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ORIGINAL CONTRIBUTION

Dairy intake, blood pressure and incident hypertension in a general British population: the 1946 birth cohort

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Abstract
Purpose We aimed to examine the association between intake of different subgroups of dairy products and blood pressure and incident hypertension 10 years later, adjusting for confounding factors.
Methods We studied 1,750 British men and women from the 1946 British birth cohort from 1989 to 1999 (age 43 and 53 years, respectively). Diet was assessed by 5-day food diaries using photographs in the estimation of portion size. Systolic (sbp) and diastolic (dbp) blood pressure and prevalent hypertension were assessed at age 43 and 53 years. Linear regression and logistic regression were used to examine 10-year blood pressure levels and incident hypertension by baseline dairy intake.
Results There was a weak non-significant trend of a protective effect of total dairy intake on blood pressure and incident hypertension, but no evidence for a dose–response relationship (OR for incident hypertension: 0.88 (95% CI 0.68;1.14) 2nd vs. 1st tertile and 0.93 (95% CI 0.72;1.18) 3rd vs. 1st tertile). Higher intake of low-fat and fermented dairy was linked to a higher sbp but in a nonlinear manner. Adjustment for other dietary factors, health behaviours and BMI attenuated these associations.
Conclusions Total dairy intake and specific dairy subgroups were not associated with blood pressure and incident hypertension among a representative sample of British adults after adjustment for confounding factors.

Keywords Dairy products · Blood pressure · Hypertension · Birth cohort · Epidemiology

Introduction

Elevated blood pressure is the major risk factor for stroke [1] and is an established risk factor for cardiovascular disease [2], type 2 diabetes [3], as well as all-cause mortality [4]. Overwhelming evidence suggests that blood pressure levels can be reduced in populations by a healthy diet and lifestyle [5–7], resulting in a substantial reduction in cardiovascular morbidity and mortality [8, 9]. Dairy products comprise one of the major energy sources in humans, substantially contributing to the overall intake of protein and fat. Both dietary fat [10, 11] and protein [12] have been associated with blood pressure, and dairy product intake has been linked to lower risk of cardiometabolic disease [13]. Dairy products may contribute to a lowering of blood pressure through their content in bioactive peptides [14] and calcium [15, 16], as well as other minerals and vitamins such as potassium [17] and magnesium [18, 19].

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The relationship between dairy intake and blood pressure has been investigated prospectively in different epidemiological studies [20–27] though results have been inconsistent both within and between studies. A main reason for this may be that despite being considered as a single food group, dairy products are quite heterogeneous nutritionally. For example, fermented dairy products contain relatively high amounts of peptides with in vitro angiotensin-converting enzyme inhibitor effects [28]. On the other hand, cheese contains considerable amounts of fat (potentially contributing to weight gain) and salt, thus could contribute to an increase rather than a decrease in blood pressure [29]. In a recent meta-analysis of five epidemiological studies, intake of low-fat dairy and fluid dairy products was associated with a lower risk of elevated blood pressure [30].

However, any association between dairy intake and blood pressure could be confounded by intake of other food items, as well as behavioural and socioeconomic factors. Socioeconomic factors in particular have not been taken into consideration as potential confounders by some studies [16, 20].

Given the above, we aimed to answer the following two questions: (1) Are total dairy intake and specific dairy subgroups (i.e. low fat, full fat, fermented) linked to blood pressure and incident hypertension after controlling for dietary, behavioural and socioeconomic factors? (2) Are these specific dairy subgroups differentially associated with blood pressure and incident hypertension? We conducted our analysis among a sample of middle-aged British men and women followed from birth (British 1946 birth cohort).

Materials and methods

Setting and population

The initial study sample of the Medical Research Council (MRC) National Survey of Health and Development (NSHD), also known as the British 1946 birth cohort, consisted of 5,362 children (boys and girls) born in England, Scotland and Wales during 1 week in March, 1946. Cohort members were interviewed in their own homes by trained research nurses in 1982, 1989 and 1999. In 1989, the sample size was 3,262, and participants lost to follow-up were due to death (6.8%), emigration and overseas residence (11.3%), failure to contact (6.9%) and refusal to participate (10.1%). From the 3,262 who participated in the 1989 screening, 2,280 had valid data on diet from a 5-day food diary. For the current analysis, participants with no data on blood pressure at baseline ($n = 45$) and follow-up ($n = 70$) and those with prevalent hypertension ($n = 415$) were excluded from analysis. The sample is thus comprised of 1,750 participants with data on dairy intake at age 43 and blood pressure at age 43 and 53 and who were not hypertensive at age 43. The 1946 birth cohort sample was initially representative of the British population born within marriage and singly in the years immediately after the Second World War [31]. In 1989, the never-married, the least literate and those from a manual social class were underrepresented. Compared to participants included in the current analysis, those excluded were more likely to be men and had on average a higher BMI but they did not differ in terms of dietary energy intake.

Nutritional assessment and dairy product intake

Diet was assessed by 5-day food diaries at age 43 years. Details of the dietary assessment have been reported earlier [32]. Participants were given a diary to record details of all food and drink consumed at home and away over a 5-day period. This method of dietary assessment has been previously validated [33]. Food intake was coded using a computerized in-house data entry program at the Medical Research Council Dunn Nutritional Laboratory in Cambridge [34, 35]. Energy intake was calculated using a food composition database based on the British Food Composition Tables [36].

The following dairy product items were coded from the 5-day diet record and were used to derive the current variables for analysis: full-fat milk; semi-skimmed milk; skimmed milk; milk-containing beverages (full fat, semi-skimmed and skimmed); full-fat cheese; low-fat cheese; full-fat yoghurt; low-fat yoghurt; fruit-flavoured yoghurt (full fat and low fat); and milk-based puddings. Total dairy was assessed as intake of all food items mentioned above. A grouping of total dairy intake excluding cheese (due to its high fat and salt content compared to other dairy products) was also created. Low-fat dairy is comprised of (1) skimmed and semi-skimmed milk and milk-containing beverages; (2) low-fat cheese; and (3) low-fat yoghurt (plain and fruit-flavoured). The percentage fat content of semi-skimmed and skimmed milk in the UK is 1.7 and 0.3%, respectively. The fat content of low-fat cheese ranges from 12 to 16%, depending on the type of cheese and brand. Specific cheese types and brands were not reported by participants. Full-fat dairy is comprised of (1) full-fat milk and milk-containing beverages; (2) full-fat cheese; and (3) cream. Full-fat milk in the UK contains 4.0% fat, full-fat cheese contains between 30 and 35% fat and cream between 19 and 24%. Fermented dairy is comprised of all yoghurts and cheese (both low fat and full fat). Consumption of composite dishes that contained substantial amounts of dairy products (i.e. macaroni cheese, lasagna) was rare in this cohort, and such dishes were thus not disaggregated.

Blood pressure and incident hypertension

Systolic blood pressure (sbp) and diastolic blood pressure (dbp) were measured at the home visits at age 43 (1989) and 53 years (1999). At age 43, blood pressure was taken using a Hawksley random zero sphygmomanometer with a regular (12 × 23 cm) upper arm cuff. At age 53, blood pressure was measured twice while the participant was seated and after 5 min of rest, using the validated Omron HEM-705 (Omron Corp., Tokyo, Japan) automated digital oscillometric sphygmomanometer. The second blood pressure measure was used for analyses, except if this measure was missing, then the first one was used. The reported differences in blood pressure readings given by the two different methods used to assess blood pressure in the two subsequent waves of data collection do not interfere with the current results as blood pressure change was not among the outcomes of interest. Study members were asked whether they had taken any blood pressure–lowering medication in the year preceding the interview. Hypertension at age 43 and 53 was defined as sbp $\geq$140 mmHg and/or dbp $\geq$90 mmHg and/or current use of antihypertensive medication. The 45 participants with missing information on blood pressure at analysis baseline (age 43) did not differ in any key characteristics from those with information on blood pressure.

Potential confounding factors

All confounding variables are from data collected at age 43 years. The occupational social class of the participants at 43 years of age (or earlier if this was unavailable) was coded according to the Registrar General classification and classified as professional, managerial, intermediate, skilled manual, semi-skilled manual or unskilled. Per day intake of fruits and vegetables, high-fibre cereal products, tea, coffee as well as total energy intake was assessed from the 5-day diet record described earlier. Information on alcohol consumption over the previous 7 days was obtained by a self-completed questionnaire on intake of beer, lager, cider, stout, wine, spirits, liqueurs, sherry, martini and port [37]. Interview-based information on cigarette smoking status was obtained by research nurses and classified as current smoker, ex-smoker or non-smoker. Participants reported the number of occasions in which they had participated in sports, exercises or other physical activities in their leisure time during the previous 4 weeks. The categories were inactive (no occasions), mildly active (one to four occasions) or moderately active (more than four occasions). Weight and height were measured by research nurses. Height was measured to the nearest 0.5 cm using a lockable tape with foot plate, head piece and spirit level, with the head in the Frankfort plane position. Weight was measured with light clothing but no shoes and rounded to the nearest 0.5 kg using CMS weighing scales. BMI was calculated as weight (kg) divided by height (m) squared.

Statistical analysis

Linear (for sbp and dbp) and logistic (for incident hypertension) regression analyses were used to study associations between intake of dairy products (1989) and blood pressure and hypertension 10 years later. For linear regression, the regression coefficients presented in the tables represent the mean difference in blood pressure comparing dairy intake tertiles 2 and 3 to the reference tertile 1 (low intake). Similarly, for logistic regression, the risk ratios for hypertension represent differences in risk with low dairy intake (1st tertile) as the reference category. The *p*-value for trend was obtained by including the ordered categorical dairy variables as well as continuous variables in the analysis. Prevalent hypertension cases were excluded at analysis baseline in order to reduce the possibility of reverse causation.

All models were adjusted for energy using the residual method [38]. The energy-adjusted intake is the sum of the residual and the expected intake of the given food item at the mean energy intake of the study sample by gender. Multivariable regression analysis was used to examine associations adjusting for potential confounders. Model 1 was adjusted for sex and social class. A second model was additionally adjusted for other diet variables (total energy intake, fruits and vegetables, high-fibre cereal products, tea and coffee). The maximally adjusted model was further adjusted for health behaviours (alcohol consumption, physical activity and smoking status) and BMI. In order to disentangle the effects of low-fat and full-fat dairy, the two variables were included together in the model (i.e. mutually adjusted).

All analyses were performed using 'Stata version 10.0' for Windows.

Results

Table 1 shows baseline (1989) associations between total dairy intake and dietary, behavioural and sociodemographic characteristics of the 1,750 participants aged 43 years (47% men) included in analysis. Both low-fat dairy and high-fat dairy increased linearly with total dairy intake. Those consuming the largest amounts of total dairy (top tertile) consumed mainly high-fat dairy products, whereas those in the lowest total dairy tertile consumed mostly low-fat dairy products. All diet factors were positively associated with intake of dairy products. Men consumed more dairy products than women as did those from manual social classes compared to those from non-manual. Intake of total dairy was generally not associated with other health behaviours or BMI.

Dairy intake in relation to incident hypertension

During follow-up, 994 new hypertension cases were identified. Overall, there was no association between intake of dairy products and incident hypertension (Table 2). In sex-adjusted analysis, there was a trend of higher hypertension risk with higher low-fat dairy intake and a trend of lower hypertension risk with higher full-fat dairy intake. None of these trends reached statistical significance.

Dairy intake in relation to systolic and diastolic blood pressure

Mean sbp increased from 117.3 to 133.5 mmHg, and mean dbp increased from 75.1 to 83.1 mmHg from 1989 to 1999. In sex-adjusted analysis, mean sbp and dbp were lower in the middle and highest total dairy intake group compared with the lowest intake group, but the associations did not follow a dose–response manner and they did not reach statistical significance (Table 3). Higher intake of low-fat dairy and fermented dairy was associated with higher sbp and dbp, while there was a weak trend of lower sbp with increasing consumption of full-fat dairy. There was no evidence for a dose–response relationship for either low-fat dairy or fermented dairy as mean blood pressure was similar in intake tertiles 2 and 3.

In multivariable-adjusted analysis ($n = 1{,}187$), only sbp was considered as it was more strongly linked to dairy intake than either dbp or incident hypertension (Tables 2, 3). In multivariable analysis (Table 4), the inverse nonlinear trend for total dairy intake was not reduced, but the effects remained small and non-significant. In addition, the non-linear inverse association between fermented and low-fat dairy and sbp remained after adjustments, but it did not reach statistical significance.

In sensitivity analysis, excluding overweight and obese participants (BMI $\geq$ 25 kg/m^2) ($n = 373$) from the analysis resulted in the attenuation of the positive association

Table 1 Baseline characteristics of 1,750 British participants aged 43 at baseline by tertiles of total dairy product intake in the MRC 1946 birth cohort

	Tertiles of total dairy intake		
	T1 ($N = 577$)	T2 ($N = 571$)	T3 ($N = 602$)
Median total dairy intake (IQR[a]), g/day	224.1 (177.2)	275.3 (152.8)	309.0 (214.2)
Low-fat dairy[b], g/day**	139.3 (17.2)	142.6 (21.0)	148.5 (25.3)
Full-fat dairy, g/day**	98.7 (27.5)	135.9 (22.1)	176.6 (34.5)
Fermented dairy, g/day**	34.9 (3.9)	38.3 (4.1)	42.7 (4.9)
Sex, male[c,]**	45.0 (261)	49.6 (287)	49.5 (287)
Social class, manual*	28.7 (*105*)	23.2 (*84*)	24.5 (*93*)
Total energy intake, kcal/day**	1,570 (353)	2,120 (304)	2,734 (538)
Fruit and vegetable, g/day**	175.0 (133.0)	193.6 (135.9)	199.6 (123.0)
Wholegrain cereal, g/day**	51.6 (51.8)	55.1 (55.3)	67.9 (64.3)
Coffee, g/day	405.9 (382.1)	437.5 (346.2)	438.6 (430.5)
Tea, g/day**	471.4 (433.3)	540.2 (417.0)	596.5 (478.3)
Beer, half-pints/week	3.6 (7.4)	4.4 (8.5)	6.0 (11.4)
Wine, glasses/week	2.3 (3.8)	2.7 (4.3)	3.0 (5.6)
Spirits, measures/week	1.5 (3.3)	1.7 (4.4)	2.1 (5.2)
Physical activity, none	40.6 (241)	41.6 (246)	41.2 (251)
Smoking, current	19.9 (104)	18.6 (99)	22.4 (124)
BMI, kg/m^2	25.3 (4.0)	24.8 (3.6)	24.3 (3.6)
Systolic blood pressure, mmHg	132.3 (17.5)	131.2 (16.3)	132.0 (18.6)
Diastolic blood pressure, mmHg	82.1 (10.7)	81.2 (10.5)	82.0 (11.7)
Hypertension[b]	40.5 (208)	38.0 (200)	38.9 (213)

IQR interquartile range

* $p < 0.05$; ** $p < 0.01$ Chi-squared tests were used for categorical and ANOVA for continuous variables

[a] All continuous measures are presented as mean (SD)

[b] All categorical measures are presented as % (n)

All diet variables are energy-adjusted by means of the residual method

Table 2 Risk ratios (95% CI) for the association between energy-adjusted dairy intake and incident hypertension after a 10-year follow-up among 1,750 middle-aged British participants in the MRC 1946 birth cohort

	Tertiles of energy-adjusted dairy intake			
	T1	T2	T3	*p* for trend
Total dairy (g/day)				
Median intake (IQR)	224.1 (177.2)	275.3 (152.8)	309.0 (214.2)	
Cases/total *n*	208/577	200/571	313/602	
RR (95% CI)	Reference	0.88 (0.68; 1.14)	0.93 (0.72; 1.18)	0.55
Total dairy excluding cheese (g/day)				
Median intake (IQR)	190.0 (165.8)	235.2 (140)	271.2 (201.8)	
Cases/total *n*	204/577	206/577	211/596	
RR (95% CI)	Reference	0.98 (0.56; 1.70)	1.18 (0.59; 2.36)	0.50
Low-fat dairy (g/day)				
Median intake (IQR)	120.7 (108.0)	145.7 (110.2)	165.9 (119.6)	
Cases/total *n*	209/536	217/601	195/613	
RR (95% CI)	Reference	1.30 (0.90; 1.88)	1.40 (0.81; 2.37)	0.23
Full-fat dairy (g/day)				
Median intake (IQR)	50.1 (126.6)	83.6 (185.2)	142.4 (237)	
Cases/total *n*	200/589	213/585	208/576	
RR (95% CI)	Reference	0.91 (0.66; 1.25)	0.71 (0.49; 1.03)	0.069
Fermented dairy (g/day)				
Median intake (IQR)	22.4 (44.4)	27.0 (43.0)	31.4 (35.0)	
Cases/total *n*	206/541	209/594	196/615	
RR (95% CI)	Reference	1.11 (0.84; 1.47)	1.01 (0.70; 1.44)	0.99

Sex-adjusted odds ratios (95% CI) calculated using logistic regression

IQR interquartile range

p-values < 0.05 are considered statistically significant

All dairy intake variables are energy-adjusted by means of the residual method

between low-fat and fermented dairy and sbp (online appendix table). In addition, exclusion of overweight and obese participants from the analysis strengthened the inverse association between total dairy intake and sbp (online appendix).

Discussion

Summary of findings

Among this sample of British men and women born in 1946, there was no evidence to support a prospective association between dairy product intake and blood pressure. There was a trend of lower blood pressure levels and hypertension risk by increasing total dairy intake, which did not reach statistical significance. As the fat content of the diet (and of dairy products) is important in relation to blood pressure and hypertension [10, 11], we investigated the role of low-fat and full-fat dairy separately. We found a pattern of higher hypertension risk and blood pressure with increasing consumption of low fat (as well as fermented dairy products). A possible explanation for this finding may be the higher consumption of low-fat and fermented dairy foods by overweight and obese participants in an attempt to lose weight. It should be noted that intake of fermented dairy in the current sample is mainly driven by consumption of yoghurts rather than cheese. When we excluded overweight and obese participants from the analysis, the positive association between low-fat and fermented dairy and sbp was abolished. In this post hoc analysis, the overall inverse association between dairy intake and sbp was strengthened.

Strengths and limitations

The current study is among the few which prospectively investigated the association between specific dairy subgroups and blood pressure, including incident hypertension in a representative British population. The major disadvantage of the current study, which also applies to all observational studies investigating diet–disease associations, is the

Table 3 Mean differences (95% CI) in blood pressure by tertiles of energy-adjusted dairy intake after a 10-year follow-up among 1,750 middle-aged British participants in the MRC 1946 birth cohort

	Tertiles of energy-adjusted dairy intake			
	T1	T2	T3	*p* for trend
Total dairy (g/day)	n = 577	n = 571	n = 602	
Median intake (IQR[b])	224.1 (177.2)	275.3 (152.8)	309.0 (214.2)	
Systolic bp (mmHg)	Reference	−1.30 (−3.42; 0.81)	−0.49 (−2.58; 1.60)	0.66
Diastolic bp (mmHg)	Reference	−1.15 (−2.47; 0.16)	−0.25 (−1.55; 1.05)	0.73
Total dairy excluding cheese (g/day)	*n* = 577	*n* = 577	*n* = 596	
Median intake (IQR)	190.0 (165.8)	235.2 (140)	271.2 (201.8)	
Systolic bp (mmHg)	Reference	−1.29 (−5.96; 3.37)	0.94 (−4.91; 6.80)	0.56
Diastolic bp (mmHg)	Reference	−1.97 (−4.87; 0.92)	−0.50 (−4.14; 3.14)	0.91
Low-fat dairy (g/day)	*n* = 536	*n* = 601	*n* = 613	
Median intake (IQR)	120.7 (108.0)	145.7 (110.2)	165.9 (119.6)	
Systolic bp (mmHg)	Reference	3.35 (0.21; 6.49)	3.56 (−0.93; 8.06)	0.14
Diastolic bp (mmHg)	Reference	2.52 (0.57; 4.47)	1.35 (−1.45; 4.14)	0.40
Full-fat dairy (g/day)	*n* = 589	*n* = 585	*n* = 576	
Median intake (IQR)	50.1 (126.6)	83.6 (185.2)	142.4 (237)	
Systolic bp (mmHg)	Reference	−0.72 (−3.38; 1.93)	−2.09 (−5.15; 0.97)	0.16
Diastolic bp (mmHg)	Reference	−0.16 (−1.52; 1.20)	−0.33 (−1.86; 1.20)	0.67
Fermented dairy (g/day)	*n* = 541	*n* = 594	*n* = 615	
Median intake (IQR)	22.4 (44.4)	27.0 (43.0)	31.4 (35.0)	
Systolic bp (mmHg)	Reference	2.79 (0.38; 5.20)	1.89 (−1.13; 4.92)	*0.26*
Diastolic bp (mmHg)	Reference	0.59 (−1.05; 2.24)	−0.69 (−2.59; 1.21)	*0.40*

Sex-adjusted difference in mean blood pressure (95% CI) by tertile of dairy intake calculated using linear regression

IQR interquartile range

p-values < 0.05 are considered statistically significant

All dairy intake variables are energy-adjusted by means of the residual method

self-reported nature of the main exposure (dairy intake in this case), which could introduce bias in the results. Unfortunately, estimated basal metabolic rate could not be accurately assessed in our study; thus, identification of diet misreporters using the Goldberg cut-off points was not possible. Another limitation of the current study is that consumption of dairy products in the UK changed dramatically from 1989 (current analysis baseline) to 1999 (end of current analysis follow-up). For example, in the current sample, mean intake of low-fat dairy increased from 142 g/day in 1989 to 245 g/day in 1999, while intake of full-fat dairy decreased from 138 g/day in 1989 to 52 g/day in 1999. Therefore, dairy intake in 1989 may not be representative of the intake during the 10 years of follow-up. We tried to account for the effects of this change in dairy intake by adjusting our analysis for the 1999 dairy intake, but the results remained unchanged (online appendix). In addition, splitting dairy products further into cheese, yoghurt and milk was not possible due to insufficient consumption and limited variation among the current study population. Finally, composite dishes including dairy products (i.e. macaroni cheese, lasagna) were not included in the calculation of dairy intake in our study; thus, habitual dairy intake may be underestimated in some individuals. However, such dishes were uncommon; thus, it is unlikely that the dairy intake of participants was underestimated at a substantial extent.

Comparison with other studies

Low-fat dairy intake was inversely associated with incident hypertension among a sample of younger [20] and older [26] Spaniards and among a sample of middle-aged and older US women [24]. The analysis from these studies used data that were gathered chronologically much later than the current study, and thus, intake of low-fat dairy was probably much higher and widespread among these populations in Spain and the US compared to the current British population. In contrast, and in line with the current findings, dairy products were not associated with 15-year incident elevated blood pressure among young US adults in the CARDIA study [22] nor associated with change in blood pressure in the French SU.VI.MAX cohort [24] and the

Table 4 Multivariable-adjusted mean difference (95% CI) in systolic blood pressure (mmHg) by tertiles of energy-adjusted dairy intake after a 10-year follow-up among 1,187 participants with valid data on all covariates

	Tertiles of energy-adjusted dairy intake			
	T1	T2	T3	*p* for trend
Total dairy (g/day)	*n* = 385	*n* = 384	*n* = 418	
Median intake (IQR)	*224.1 (177.2)*	*275.3 (152.8)*	*309.0 (214.2)*	
Sex + social class adjusted	Reference	−1.28 (−3.77; 1.21)	−0.24 (−2.70; 2.20)	0.86
+Dietary factors[a]	Reference	−1.96 (−5.07; 1.14)	−1.69 (−6.50; 3.11)	0.44
+Dietary factors + health behaviours[b] + BMI	Reference	−1.19 (−4.23; 1.86)	−0.67 (−5.39; 4.04)	0.73
Total dairy excluding cheese (g/day)	*n* = 382	*n* = 386	*n* = 419	
Median intake (IQR)	190.0 (165.8)	235.2 (140)	271.2 (201.8)	
Sex + social class adjusted	Reference	−1.83 (−4.33; 0.68)	−0.33 (−2.79; 2.13)	0.83
+Dietary factors[a]	Reference	−2.61 (−5.68; 0.45)	−1.89 (−6.65; 2.88)	0.36
+Dietary factors + health behaviours[b] + BMI	Reference	−2.00 (−5.01; 1.01)	−1.17 (−5.85; 3.50)	0.54
Low-fat dairy (g/day)	*n* = 364	*n* = 416	*n* = 407	
Median intake (IQR)	120.7 (108.0)	145.7 (110.2)	165.9 (119.6)	
Sex + social class adjusted	Reference	2.38 (−0.63; 5.39)	0.94 (−3.27; 5.14)	0.70
+Dietary factors[a]	Reference	2.83 (−1.34; 6.99)	1.70 (−4.91; 8.32)	0.79
+Dietary factors + health behaviours[b] + BMI	Reference	2.37 (−1.73; 6.47)	2.84 (−3.66; 9.35)	0.45
Full-fat dairy (g/day)	*n* = 385	*n* = 393	*n* = 409	
Median intake (IQR)	50.1 (126.6)	83.6 (185.2)	142.4 (237)	
Sex + social class adjusted	Reference	−1.51 (−4.12; 1.10)	−0.19 (−3.08; 2.69)	0.93
+Dietary factors[a]	Reference	−1.83 (−4.99; 1.34)	−0.96 (−6.04; 4.11)	0.63
+Dietary factors + health behaviours[b] + BMI	Reference	−0.98 (−4.10; 2.14)	−0.44 (−5.42; 4.55)	0.81
Fermented dairy (g/day)	*n* = 363	*n* = 415	*n* = 409	
Median intake (IQR)	22.4 (44.4)	27.0 (43.0)	31.4 (35.0)	
Sex + social class adjusted	Reference	3.19 (0.43; 5.94)	1.48 (−2.05; 5.00)	0.43
+Dietary factors[a]	Reference	4.45 (0.53; 8.36)	3.71 (−2.50; 9.93)	0.34
+Dietary factors + health behaviours[b] + BMI	Reference	3.65 (−0.21; 7.50)	4.02 (−2.09; 10.13)	0.25

Multivariate-adjusted difference in mean systolic blood pressure (95% CI) by tertile of dairy intake calculated using linear regression

IQR interquartile range

p-values < 0.05 are considered statistically significant

[a] Fruit and vegetable intake, wholegrain cereal intake, coffee and tea consumption, total energy intake

[b] Alcohol consumption, physical activity, smoking status

All dairy intake variables are energy-adjusted by means of the residual method

Dutch Hoorn cohort [26]. In two other recent Dutch studies, there was a weak effect of ~20% reduction in incident hypertension in those with a higher intake of low-fat dairy [39, 40]. In the Rotterdam Study [40], dairy products excluding cheese were inversely associated with 2-year sbp and dbp and incident hypertension, but these effects were attenuated after 6 years of follow-up. As with the current study, no significant associations were observed between fermented dairy, cheese and cheese products and blood pressure.

Evidence from trials is also not supportive of an association between dairy intake and blood pressure. In the Dietary Approaches to Stop Hypertension (DASH) trial, a diet high in low-fat dairy products (together with reduced consumption of red meat, fats and oils) was efficient in reducing blood pressure in the experimental group [41], but the specific effect of low-fat dairy could not be isolated. Two small-scale trials specifically looking at the effect of increased dairy consumption on several cardiometabolic risk factors did not find any effect of increased dairy intake on blood pressure [42, 43].

In conclusion, there was no conclusive evidence of an association between intake of dairy products and blood pressure in the current epidemiological study. As in the current study, most prospective evidence points to a weak or null association between dairy product intake and blood pressure.

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Conflict of interest The authors declare that they have no conflict of interest.

Ethical standards This study was conducted according to the guidelines laid down in the 1964 Declaration of Helsinki, and all procedures involving human subjects were approved by an ethics committee. Written informed consent was obtained from all participants prior to their inclusion in the study. The data are the responsibility of the MRC National Survey of Health and Development (http://www.nshd.mrc.ac.uk) and are available in so far as consent and ethical approval permit and as it is within the scope of the team's resources to make them available.

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