Brief Report

Energy intake at breakfast and weight change: prospective study of 6,764 middle-aged men and women

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Word count

Abstract	200	Main text	1996

Abstract

To investigate the association between percentage of total daily energy intake consumed at breakfast and weight change in middle-aged men and women, we analysed data from a prospective population-based cohort study from Norfolk, UK. Participants were 6,764 men and women, aged 40-75 years at baseline (1993-1997). Participants completed a seven day food diary at baseline and objective measures of height and weight were carried out at

baseline and follow up (1998–2000). Mean baseline BMI was lowest in individuals in the highest quintile of percentage of daily energy consumed at breakfast (mean 26.0 kg/m^2 highest quintile and 26.3 kg/m^2 lowest quintile) despite higher daily total energy intake in this group. Although all individuals gained weight, increased percentage of daily energy consumed at breakfast was associated with relatively lower weight gain (adjusted β coefficient = -0.021; 95% CI -0.035, -0.007; p = 0.004). The association between percentage of daily energy intake consumed at breakfast and weight gain was independent of age, sex, smoking, total energy intake, macronutrient intake, social class and physical activity. Redistribution of daily energy intake, so that more energy is consumed at breakfast and less later in the day, may help to reduce weight gain in middle-aged adults.

Prospective studies, Obesity, Weight Gain, Feeding behaviour

The proportion of people regularly consuming breakfast is in decline (1, 2) and skipping breakfast is associated with other lifestyle choices such as low levels of physical activity and high levels of soft drink consumption. (2) Obesity and weight gain are associated with low socioeconomic position (3) and skipping breakfast is more common in children and adolescents of low socioeconomic position. (2) Compared to lean women, obese women consume fewer calories in the morning. (4) By contrast, regular breakfast consumption is associated with successful weight loss maintenance (5), suggesting that consuming fewer calories in the morning or skipping breakfast could contribute to the development of obesity.

A cross-sectional association between skipping breakfast and obesity has been shown in adults. (6, 7) Regular consumption of breakfast cereal is associated with lower body mass index (BMI) in adults (8) and children (9) and greater energy intake at breakfast is associated with lower BMI in adolescents. (10) A large prospective study in men showed a decreased risk of weight gain in regular consumers of breakfast cereals. (11) However, this study did not assess the time of day when cereal was eaten, and therefore does not provide direct evidence of an association between breakfast consumption and weight change. Currently the prospective association between energy intake at breakfast and weight change in adults is not known. We therefore investigated the association

between percentage of total daily energy intake consumed at breakfast and weight change in a prospective population based cohort of middle-aged men and women.

MATERIALS AND METHODS

We used data from the European Prospective Investigation into Cancer and Nutrition (EPIC) Norfolk cohort. The study was approved by the Norfolk Health District Ethics Committee and full details of participant recruitment and study procedures have been published previously. (12) Briefly, recruitment started in March 1993 and was completed by the end of 1997 when 25,631 individuals had attended a baseline health check. Between 1998 and 2000 15,028 individuals completed a follow up health check. Of these participants, 13,705 (91%) had a measure of weight change and did not report a stroke, cancer or heart attack at baseline. A further 6,941 participants were excluded because they did not have complete food diary data. This exclusion left 6,764 participants for analysis. Compared with individuals with no diary information, there was no difference in subsequent weight change in participants included in the analysis ($P > 0.05$), indicating that our analytical cohort is unlikely to be a biased subset of the eligible cohort.

At both health checks height and weight were measured (13) and BMI was calculated as weight (kg)/height^2 (m). All participants completed a health and lifestyle questionnaire. Smoking was coded as never, former or current. Information on occupational and leisure-time physical activity was assembled into a previously validated four-point physical activity index (correlation with objectively measured daytime energy expenditure r=0.28, p <0.001). (14) The Registrar General's occupational classification was used to assess social class and was coded as I professional; II intermediate; IIIa skilled non-manual IIIb skilled manual; IV semi-skilled; and V unskilled.(15, 16)

At baseline dietary intake was assessed by a validated seven day food diary (correlation coefficients compared to 16 day weighed records: energy 0.59, fat 0.63, protein 0.66, carbohydrate 0.71). (17) Portion sizes were indicated using convenient household measures such as tablespoons, bowls, glasses, numbers, units, slices or packet weights or by reference to 17 sets of colour photographs.(18) Data were entered using an in-house program DINER (Data into nutrients for epidemiological research).(19) Total daily energy intake and energy intake during specified periods (pre breakfast, breakfast, mid morning, lunch, mid afternoon, evening and late evening) were calculated by dividing the total energy intake in each time period by the number of days included in the

diet diary. The mean percentage of total daily energy intake consumed in each period was calculated by dividing the energy consumed in each period by the total daily energy intake. Energy intake pre breakfast and at breakfast were combined to give total breakfast energy intake (% TEI at breakfast). Energy intake in the evening and late evening were combined to give total evening energy intake. Energy intakes mid morning and mid afternoon were combined to give between-meal energy intake.

All analyses were carried out using STATA version 8 (Stata Corporation, College Station, Texas). All primary analyses were done using %TEI at breakfast as a continuous variable. However, for ease of data interpretation, we have presented some information by quintiles of %TEI at breakfast. We used linear regression to assess the relation between %TEI at breakfast, baseline BMI and weight change over the follow up. We examined whether the association between %TEI at breakfast and BMI was confounded by age, sex, baseline BMI, smoking, physical activity level, fruit and vegetable intake, plasma vitamin C level, follow up time and social class. We have previously shown that plasma vitamin C levels in this cohort positively correlate with fruit and vegetable intake;(20) we therefore used this biomarker as an additional and indicative measure of fruit and vegetable intake as skipping breakfast has been previously associated with low levels of fruit and vegetable

intake.(2) In an exploratory analysis, we also added daily fat, carbohydrate and protein intake, alcohol consumption, meal frequency and %TEI between meals as potential confounding variables to this multivariable model.

In additional exploratory analyses, we assessed whether any association between %TEI at breakfast and baseline BMI was modified by sex (7) or social class.(2) For the prospective analysis, we examined whether sex, social class or BMI at baseline modified any association between %TEI at breakfast and subsequent weight change. Finally, we assessed whether any associations between %TEI at breakfast, BMI and weight change were mediated by percentage of total daily energy intake consumed in the evening.

RESULTS

Complete data were available for 6,764 individuals. The percentage of total energy intake consumed at breakfast ranged from 0 to 50%. Compared with the lowest quintile of %TEI at breakfast, mean BMI was lowest in individuals in the highest quintile of %TEI at breakfast (Table 1) in men and women (p for trend =0.018). Total energy intake was greatest in the highest quintile of %TEI at breakfast (p for trend <0.001). Individuals in the highest quintile of %TEI at breakfast were older (p for trend <0.001) and of higher

socioeconomic position (p for χ2 test for heterogeneity <0.001). We found no evidence for a statistically significant interaction between %TEI at breakfast and sex, and %TEI at breakfast and social class (p for both interactions >0.1), with BMI at baseline (data not shown).

All participants gained weight on average over the follow up period (Table 1). However, we found that weight change was inversely associated with %TEI at breakfast. In the unadjusted model, a 1% increase in %TEI at breakfast was associated with a relatively lower weight gain of -0.032 kg (Table 2). Thus individuals who consumed a greater proportion of their daily calories at breakfast gained relatively less weight. This inverse association remained statistically significant after adjusting for age and sex, and other confounders (Table 2). In an exploratory analysis, further adjustment for daily fat, carbohydrate and protein intake, alcohol consumption, meal frequency and energy intake between meals did not materially alter this association (data not shown). Results stratified by sex, social class and by baseline BMI were similar to the unstratified results presented (all P for interactions > 0.4).

Percentage of total energy intake at breakfast was inversely correlated with percentage of total daily energy intake in the evening (r=-0.39; p<0.001). However, although additional

adjustment for percentage of total energy intake consumed in the evening marginally attenuated the association between %TEI at breakfast and weight change (β=-0.017; 95% CI -0.032, -0.001; p=0.033), it did not explain this association.

DISCUSSION

In our study, all participants gained weight on average over the follow up period; however, our data indicate that consuming a higher proportion of total daily calories at breakfast is associated with relatively lower weight gain in middle age. This association is independent of total daily energy intake and does not appear to be mediated by a corresponding reduction in the percentage of total daily energy intake consumed in the evening. However, the association could be accounted for by other unknown confounders.

Although total energy intake was greatest in individuals in the highest quintile of %TEI at breakfast, BMI and weight change were lowest in this group. Previous cross-sectional studies have shown similar associations among individuals who consumed breakfast compared to those who did not. (2, 6, 7, 21) However, to our knowledge, no other epidemiological studies have specifically assessed the prospective relation between %TEI at breakfast and weight gain. Thus we cannot make any direct comparison of our

results with others. Nevertheless, one prospective study has shown a reduced risk of weight gain in regular consumers of breakfast cereals. (11) Specifically, this study showed that individuals consuming whole grain cereals at least once a day gained less weight than those who never consumed whole grain cereals (2.28 kg $\pm$ 0.06 compared with 1.87 kg $\pm$ 0.12 kg; p for trend < 0.05). Studies have also shown that energy intake in the evening was positively related to change in BMI in adults (10) and adolescents. (22) In our study, although %TEI at breakfast was inversely correlated with %TEI in the evening, our results indicate that the association between %TEI at breakfast and weight change is not explained by a corresponding decrease in %TEI in the evening.

Skipping breakfast is associated with low levels of physical activity and fruit and vegetable intake, and increased levels of dietary fat and soft drink consumption. (2, 6, 21) These correlated factors, which are also risk factors for obesity, might explain the association between increased energy intake at breakfast and weight change. However, statistical adjustment for physical activity, fruit and vegetable intake, plasma vitamin C, fat, carbohydrate, protein or social class did not materially alter the magnitude or direction of the association between %TEI at breakfast and weight change. This observation suggests that these factors are unlikely to confound the association. Yet, because of random measurement error, we cannot

exclude the possibility of residual confounding by these or other unmeasured variables. Examination of the relation between energy intake at breakfast and weight change in other populations will help clarify the broader relevance of this association.

Two intervention studies have shown that weight loss was greater when a single meal was ingested at breakfast compared with the equivalent meal consumed in the evening. (23, 24) Similarly, a six week weight loss study also showed greater weight loss with large morning meals compared to large evening meals. (25) A potential mechanism underlying the inverse association between %TEI at breakfast and weight change is the lipogenic action of insulin. Increased blood levels of insulin will promote lipogensis and studies have shown that breakfast skipping, and prolonged fasting, lead to an elevated insulin response following a test meal. (26-28) Relatively higher circulating levels of insulin in response to food consumption may increase lipogenesis. Therefore an increased insulin response following prolonged fasting, such as skipping breakfast, may lead to increased fat storage and weight gain.

Major strengths of our study include the longitudinal design, repeated objective measures of weight and the use of prospective seven day food diaries. As a limitation, all dietary recording methods, including diet diaries, tend to under report actual intake

and greater under reporting of dietary intake by obese individuals is well established. (29) However, in the context of systematic error, differential reporting of dietary intake by meal time is unlikely and therefore we would not expect the association between %TEI at breakfast and weight change to be biased.

In conclusion, in this prospective study in 6,764 middle-aged men and women, we found an inverse association between percentage of total daily energy intake at breakfast and weight change. From a public health perspective, redistribution of daily energy intake, so that a larger percentage is consumed at breakfast and a lower percentage over the rest of the day, may help reduce weight gain.

Acknowledgements

The European Prospective Investigation into Cancer and Nutrition-Norfolk cohort study is supported by research program funding from Cancer Research UK and the Medical Research Council with additional grants from the Stroke Association, the British Heart Foundation, the Department of Health, the Europe against Cancer Program Commission of the European Union, the Food Standards Agency, and the Wellcome Trust.

REFERENCES

Table 1: Characteristics of 6,764 men and women in the EPIC-Norfolk cohort from 1993 – 1997 by quintiles of percentage of total daily energy intake consumed at breakfast

Quintiles of percentage total daily intake at breakfast	1	2	3	4	5	P value*
Baseline data						
Range of total daily intake at breakfast (%)	0 - 11	12 – 14	15 – 17	18 - 21	22 - 50	
N Men:Women	636 : 717	573 : 780	619 : 734	648 : 705	781 : 571	<0.001†
Age (years)	59.1 (0.23)	60.4 (0.23)	61.3 (0.24)	62.2 (0.23)	62.7 (0.23)	<0.001
Weight (kg)	73.8 (0.35)	73.0 (0.34)	73.3 (0.35)	73.6 (0.34)	73.9 (0.35)	0.403
BMI (kg/m^2)	26.3 (0.10)	26.3 (0.10)	26.2 (0.10)	26.3 (0.10)	26.0 (0.10)	0.018
Follow up time (years)	3.7 (0.02)	3.7 (0.02)	3.7 (0.02)	3.7 (0.02)	3.7 (0.02)	0.316
Total energy intake (kj/ day)	8158 (60)	8125 (53)	8204 (57)	8314 (56)	8506 (59)	<0.001
Fruit and vegetable intake (g/day)	239 (4.3)	258 (4.1)	266 (4.1)	254 (3.7)	274 (4.4)	<0.001
Plasma vitamin C (umol/l)	53.2 (0.53)	55.1 (0.52)	55.8 (0.54)	54.9 (0.52)	54.5 (0.55)	0.109
Smoking N (%)‡						
Current	190 (14)	113 (8)	82 (6)	102 (8)	97 (7)	
Former	553 (41)	571 (42)	600 (44)	592 (44)	593 (44)	<0.001†
Never	610 (45)	669 (49)	671 (50)	659 (49)	662 (49)	

Physical activity N (%)[‡]						
Inactive	377 (28)	386 (29)	381 (28)	370 (27)	402 (30)	
Moderately inactive	368 (27)	366 (27)	385 (28)	436 (32)	376 (28)	0.129[†]
Moderately active	345 (26)	339 (25)	331 (24)	285 (21)	312 (23)	
Active	263 (19)	262 (19)	256 (19)	262 (19)	262 (19)	
Social class N (%)[‡]						
I	83 (6)	87 (6)	91 (7)	111 (8)	121 (9)	
II	466 (34)	525 (39)	555 (41)	528 (39)	557 (41)	
IIIa	214 (16)	231 (17)	242 (18)	233 (17)	221 (16)	<0.001[†]
IIIb	358 (26)	291 (22)	265 (20)	269 (20)	246 (18)	
IV & V	232 (17)	219 (16)	200 (15)	212 (16)	207 (15)	
Follow up data						
Average weight change (kg)	1.23 (0.12)	1.17 (0.10)	1.19 (0.11)	1.02 (0.11)	0.79 (0.11)	<0.001[†]

All values are means and standard errors unless otherwise stated
[*] %TEI at breakfast is treated as a continuous variable to calculate p for linear trend
[†] P value for χ^2 test for heterogeneity
[‡] Some totals may not equal 100% due to rounding

Table 2: Association between %TEI at breakfast and weight change over follow up (n = 6764)

	Weight change over follow up (kg)		
	Unadjusted	**Adjusted***	**Fully Adjusted†**
β coefficient	-0.032	-0.021	-0.021
95% CI	-0.046 -0.018	-0.035 -0.007	-0.035 -0.007
P for trend	<0.001	0.003	0.004

* Adjusted for age and sex

† Adjusted for TEI, age, sex, baseline BMI, smoking, PA level, fruit and vegetable intake, plasma vitamin C, follow up time, and social class