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Original Contribution

Energy Intake at Breakfast and Weight Change: Prospective Study of 6,764 Middle-aged Men and Women

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To investigate the association between percentage of total daily energy intake consumed at breakfast and weight change in middle-aged men and women, the authors analyzed data from a prospective population-based cohort study from Norfolk, United Kingdom. Participants were 6,764 men and women aged 40–75 years at baseline (1993–1997). Participants completed a 7-day food diary at baseline, and objective measurements of height and weight were carried out at baseline and follow-up (1998–2000). Mean baseline body mass index (weight (kg)/height (m)^2) was lowest among persons in the highest quintile of percentage of daily energy consumed at breakfast (mean values were 26.0 in the highest quintile and 26.3 in the lowest quintile), despite higher daily total energy intake in this group. Although all participants gained weight, increased percentage of daily energy consumed at breakfast was associated with relatively lower weight gain (adjusted β coefficient = −0.021, 95% confidence interval: −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 energy is consumed later in the day, may help to reduce weight gain in middle-aged adults.

body mass index; diet; feeding behavior; food; obesity; prospective studies; weight gain

Abbreviations: BMI, body mass index; %TEI, percentage of total energy intake.

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 among children and adolescents of low socioeconomic position (2). Compared with lean women, obese women consume fewer calories in the morning (4). By contrast, regular breakfast consumption is associated with successful maintenance of weight loss (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

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adolescents (10). A large prospective study conducted in men showed a decreased risk of weight gain among regular consumers of breakfast cereal (11). However, this study did not assess the time of day when cereal was eaten and therefore did 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. Therefore, we investigated the association between percentage of total daily energy intake consumed at breakfast and weight change in a prospective population-based cohort study of middle-aged men and women.

MATERIALS AND METHODS

We used data from the European Prospective Investigation into Cancer and Nutrition–Norfolk cohort. The study was approved by the Norfolk, United Kingdom, Health District Ethics Committee, and full details on 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 persons attended a baseline health check. Between 1998 and 2000, 15,028 persons aged 40–75 years at baseline completed a follow-up health check. Of these participants, 13,705 (91 percent) had a measure of weight change and did not report a stroke, cancer, or heart attack at baseline. Some participants ($n = 6{,}941$) were excluded because they did not have complete food diary data. This exclusion left 6,764 participants for analysis. Compared with persons with no diary information, there was no difference in subsequent weight change among participants included in the analysis ($p > 0.05$), indicating that our analytical cohort was 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^2). All participants completed a health and lifestyle questionnaire. Smoking was coded as never, former, or current smoking. 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, which was coded as I (professional), II (intermediate), IIIa (skilled nonmanual), IIIb (skilled manual), IV (semiskilled), or V (unskilled) (15, 16).

At baseline, dietary intake was assessed by means of a validated 7-day food diary (correlation coefficients for comparison with 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 color photographs (18). Data were entered using the in-house data entry program DINER (19). Total daily energy intake and energy intake during specified periods (prebreakfast, breakfast, midmorning, lunch, midafternoon, 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 intakes before breakfast and at breakfast were combined to obtain total breakfast energy intake. Energy intakes in the evening and late evening were combined to obtain total evening energy intake. Energy intakes midmorning and midafternoon were combined to obtain between-meal energy intake.

All analyses were carried out using STATA, version 8 (Stata Corporation, College Station, Texas). All primary analyses were conducted using percentage of total energy intake (%TEI) consumed at breakfast as a continuous variable. However, for ease of data interpretation, we have presented some information by quintile of %TEI at breakfast. We used linear regression to assess the relation between %TEI at breakfast, baseline BMI, and weight change over the course of 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 are positively correlated with fruit and vegetable intake (20); therefore, we used this biomarker as an additional measure that was indicative of fruit and vegetable intake, since skipping breakfast has been previously associated with low 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 potentially 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 %TEI consumed in the evening.

RESULTS

Complete data were available for 6,764 persons. %TEI consumed at breakfast ranged from 0 percent to 50 percent. Compared with the lowest quintile of %TEI at breakfast, mean BMI was lowest in persons in the highest quintile of %TEI at breakfast (p for trend $= 0.018$) (table 1). Total energy intake was greatest in the highest quintile of %TEI at breakfast (p for trend < 0.001). Persons in the highest quintile of %TEI at breakfast were older (p for trend $<$ 0.001) and of higher socioeconomic position (χ^2 test for heterogeneity: $p < 0.001$). We found no evidence for a statistically significant interaction with sex or social class (for both interactions, $p > 0.1$) in the relation between %TEI at breakfast and BMI at baseline (data not shown).

On average, all participants gained weight over the follow-up period (table 1). However, we found that weight

TABLE 1. Characteristics of participants by quintile of percentage of total daily energy intake consumed at breakfast ($n = 6{,}764$), European Prospective Investigation into Cancer and Nutrition–Norfolk, 1993–1997

	Quintile of % of total daily energy intake consumed at breakfast										*p* value*
	1 (0–11%)		2 (12–14%)		3 (15–17%)		4 (18–21%)		5 (22–50%)		
	Baseline data (1993–1997)										
	Mean (SE†)		Mean (SE)		Mean (SE)		Mean (SE)		Mean (SE)		
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
Body mass index‡	26.3 (0.10)		26.3 (0.10)		26.2 (0.10)		26.3 (0.10)		26.0 (0.10)		0.018
Total energy intake (KJ/day)	8,158 (60)		8,125 (53)		8,204 (57)		8,314 (56)		8,506 (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 level (μmol/liter)	53.2 (0.53)		55.1 (0.52)		55.8 (0.54)		54.9 (0.52)		54.5 (0.55)		0.109
	No.	%	No.	%	No.	%	No.	%	No.	%	
Ratio of men:women	636:717		573:780		619:734		648:705		781:571		<0.001§
Smoking¶											
Current smoker	190	14	113	8	82	6	102	8	97	7	<0.001§
Former smoker	553	41	571	42	600	44	592	44	593	44	
Never smoker	610	45	669	49	671	50	659	49	662	49	
Physical activity¶											
Inactive	377	28	386	29	381	28	370	27	402	30	0.129§
Moderately inactive	368	27	366	27	385	28	436	32	376	28	
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¶,#											
I	83	6	87	6	91	7	111	8	121	9	<0.001§
II	466	34	525	39	555	41	528	39	557	41	
IIIa	214	16	231	17	242	18	233	17	221	16	
IIIb	358	26	291	22	265	20	269	20	246	18	
IV and V	232	17	219	16	200	15	212	16	207	15	
	Follow-up data (1998–2000)										
	Mean (SE)		Mean (SE)		Mean (SE)		Mean (SE)		Mean (SE)		
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
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§

* Percentage of total energy intake consumed at breakfast was treated as a continuous variable for calculation of *p* for linear trend.
† SE, standard error.
‡ Weight (kg)/height (m)^2.
§ *p* value from χ^2 test for heterogeneity.
¶ Some percentages may not sum to 100 because of rounding.
\# Social class was coded as I (professional), II (intermediate), IIIa (skilled nonmanual), IIIb (skilled manual), IV (semiskilled), or V (unskilled) (15, 16).

change was inversely associated with %TEI consumed at breakfast. In the unadjusted model, a 1-percentage-point increase in %TEI at breakfast was associated with a relatively lower weight gain of −0.032 kg (table 2). Thus, persons who consumed a greater proportion of their daily calories at breakfast gained relatively less weight. This inverse association remained statistically significant after adjustment 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 baseline BMI were similar to the unstratified results presented (for interactions, all p's > 0.4).

%TEI consumed at breakfast was inversely correlated with %TEI consumed in the evening ($r = -0.39$; $p < 0.001$). However, although additional adjustment for %TEI in the evening marginally attenuated the association between %TEI at breakfast and weight change ($\beta = -0.017$, 95 percent confidence interval: −0.032, −0.001; $p = 0.033$), it did not explain this association.

TABLE 2. Association between percentage of total daily energy intake consumed at breakfast (per 1-percentage-point increase) and weight gain over the course of follow-up (*n* = 6,764), European Prospective Investigation into Cancer and Nutrition–Norfolk, 1993–1997

Model	Weight gain (kg) over follow-up	95% confidence interval	*p* for trend
Unadjusted	−0.032	−0.046, −0.018	<0.001
Adjusted*	−0.021	−0.035, −0.007	0.003
Fully adjusted†	−0.021	−0.035, −0.007	0.004

* Adjusted for age and sex.

† Adjusted for total energy intake, age, sex, baseline body mass index, smoking, physical activity level, fruit and vegetable intake, plasma vitamin C level, follow-up time, and social class.

DISCUSSION

In our study, all participants gained weight over the follow-up period, on average; 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 was independent of total daily energy intake and did not appear to be mediated by a corresponding reduction in %TEI consumed in the evening. However, the association could be accounted for by other, unknown confounders.

Although total energy intake was greatest in persons 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 persons who regularly ate breakfast as compared with those who did not (2, 6, 7, 21). However, to our knowledge, no other epidemiologic 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 those of other studies. Nevertheless, one prospective study has shown a reduced risk of weight gain among regular consumers of breakfast cereal (11). Specifically, that study showed that persons consuming whole-grain cereals at least once a day gained less weight than those who never consumed whole-grain cereals (mean weight gain of 2.28 kg (standard error, 0.06) as compared with 1.87 kg (standard error, 0.12); 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 indicated that the association between %TEI at breakfast and weight change was 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 level, fat, carbohydrate, and protein intakes, and 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 to 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 than when an equivalent meal was consumed in the evening (23, 24). Similarly, a 6-week weight loss study also showed greater weight loss with large morning meals as compared with 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 lipogenesis, 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 of breakfast, may lead to increased fat storage and weight gain.

Major strengths of our study include the longitudinal design, the repeated objective measures of weight, and the use of prospective 7-day food diaries. As a limitation, all dietary recording methods, including diet diaries, are associated with underreporting of actual intake, and greater underreporting of dietary intake by obese persons is well established (29). However, in the context of systematic error, differential reporting of dietary intakes by meal time is unlikely; therefore, we would not expect the association between %TEI at breakfast and weight change to be biased.

In conclusion, in this prospective study of 6,764 middle-aged men and women, we found an inverse association between %TEI consumed 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 is consumed over the rest of the day, may help to reduce weight gain in middle-aged adults.

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