Primary care

Frequency of eating and concentrations of serum cholesterol in the Norfolk population of the European prospective investigation into cancer (EPIC-Norfolk): cross sectional study

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Abstract

Objectives To examine the relation between self reported eating frequency and serum lipid concentrations in a free living population.
Design Cross sectional population based study.
Setting Norfolk, England.
Participants 14 666 men and women aged 45-75 years from the Norfolk cohort of the European prospective investigation into cancer (EPIC-Norfolk).
Main outcome measures Concentrations of blood lipids.
Results Mean concentrations of total cholesterol and low density lipoprotein cholesterol decreased in a continuous relation with increasing daily frequency of eating in men and women. No consistent relation was observed for high density lipoprotein cholesterol, body mass index, waist to hip ratio, or blood pressure. Mean cholesterol concentrations differed by about 0.25 mmol/l between people eating more than six times a day and those eating once or twice daily; this difference was reduced to 0.15 mmol/l after adjustment for possible confounding variables, including age, obesity, cigarette smoking, physical activity, and intake of energy and nutrients (alcohol, fat, fatty acids, protein, and carbohydrate).
Conclusions Concentrations of total cholesterol and low density lipoprotein cholesterol are negatively and consistently associated with frequency of eating in a general population. The effects of eating frequency on lipid concentrations induced in short term trials in animals and human volunteers under controlled laboratory conditions can be observed in a free living general population. We need to consider not just what we eat but how often we eat.

Introduction

Reports on the relation between eating frequency, lipid profile, and glucose metabolism are not new. Early evidence came from studies showing that when nibbling animals were made to acquire a gorging diet pattern, concentrations of serum lipids increased as a result of enhanced lipogenesis and synthesis of cholesterol.[1–3] The biological mechanisms that possibly underlie these alterations have been called "adaptive hyperlipogenesis."

Small, time limited trials in humans and some case-control studies also indicated that people who eat frequently tend to have lower concentrations of total cholesterol and low density lipoprotein cholesterol than people who eat a gorging diet.[4–9] Results have been less conclusive with respect to concentrations of high density lipoprotein cholesterol, apolipoproteins, and serum glucose and secretion of insulin.[4 6 10]

An American study involving more than 2000 participants reported that despite an increase in energy intake a higher meal frequency was related to lower concentrations of total cholesterol and low density lipoprotein cholesterol, even after adjustment for confounding variables.[11] Another study found an inverse relation between meal frequency and prevalence of ischaemic heart disease.[12]

Data from free living populations are limited, and it is not clear whether the effects observed in trials pertain only at the extremes of eating frequency or are continuous over the whole distribution of eating frequency. To investigate this we examined the relation between frequency of eating and concentrations of total cholesterol, low density lipoprotein cholesterol, and high density lipoprotein cholesterol in middle aged men and women in a British population based study.

Methods

We used data from the Norfolk cohort of the European prospective investigation into cancer. This is an ongoing prospective cohort of approximately 25 000 people aged 45-75, resident in Norfolk, and recruited from general practice registers between 1993 and 1997. All participants gave informed consent. At the baseline survey participants completed a detailed health and lifestyle questionnaire and participated in a health examination. Details of recruitment and procedures have been published.[13]

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Measurements

Trained nurses carried out a health check by following standardised protocols. Anthropometric measurements were taken with participants wearing light clothes and no shoes or socks. The nurses measured height with a stadiometer to the nearest 0.1 cm after inhalation, with the participant standing as tall and straight as possible with feet together, and recorded weight to the nearest 0.1 kg. They measured circumference with a D loop, non-stretch fibreglass tape after the end of a normal expiration and at the narrowest point—that is, the circumference between the lower rib margin and the iliac crest. If the minimum circumference was not identifiable the nurse measured the waist at the level of the navel. Hip circumference was defined as the widest point, between the iliac crest and the crotch. The nurses recorded both circumferences to the nearest 0.1 cm. Body mass index was calculated as weight in kilograms divided by height in metres squared. Waist to hip ratio was calculated as waist circumference divided by hip circumference.

The nurses measured blood pressure twice in the right arm, with the participant sitting after a three minute rest, by using an Accutorr sphygmomanometer (Datascope, Huntingdon, UK). We used the mean of the two measurements for these analyses.

We obtained non-fasting blood samples by venepuncture. We measured serum concentrations of total cholesterol and high density lipoprotein cholesterol with the RA 1000 Technicon analyser (Bayer Diagnostics, Basingstoke). We calculated the concentration of low density lipoprotein cholesterol by using the Friedewald formula, except when the concentration of triglyceride exceeded 4 mmol/l.[14]

Questionnaires

We assessed frequency of eating by using the question "How many times a day do you eat, including meals, snacks, biscuits with coffee breaks, etc?" We classified participants into five categories of eating frequency: one or two times a day, three times a day, four times a day, five times a day, and six or more times a day.

Participants also completed a 160 item food frequency questionnaire.[15] From this questionnaire we estimated average daily total energy intake as well as consumption of fat; saturated, monounsaturated, and polyunsaturated fatty acids; carbohydrate; protein; and alcohol. Because alcohol intake has a skewed distribution we entered this variable in models as a categorical variable (0, 10-19, 20-29, 30-39, 40-49, 50-59, 60-69, 70-79, 80-89, 90-99, and ≥100 g/day). Other nutrients had a normal distribution.

We classified participants as current smokers or non-current smokers according to the health and lifestyle questionnaire. We assessed physical activity by self reported evaluation of amount of activity involved in

Table 1 Distribution of variables by reported daily eating frequency in men and women aged 45-75, EPIC-Norfolk 1993-7

	Eating frequency (No of times a day)					
	1 or 2	3	4	5	6 or more	P value*
Men	(n=353)	(n=2176)	(n=2525)	(n=1211)	(n=625)	
Measured variables (mean (SD)):						
Age (years)	55.5 (7.8)	58.0 (8.4)	58.0 (8.3)	57.6 (8.5)	57.5 (8.2)	0.2
Body mass index (kg/m^2)	26.6 (3.3)	26.6 (3.2)	26.4 (3.3)	26.0 (3.1)	26.0 (3.2)	<0.001
Waist:hip ratio	0.930 (0.057)	0.930 (0.060)	0.927 (0.060)	0.921 (0.057)	0.920 (0.059)	<0.001
Cholesterol (mmol/l)	6.17 (1.11)	6.10 (1.10)	5.97 (1.04)	6.00 (1.02)	5.88 (1.07)	<0.001
LDL cholesterol (mmol/l)	4.09 (1.03)	4.00 (1.00)	3.91 (0.92)	3.84 (0.94)	3.83 (0.95)	<0.001
HDL cholesterol (mmol/l)	1.26 (0.35)	1.25 (0.34)	1.22 (0.33)	1.22 (0.33)	1.21 (0.31)	<0.001
Systolic blood pressure (mm Hg)	136.3 (17.5)	136.6 (17.4)	135.3 (17.0)	135.0 (16.6)	136.7 (16.4)	0.11
Diastolic blood pressure (mm Hg)	85.1 (11.9)	84.5 (11.3)	83.4 (10.8)	83.3 (10.7)	84.5 (10.4)	0.02
Lifestyle variables (% (No)):						
More than 10 g alcohol intake per day	53.3 (188)	48.0 (1045)	37.7 (952)	34.1 (413)	33.1 (207)	<0.001
Current smokers	24.9 (88)	14.3 (311)	9.7 (245)	7.3 (88)	11.0 (69)	<0.001
Sedentary occupation	42.8 (151)	44.1 (960)	38.7 (977)	34.0 (412)	30.6 (191)	<0.001
Standing occupation	26.3 (93)	23.5 (512)	24.5 (618)	22.9 (277)	25.1 (157)	
Physical work	24.9 (88)	26.8 (583)	28.8 (726)	35.3 (428)	37.0 (231)	
Heavy manual work	5.9 (21)	5.6 (121)	8.1 (204)	7.8 (94)	7.4 (46)	
Women	(n=362)	(n=2182)	(n=2877)	(n=1511)	(n=844)	
Measured variables (mean (SD)):						
Age (years)	55.7 (8.1)	57.3 (8.2)	56.6 (8.2)	55.7 (7.9)	55.2 (7.4)	<0.001
Body mass index (kg/m^2)	25.5 (4.2)	26.1 (4.2)	26.0 (4.1)	25.6 (4.2)	26.0 (4.7)	0.7
Waist:hip ratio	0.792 (0.061)	0.789 (0.061)	0.785 (0.061)	0.781 (0.058)	0.783 (0.064)	<0.001
Cholesterol (mmol/l)	6.24 (1.14)	6.29 (1.17)	6.20 (1.14)	6.08 (1.15)	6.02 (1.11)	<0.001
LDL cholesterol (mmol/l)	3.98 (1.08)	4.00 (1.08)	3.96 (1.06)	3.86 (1.07)	3.81 (1.01)	<0.001
HDL cholesterol (mmol/l)	1.58 (0.43)	1.61 (0.43)	1.56 (0.41)	1.56 (0.42)	1.54 (0.40)	<0.001
Systolic blood pressure (mm Hg)	130.0 (17.3)	132.0 (18.5)	132.0 (17.8)	130.8 (17.9)	131.4 (17.6)	0.81
Diastolic blood pressure (mm Hg)	79.0 (10.5)	80.3 (11.3)	80.3 (10.8)	79.7 (10.4)	80.5 (10.7)	0.43
Lifestyle variables (% (No)):						
More than 10 g alcohol intake per day	28.2 (102)	24.8 (540)	17.4 (499)	14.6 (220)	14.8 (125)	<0.001
Current smokers	30.1 (109)	12.8 (279)	11.2 (322)	8.0 (121)	8.4 (71)	<0.001
Sedentary occupation	34.0 (123)	36.1 (787)	33.7 (969)	32.4 (489)	37.0 (312)	0.1
Standing occupation	43.4 (157)	46.5 (1014)	46.8 (1345)	47.1 (711)	43.4 (366)	
Physical work	22.7 (82)	17.4 (379)	19.5 (561)	20.5 (310)	19.7 (166)	
Heavy manual work	0 (0)	0 (2)	0 (2)	0 (1)	0 (0)	

LDL=low density lipoprotein; HDL=high density lipoprotein.
*P value for linear trend calculated by analysis of variance for continuous variables and χ^2 for categorical variables.

work: sedentary occupation, standing occupation, physical work (handling of heavy objects and use of tools), and heavy manual work.

Statistical analysis

We used data on participants aged 45-75 who had no missing information on eating frequency, physical activity, lipid concentrations, nutrient intake, blood pressure, weight, height, or waist or hip circumference, which resulted in 14 666 participants (6890 men and 7776 women) being included in these analyses. The main reason for exclusion was missing data for physical activity, as many participants did not answer this question. We have more detailed questions on physical activity, but these had not yet been coded and analysed for the whole cohort.

We analysed the data, separately for men and women, by using the SAS software (SAS Institute, Cary, NC). We calculated the distribution of variables according to categories of eating frequency and tested for linear trend by using analysis of variance for continuous variables and χ^2 linear trend for categorical variables. We used analysis of covariance to examine mean lipid concentrations, blood pressure, and anthropometric measurements by categories of eating frequency, adjusting for the effect of age, body mass index, waist to hip ratio, energy intake, physical activity, smoking status, and alcohol intake; we used statistical testing for linear trend. We also used multiple regression to examine the independent relation of eating frequency to lipid concentrations and other cardiovascular risk factors.

Results

Table 1 shows the distribution of variables by category of eating frequency. Mean age did not differ linearly by eating frequency in men but was negatively related to eating frequency in women. Mean body mass index and waist to hip ratio decreased slightly and mean blood pressure increased with increasing reported eating frequency, but trends were not consistent. The percentage of current smokers and the mean alcohol intake were higher in people reporting eating two or fewer times a day. No clear trend for physical activity with eating frequency was observed in women, but men eating more frequently tended to be more likely to participate in physical or heavy manual work.

Mean concentrations of total cholesterol and low density lipoprotein cholesterol decreased with increasing eating frequency in both men and women in a continuous relation. Mean concentration was 0.29 mmol/l lower for total cholesterol and 0.26 mmol/l lower for low density lipoprotein cholesterol in men reporting eating once or twice a day compared with men eating six times or more a day; the differences for mean concentrations of total cholesterol and low density lipoprotein cholesterol in women were 0.22 mmol/l and 0.17 mmol/l. The concentration of high density lipoprotein cholesterol also decreased with increasing eating frequency in both men and women; the overall ratio of low density lipoprotein cholesterol to high density lipoprotein cholesterol decreased with increasing eating frequency.

Increased eating frequency was associated with higher daily intake of energy, as well as of fat, fatty acids, carbohydrate, and protein (table 2).

Table 3 shows mean lipid concentrations and blood pressure in men and women after adjustment for age, body mass index, waist to hip ratio, smoking status, physical activity, total energy intake, and alcohol consumption; the table also shows obesity indices after adjustment for covariates with analysis of covariance. The significant inverse relation of concentrations of total cholesterol and low density lipoprotein cholesterol to eating frequency was still present, but high density lipoprotein cholesterol concentration was no longer significantly inversely related to eating frequency in men.

Body mass index was weakly significantly associated with increasing eating frequency in men and women (after adjustment for all variables except body mass index) but in opposite directions: negatively in men and positively in women. Waist to hip ratio was still significantly negatively associated with eating

Table 2 Distribution of daily nutrient intake estimated with food frequency questionnaire by reported daily eating frequency in men and women aged 45-75, EPIC-Norfolk 1993-7. Values are mean (SD) unless otherwise stated

	Eating frequency (No of times a day)					
	1 or 2	3	4	5	6 or more	P value*
Men	(n=353)	(n=2176)	(n=2525)	(n=1211)	(n=625)	
Energy (kjoule/day)	8225 (2602)	8482 (2316)	9342 (2579)	9972 (2684)	10 639 (2 899)	<0.001
Fat (g/day)	73.2 (30.6)	75.1 (28.0)	85.0 (31.0)	91.4 (31.9)	100.0 (35.4)	<0.001
Saturated fatty acids (g/day)	28.6 (13.3)	29.0 (12.7)	33.0 (13.7)	35.0 (13.8)	39.0 (15.9)	<0.001
Monounsaturated fatty acids (g/day)	25.9 (11.5)	26.4 (10.5)	30.0 (11.6)	32.3 (12.1)	35.6 (13.4)	<0.001
Polyunsaturated fatty acids (g/day)	12.4 (6.1)	13.2 (6.0)	15.0 (6.9)	16.4 (7.2)	17.5 (7.9)	<0.001
Polyunsaturated:saturated ratio	0.47 (0.20)	0.50 (0.23)	0.50 (0.23)	0.50 (0.21)	0.49 (0.22)	<0.001
Protein (g/day)	77.2 (23.3)	82.0 (21.5)	86.3 (21.4)	88.5 (21.2)	92.2 (22.2)	<0.001
Carbohydrate (g/day)	224.8 (84.2)	241.1 (73.8)	275.6 (83.4)	299.4 (88.8)	319.1 (96.1)	<0.001
Women	(n=362)	(n=2182)	(n=2877)	(n=1511)	(n=844)	
Energy (kjoule/day)	7577 (2390)	7474 (2017)	8054 (2210)	8594 (2222)	9 262 (2 520)	<0.001
Fat (g/day)	68.1 (28.6)	64.1 (24.2)	70.6 (26.4)	75.9 (27.0)	83.1 (29.8)	<0.001
Saturated fatty acids (g/day)	26.1 (12.4)	24.2 (11.0)	27.0 (11.5)	28.6 (12.0)	31.1 (12.6)	<0.001
Monounsaturated fatty acids (g/day)	23.6 (11.2)	22.0 (8.9)	24.2 (9.7)	26.3 (10.1)	28.7 (11.1)	<0.001
Polyunsaturated fatty acids (g/day)	12.0 (5.6)	11.5 (5.2)	12.8 (6.0)	13.6 (6.0)	15.2 (7.0)	<0.001
Polyunsaturated:saturated ratio	0.50 (0.20)	0.52 (0.22)	0.52 (0.22)	0.52 (0.22)	0.53 (0.22)	<0.001
Protein (g/day)	75.8 (20.8)	78.2 (19.3)	81.8 (20.3)	84.2 (20.3)	88.3 (22.5)	<0.001
Carbohydrate (g/day)	221.0 (80.7)	222.2 (67.0)	243.0 (72.8)	263.2 (73.5)	285.0 (83.8)	<0.001

*P value for linear trend using analysis of variance.

Table 3 Mean values for cardiovascular risk factors adjusted for age, obesity, cigarette smoking, physical activity, alcohol intake, and caloric intake with analysis of variance by reported daily eating frequency in men and women aged 45-75, EPIC-Norfolk 1993-7

	Eating frequency (No of times a day)					
	1 or 2	3	4	5	6 or more	P value*
Men	(n=353)	(n=2176)	(n=2525)	(n=1211)	(n=625)	
Cholesterol (mmol/l)	6.11	6.06	5.98	5.94	5.94	<0.01
LDL cholesterol (mmol/l)	4.06	3.98	3.91	3.86	3.86	<0.001
HDL cholesterol (mmol/l)	1.24	1.24	1.23	1.22	1.22	0.42
Body mass index (kg/m^2)*	26.2	26.5	26.4	26.1	26.1	0.02
Waist:hip ratio†	0.93	0.926	0.925	0.928	0.925	0.67
Systolic blood pressure (mm Hg)	136.0	136.1	135.3	135.8	137.7	0.01
Diastolic blood pressure (mm Hg)	84.3	84.0	83.4	83.8	85.2	<0.01
Women	(n=362)	(n=2182)	(n=2877)	(n=1511)	(n=844)	
Cholesterol (mmol/l)	6.26	6.25	6.19	6.12	6.08	<0.001
LDL cholesterol (mmol/l)	4.00	3.97	3.95	3.90	3.85	0.02
HDL cholesterol (mmol/l)	1.57	1.60	1.56	1.55	1.56	<0.01
Body mass index (kg/m^2)*	25.5	25.9	26.0	25.8	26.1	0.03
Waist:hip ratio†	0.793	0.787	0.784	0.784	0.784	0.03
Systolic blood pressure (mm Hg)	130.6	131.3	131.8	131.6	132.1	0.48
Diastolic blood pressure (mm Hg)	79.3	80.0	80.2	80.1	80.6	0.29

LDL=low density lipoprotein; HDL=high density lipoprotein.
*Adjusted for all variables except body mass index.
†Adjusted for all variables except waist:hip ratio.

frequency only in women (after adjustment for all variables except waist to hip ratio). Blood pressure was not significantly related to eating frequency in women but was positively associated in men.

We undertook multiple regression analyses of lipid concentrations on eating frequency after adjustment firstly for age, body mass index, waist to hip ratio, smoking status, physical activity, total energy intake, and alcohol consumption and secondly for these variables and for specific nutrients (fat, carbohydrate, and protein). Findings were similar, and table 4 shows regression coefficients after adjustment for covariates including specific nutrients. Concentrations of total cholesterol and low density lipoprotein cholesterol remained inversely and significantly associated with daily eating frequency. High density lipoprotein cholesterol concentration was negatively associated with eating frequency only in women. Body mass index was negatively associated in men but not in women; waist to hip ratio was negatively associated in women but not in men. Blood pressure was not independently related to eating frequency in either sex after adjustment for possible confounding factors.

Table 4 Multivariate regression of risk factors on eating frequency in men and women aged 45-75, EPIC-Norfolk 1993-7, adjusted for age, obesity, cigarette smoking, physical activity, and intake of calories, alcohol, fat, protein, and carbohydrate

	Men		Women	
	β coefficient (SE)	P value	β coefficient (SE)	P value
Total cholesterol (mmol/l)	−0.046 (0.013)	<0.001	−0.055 (0.012)	<0.001
LDL cholesterol (mmol/l)	−0.048 (0.012)	<0.001	−0.039 (0.011)	<0.001
HDL cholesterol (mmol/l)	−0.004 (0.004)	0.28	−0.012 (0.004)	<0.01
Body mass index (kg/m^2)*	−0.079 (0.033)	0.02	0.047 (0.043)	0.27
Waist:hip ratio†	−0.001 (0.001)	0.42	−0.001 (0.001)	0.02
Systolic blood pressure (mm Hg)	0.274 (0.199)	0.17	0.233 (0.183)	0.2
Diastolic blood pressure (mm Hg)	0.142 (0.132)	0.28	0.168 (0.116)	0.15

β Coefficient represents the change in risk factor in units indicated per unit increase in daily eating frequency in the range 2 to 6 or more times daily after adjusting for age, obesity, cigarette smoking status, physical activity, and intake of calories, alcohol, fat, protein, and carbohydrates.
LDL=low density lipoprotein; HDL=high density lipoprotein.
*Adjusted for all variables except body mass index.
†Adjusted for all variables except waist:hip ratio.

We also compared the findings for ages 45-59 and 60-75 years separately. The regression slope for total cholesterol adjusted for age, sex, and covariates for each increase in eating frequency was −0.055 (SE 0.011, $P<0.001$) for participants aged 45-59 years and −0.041 (0.019, $P=0.003$) for those aged 60-75 years.

Discussion

In this free living British population, increased daily frequency of eating was inversely and significantly associated with lower concentrations of total cholesterol and low density lipoprotein cholesterol.

The fact that such an effect could be shown in this study is surprising, given the large potential errors in measurement. These include the single measurement of lipid concentrations to characterise individual participants as well as the assessment of eating frequency. Different participants might well interpret the question differently or report their usual eating frequency inaccurately; each person's eating pattern will also vary. Such random measurement errors are likely to obscure or minimise the effect size of any association.

Potential confounding factors

The inverse relation between blood lipid concentrations and eating frequency might be explained by confounding factors—that is, frequency of eating might simply be a marker of particular lifestyle factors, such as physical activity or alcohol intake, that may directly influence lipid concentrations. However, the relation persisted after adjustment for possible confounding variables including age, obesity, smoking, alcohol consumption, dietary intake, and physical activity. In contrast, blood pressure was not consistently inversely related to eating frequency. We cannot exclude residual confounding, but the specificity of the independent association of eating frequency with lipid concentrations but not with blood pressure makes it unlikely that higher eating frequency was simply a marker for a healthy lifestyle. The association was also consistent in men and women and in different age groups.

In addition, this finding is consistent with observational studies and controlled intervention studies on metabolic wards, which show a strong and independent relation between lipid concentrations and frequency of eating.[4-8 11] Our data show a decrease of approximately 5% in concentrations of total cholesterol and low density lipoprotein cholesterol in men and women who eat six or more times a day compared with those who eat once or twice a day. This finding was particularly striking in view of the increased energy intake, including fat intake, in people who reported eating more frequently.

Possible mechanisms

Several authors have proposed biological mechanisms that might underlie the lipid lowering effect of increased eating frequency. Fábry and Tepperman suggested that gorging animals have an adaptive metabolism—they are able to store energy from a few periodic loads of food, in contrast to nibbling animals, which feed continuously and have a steady metabolism.[1] This biological process, called "adaptive hyperlipogenesis," is characterised by higher gastrointestinal absorption of glucose and increased activity of pancreatic enzymes; increased ability to produce fat from glucose (that is, an enhanced hepatic lipogenesis possibly mediated by insulin action); increased hepatic synthesis of cholesterol; increased total mass of fat; and higher postprandial peaks of insulin and increased sensitivity to insulin in fat tissue. The increase in serum cholesterol concentration can be explained by the activation by insulin of hydroxymethyl glutaryl coenzyme A reductase, an enzyme involved in hepatic synthesis of cholesterol.[4] Other enzymes involved in hepatic lipogenesis, such as glucose-6-phosphate dehydrogenase and 6-phosphogluconate dehydrogenase, also seem to have enhanced activity in gorging animals.[7]

Implications of the findings

These metabolic adaptations to gorging may also apply in humans, leading to an increased risk of cardiovascular disease due to changes in lipid profiles and glucose metabolism. Fábry reported 30.4%, 24.2%, and 19.9% prevalence of ischaemic heart disease in men aged 60-64 years reporting eating ≤3, 3-4, or ≥5 meals or snacks daily.[12]

The magnitude of effect in our study was a difference of approximately 0.25 mmol/l in cholesterol concentration (0.15 mmol/l after multivariate adjustment) between people eating six or more times daily and those eating once or twice daily. Although not large, this difference in cholesterol concentration is comparable to that achieved in metabolic studies involving alteration of intake of dietary fat or cholesterol,[16] as well as in the controlled trials of eating frequency.[4] This difference in cholesterol concentration is also associated in observational studies and trials with reductions in coronary heart disease ranging from 10% to 21%.[17,18] If applied population-wide, such reductions might have a substantial impact, particularly in older people, who have higher absolute rates of heart disease.

The relation between eating frequency and lipid concentrations may differ in populations that have different nutritional patterns, lipid profiles, or both. This study was conducted in an older cohort with relative high average cholesterol concentrations (around 6.1 mmol/l). Nevertheless, the people in the Norfolk cohort have cholesterol concentrations similar to or slightly lower than those reported for national British samples, which are about 6.4-6.8 mmol/l in this age group.[13,19]

Conclusions

The results from this study support findings from short term experiments that concentrations of total cholesterol and low density lipoprotein cholesterol are inversely related to eating frequency in a free living general population, independently of energy intake, physical activity, or other known confounding factors. We need to consider not just what we eat but how often we eat.

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Contributors: K-TK, ND, and SB originated and designed the EPIC-Norfolk population study. SO is study coordinator and organised data collection, including quality control of blood samples and measurement procedures. SB and AW carried out the nutritional analyses. RL was responsible for data management and computing overall and assisted with analyses. SMOT conducted the data analyses and wrote the paper with K-TK. K-TK is guarantor for this paper.

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Competing interests: None declared.

What is already known on this topic

Studies in animals and small human trials indicate that eating frequency is inversely related to serum lipid concentrations

Few studies have examined this in a free living population under no dietary restrictions

What this study adds

In a free living population increased eating frequency was negatively and significantly associated with concentrations of total cholesterol and low density lipoprotein cholesterol

This association was still present after adjustment for body mass index, physical activity, cigarette smoking, and dietary intake

Mean age adjusted cholesterol concentrations differed by 0.25 mmol/l between people eating more than six times a day and those eating less than twice daily

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