 (0.86-1.75)	0.24	1.11 (0.93-1.31)
Multivariable[2]	1.00	1.48 (1.05-2.09)	1.21 (0.85-1.73)	0.27	1.10 (0.93-1.31)
Multivariable[3]	1.00	1.45 (1.02-2.06)	1.21 (0.85-1.73)	0.28	1.10 (0.93-1.31)
Cheese					
Tertile range	0-0.20	0.30-0.40	0.50-2.60		
Person-years	16167	7552	8553		
Cases, n	100	44	57		
Age- and sex-adjusted model	1.00	1.00 (0.70-1.42)	1.18 (0.85-1.64)	0.35	1.08 (0.92-1.27)
Multivariable[1]	1.00	0.95 (0.66-1.36)	1.05 (0.75-1.47)	0.82	1.02 (0.86-1.21)
Multivariable[2]	1.00	0.98 (0.68-1.40)	1.09 (0.78-1.53)	0.65	1.04 (0.88-1.23)
Multivariable[3]	1.00	1.01 (0.70-1.45)	1.07 (0.76-1.50)	0.70	1.03 (0.87-1.22)

[1] Cox model adjusted for age, sex, educational level (≤primary, secondary, university), smoking status (never smoker, former smoker, current smoker), alcohol consumption (abstainer, moderate, heavy drinker), BMI (tertiles of kg/m^2), physical activity (tertiles of MET-h/wk), sleep duration (tertiles of h/d), energy intake (tertiles of kcal/d), MEDAS score (tertiles), hypertension, diabetes, and use of sleeping pills.

[2] Cox model additionally adjusted for osteomuscular disease.

[3] Cox model additionally adjusted for the other types of dairy products.