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REVIEW

Are people who regularly eat breakfast cereals slimmer than those who don't? A systematic review of the evidence

A. de la Hunty[*] and M. Ashwell[*†]

[*]Ashwell Associates (Europe) Ltd, Ashwell, Hertfordshire, UK;
[†]Department of Nutrition and Food Science Oxford Brookes University, Headington Campus, Oxford, UK

Summary

There is growing evidence that people who eat breakfast regularly tend to be slimmer than those who skip breakfast. However, this is not a consistent finding and it is not true for all types of breakfast. Also the relationship with breakfast can disappear in studies when adjusted for breakfast cereal consumption, suggesting it is breakfast cereal that is driving the association. This systematic review, therefore, looked specifically at the relationship between breakfast cereal consumption and weight.

A systematic search of the literature identified nine references looking at the relationship between the consumption of breakfast cereals and BMI as an outcome measure.

Five of the nine included studies were in adults. These studies consistently showed that people who eat breakfast cereals regularly tend to have a lower BMI and are less likely to be overweight than those who do not eat breakfast cereals regularly. Although not all of the results were statistically significant, they all point in the same direction. There was no evidence that regular breakfast cereal consumers have lower daily energy intakes than infrequent consumers.

Four of the nine included studies were in children. As for adults, the evidence from the included studies is consistent that children who eat breakfast cereals regularly tend to have a lower BMI and are less likely to be overweight than those who eat breakfast cereals infrequently. There was no evidence that children who consume breakfast cereals regularly have lower energy intakes than infrequent cereal consumers.

This systematic review considered whether the relationship between breakfast cereal consumption and weight is likely to be mediated either through lower energy intakes or higher energy expenditures. We found no clear evidence for this or for any other proposed mechanism. The relationship could arise out of confounding by lifestyle factors.

Correspondence: Anne de la Hunty, Ashwell Associates (Europe) Ltd, Ashwell Street, Ashwell, Hertfordshire SG7 5PZ, UK.
E-mail: annedelahunty@btinternet.com

There is consistent evidence of an association between breakfast cereal consumption and a healthy weight, but limited evidence for any proposed mechanism that would point to it being a causal relationship.

Keywords: adults, body mass index, breakfast cereals, children, energy intakes, weight

Introduction

Breakfast has long been recommended as part of a healthy diet. People who eat breakfast tend to have higher micronutrient intakes, in part owing to the fortification of breakfast cereals, and a better macronutrient profile than those who skip breakfast (Ruxton & Kirk 1997). There is also evidence that children benefit from improved concentration and learning after eating breakfast (Pollitt & Mathews 1998).

There is also increasing evidence that people who eat breakfast regularly tend to be slimmer than those who skip breakfast. However, this is not a consistent finding across all studies (see for example Song *et al*. 2005) and is not true for all types of breakfast. For example, in one study people who ate 'meat and eggs', dairy products or 'fats and sweets' for breakfast did not have a lower body mass index (BMI) than those who skipped breakfast. Only those who ate ready-to-eat cereals, cooked cereal or quick breads (such as pancakes, pastries and waffles) had a significantly lower BMI than those who skipped breakfast (Cho *et al*. 2003). Other studies have found that a relationship with breakfast disappears when breakfast cereal consumption is taken into account (Barton *et al*. 2005).

This systematic review, therefore, looks specifically at the relationship between breakfast cereal consumption and body weight to see whether this is more consistent and might explain some of the contradictory findings in the study of breakfast consumption and weight. This paper systematically reviews the evidence that people who eat breakfast cereals regularly tend to have a lower BMI, are less likely to be overweight and tend to put on less weight over time than those who do not eat breakfast cereals regularly. The assumption is made that breakfast cereal consumption is at breakfast, although it is recognised that, especially for children, breakfast cereals are eaten at other times of the day as well.

This paper also discusses whether any relationship between breakfast cereal consumption and weight is likely to be a causal relationship.

Literature search

Search terms and search history

The initial searches were carried out in April 2006. Additional searches were carried out in June 2006. The databases searched were MedLine and the Cochrane Register of Controlled Trials. The search terms used and the numbers of references picked up are listed in Table 1. The search was limited to studies in humans.

A further eight references were identified from the reference lists of retrieved papers or from personal reference lists.

Inclusion and exclusion criteria

A protocol was developed to identify which references should be included in the review. The inclusion and exclusion criteria are listed in Table 2.

The number of references excluded at each stage is listed in Table 3.

After applying the inclusion and exclusion criteria, nine references were identified for breakfast cereals and BMI (Schlundt *et al*. 1992; Gibson & O'Sullivan 1995; Ortega *et al*. 1998; Bertrais *et al*. 2000; Albertson *et al*. 2003; Cho *et al*. 2003; Barton *et al*. 2005; Bazzano *et al*. 2005; Song *et al*. 2005), one for breakfast cereals and weight gain (Bazzano *et al*. 2005) and one for breakfast cereals and waist–hip ratio (Bertrais *et al*. 2000).

Results

Studies in adults

Breakfast cereal consumption and BMI

Of the nine studies identified which looked at the relationship between breakfast cereal consumption and BMI, five studies were in adults. They comprised three cross-sectional observational studies, one prospective study and one randomised trial. The relationship with BMI was analysed in two different ways: some studies

compared the average BMI between low and high consumers of breakfast cereals, while others calculated the odds ratio of having a BMI greater than 25 for different consumers of breakfast cereals, or they gave the percentages with a BMI greater than 25 for the different groups.

Cross-sectional observational studies

Two studies were performed in the general population in USA and one was in the general population in France (Bertrais *et al*. 2000; Cho *et al*. 2003; Song *et al*. 2005). In addition, the cross-sectional baseline analysis of the (prospective) Physicians Health Study compared BMI

Table 1 Search terms used and the number of papers identified

Search terms	Number of papers identified
Breakfast cereals and BMI	13
Breakfast cereals and weight	73
Breakfast cereals and weight gain	2
Breakfast cereals and waist–hip ratio	0
Breakfast cereals and waist circumference	0
Ready-to-eat cereals and BMI	7
Breakfast and BMI	153
Breakfast and weight gain	37
Breakfast and waist–hip ratio	3
Breakfast and waist circumference	2

BMI, body mass index.

Table 2 Inclusion and exclusion criteria

Exclusion criteria	Inclusion criteria
Exclude abstracts, reviews, position statements, guidelines, editorials, case reports etc.	Include original research in humans published in peer-reviewed journals
Exclude if does not look directly at the relationship between consumption of breakfast and either BMI, weight gain or waist–hip ratio	Include if looks directly at the relationship between consumption of breakfast and either BMI, weight gain or waist–hip ratio
Exclude if does not look at the relationship between consumption of breakfast cereals and either BMI, weight gain or waist–hip ratio	Include if looks at the relationship between consumption of breakfast cereals and either BMI, weight gain or waist–hip ratio
Exclude if looks at the effect of additional breakfast cereal consumption at other times of day	Include if looks at consumption of breakfast cereals at breakfast time

BMI, body mass index.

Table 3 The numbers of references excluded at each stage according to the outcome measure

Exclusion criteria	Number of papers excluded
Breakfast cereals and BMI – started with 162 papers	
Exclude abstracts, reviews, position statements, guidelines, editorials, case reports etc.	3
Exclude if does not look directly at the relationship between consumption of breakfast and BMI	134
Exclude if does not look at the relationship between consumption of breakfast cereals and BMI	14
Exclude if looks at the effect of additional breakfast cereal consumption at other times of day	2
Included papers	***9***
Breakfast cereals and weight gain – started with 37 papers	
Exclude abstracts, reviews, position statements, guidelines, editorials, case reports etc.	6
Exclude if does not look at the relationship between consumption of breakfast and weight gain	28
Exclude if does not look at the relationship between consumption of breakfast cereals and weight gain	2
Exclude if looks at the effect of additional breakfast cereal consumption at other times of day	0
Included papers	***1***
Breakfast cereals and waist–hip ratio – started with 5 papers	
Exclude abstracts, reviews, position statements, guidelines, editorials, case reports etc	0
Exclude if does not look at the relationship between consumption of breakfast and waist–hip ratio	2
Exclude if does not look at the relationship between consumption of breakfast cereals and waist–hip ratio	2
Exclude if looks at the effect of additional breakfast cereal consumption at other times of day	0
Included papers	***1***

BMI, body mass index.

and risk of overweight according to breakfast cereal consumption (Bazzano *et al*. 2005) (see Table 4 for full details of the studies).

Bertrais *et al*. (2000) analysed the dietary records of 5039 adults enrolled in the SU.VI.MAX trial. This was a randomised, placebo-controlled primary prevention trial of antioxidant vitamins and minerals in adults aged 35–60 years in France. They found that men who ate breakfast cereals most often (on 10–12 days out of a possible 12 days) had a lower BMI than those who rarely ate breakfast cereals (0–1 days out of a possible 12 days), but there was no significant difference in women. There was no significant difference in energy intakes in men, but women who ate most breakfast cereals had significantly higher energy intakes than those who ate least.

Cho *et al*. (2003) analysed dietary recall records from the Third National Health and Nutrition Examination Survey (NHANES III) of 16 452 adults aged 18 years and over. They found that people who ate breakfast cereals had significantly lower BMI than those who did not eat breakfast (the 'breakfast skippers') or who had a 'meat and egg' type of breakfast after adjusting for age, gender, race, smoking, alcohol intake, physical activity and poverty index ratio. People who ate breakfast cereals had significantly higher energy intakes than breakfast skippers and those who ate fruit and vegetables at breakfast had significantly lower energy intakes than those who had a 'meat and egg' type of breakfast.

An analysis of the 24-h dietary recall records from the NHANES 1999–2000 survey of 4218 adults aged 19 years and over found that women who ate breakfast cereals on the day in question were significantly less likely to be overweight than women who did not eat breakfast cereals after adjusting for age, ethnicity, smoking, energy intake, exercise and control weight (Song *et al*. 2005). The odds ratio for BMI > 25 was 0.70 with 95% confidence intervals of 0.52–0.94. There was no significant difference in men. There were no significant differences in energy intakes between people who ate breakfast cereals and those who didn't.

Bazzano *et al*. (2005) found in their baseline analysis of the Physician's Health Study (see section on breakfast cereal consumption and weight gain) that men who ate breakfast cereals every day had lower BMI and were less likely to be overweight than those who rarely or never ate breakfast cereals.

Randomised controlled trials of weight loss

One randomised controlled trial of the effect of eating or not eating breakfast on weight was included in the review (Schlundt *et al*. 1992) (see Table 5). This 12-week trial investigated the effect of eating or not eating breakfast cereals as part of an otherwise identical weight loss programme in 52 moderately obese women. In addition, the subjects were stratified according to whether they habitually ate breakfast or not. Of those who habitually ate breakfast, the breakfast skippers lost 8.9 kg, while the breakfast cereal eaters lost 6.2 kg. Of those who did not habitually eat breakfast, the breakfast skippers lost 6.0 kg, while the breakfast cereal eaters lost 7.7 kg. They found no significant differences between the four groups in the amount of weight lost. However, results were not reported for just a breakfast *vs*. no-breakfast comparison without stratification by previous breakfast habits. Those in the breakfast treatment group ate fewer unplanned impulsive snacks during the day than those in the no-breakfast group.

Breakfast cereal consumption and weight gain

The one prospective study of breakfast cereals and BMI and weight gain included in the review was an analysis within the data from the Physician's Health Study. This was a randomised trial of low dose aspirin and β-carotene in the primary prevention of cardiovascular disease and cancer. The study included 17 881 men aged 40–84 years at baseline, followed up for 8 and 13 years (Bazzano *et al*. 2005). Participants completed annual questionnaires which included an abbreviated, semi-quantitative food frequency questionnaire (FFQ). An analysis of the cohort found that men who ate breakfast cereals everyday at baseline were less likely to become overweight after 8 and 13 years and were less likely to have major weight gain (>10 kg) over this time period than men who ate cereals rarely or never. The analysis controlled for age, smoking, baseline BMI, alcohol, physical activity, history of hypertension, history of high cholesterol and use of multivitamins (see Table 6).

Breakfast cereal consumption and waist–hip ratio

The data from the SU.VI.MAX trial allowed analysis of the relationship between breakfast cereal consumption and waist–hip ratio (Bertrais *et al*. 2000). It found that men and women who ate breakfast cereals most often (on 10 to 12 days out of a possible 12 days) had significantly lower waist–hip ratios (*i.e*. were less likely to exhibit central obesity) than those who rarely ate breakfast cereals (0–1 days out of a possible 12 days) (see Table 7).

Summary

The included studies consistently show that people who eat breakfast cereals regularly tend to have a lower BMI

Table 4 Cross-sectional studies of breakfast cereal consumption and BMI in adults

Reference	Subjects	Age	Number	Method of dietary assessment	Categories of breakfast cereal consumption	Energy intakes	Relationship with BMI
Bazzano *et al.* (2005)	Adult men	40–84 years	17 881	Semi-quantitative FFQ	Daily *vs.* rarely breakfast cereal consumption	Not reported	*BMI* Daily 24.2[a] Rarely 24.9[b] *%BMI > 25* Daily 33%[a] Rarely 45%[b]
Bertrais *et al.* (2000)	Adults SU.VI.MAX study	35–60 years	5 039	12 24-hour diet records	0–1 day/12 breakfast cereal consumption 2–5 days/12 breakfast cereal consumption 6–9 days/12 breakfast cereal consumption 10–12 days/12 breakfast cereal consumption	*Women* 10–12 days 1898 kcal[a] 0–1 days 1799 kcal[b] *Men* 10–12 days 2413 kcal[c] 0–1 days 2449 kcal[c]	*Women* Heavy consumers 22.1[a] Non-consumers 23.0[a] *Men* Heavy consumers 24.5[b] Non-consumers 25.4[c]
Cho *et al.* (2003)	Adults, NHANES III	Over 18 years	16 452	24-hour diet recall	Individuals assigned to different breakfast categories according to which category contributed more calories than any other category. Breakfast cereals was one category	Breakfast cereal 2241 kcal[bc] Skipper 2027 kcal[a] Fruit and vegetable 2046 kcal[a] Meat and egg 2433 kcal[d]	Breakfast cereal 26.03[ab] Skipper 26.92[c] Fruit and vegetable 26.41[abc] Meat and egg 27.04[c]
Song *et al.* (2005)	Adults NHANES 1999–2000	Over 19 years	4 218	24-hour diet recall	Breakfast cereal consumers *vs.* non breakfast cereal consumers	*Women* Breakfast cereal 1939 kcal[a] Non-breakfast cereal 1853 kcal[a] *Men* Breakfast cereal 2642 kcal[c] Non-breakfast cereal 2633 kcal[c]	OR for BMI > 25 *Women* 0.70 (0.52–0.94) *Men* 0.99 (0.67–1.49)

Values with different superscripts are significantly different to each other.

BMI, body mass index; NHANES III, Third National Health and Nutrition Examination Survey; FFQ, food frequency questionnaire; OR, odds ratio.

Table 5 Randomised trial of breakfast cereal consumption and weight loss in adults

Reference	Subjects	Age	Number	Length	Categories of breakfast cereal consumption	Treatment	Weight loss
Schlundt *et al.* (1992)	Moderately obese, healthy women	18–55 years	52	12 weeks	4+ *vs.* 3 or less/week	Breakfast group given breakfast cereals and advised to eat 1200 kcal diet over 3 meals/day No-breakfast group given bran muffins and advised to eat 1200 kcal diet over 2 meals/day	*Breakfast eaters* Breakfast 6.2 kg No breakfast 8.9 kg *Breakfast skippers* Breakfast 7.7 kg No breakfast 6.0 kg

Table 6 Prospective study of breakfast cereal consumption and BMI and weight gain in adults

Reference	Subjects	Age	Number	Length	Method of dietary assessment	Categories of breakfast cereal consumption	Weight gain	Risk of developing BMI > 25
Bazzano *et al.* (2005)	Adult men	40–84 years	17 881	8 and 13 years	Semi-quantitative FFQ	Daily *vs.* rarely breakfast cereal consumption	*After 8 years* Daily 1.07 kg[a] Rarely 1.66 kg[b] *After 13 years* Daily 1.81 kg[a] Rarely 2.27 kg[b]	*After 8 years* Whole grain cereals 0.83 (0.71–0.98) Refined cereals 0.81 (0.64–1.03) Total cereals 0.78 (0.67–0.91) *After 13 years* Whole grain cereals 0.91 (0.79–1.05) Refined cereals 0.81 (0.65–1.01) Total cereals 0.88 (0.76–1.00)

Values with different superscripts are significantly different to each other.
BMI, body mass index; FFQ, food frequency questionnaire.

and are less likely to be overweight than those who do not eat breakfast cereals regularly (see Table 8). Although not all of the results are statistically significant, they all point in the same direction. Regular breakfast cereal consumers are less likely to put on weight over time, although this conclusion is based on only one (large) study. There is also limited evidence that they have a lower waist–hip ratio than infrequent breakfast cereal consumers.

Studies in children

Four studies in children were identified. They all investigated the relationship between breakfast cereal consumption and BMI; three studies were cross-sectional studies and one was a prospective study.

Cross-sectional observational studies

Three cross-sectional studies were identified, one in the USA, one in the UK and one in Spain (see Table 9).

Albertson *et al.* (2003) examined the relationship between breakfast cereal consumption and BMI in a group of 603 US children aged 4–12 years. They assessed diet using a 14-day food record. They found that those in the highest tertile of cereal consumption had lower mean BMIs than those in the lowest tertile across all age groups. The proportion of children who were at risk of overweight was significantly higher in the lowest tertile of consumption. Children in the highest tertile of consumption had non-significantly lower energy intakes.

Gibson and O'Sullivan (1995) analysed the data from a survey of British Schoolchildren carried out in 1983.

Table 7 Cross-sectional study of breakfast cereal consumption and waist–hip ratio (WHR) in adults

Reference	Subjects	Age	Number	Method of dietary assessment	Measurement of breakfast cereal consumption	Energy Intakes	Relationship with WHR
Bertrais *et al.* (2000)	Adults SU.VI.MAX study	35–60 years	5039	12 24 hour diet records	0–1 day/12 breakfast cereal consumption 2–5 days/12 breakfast cereal consumption 6–9 days/12 breakfast cereal consumption 10–12 days/12 breakfast cereal consumption	*Women* 10–12 days 1898 kcal[a] 0–1 days 1799 kcal[b] *Men* 10–12 days 2413 kcal[c] 0–1 days 2449 kcal[c]	*Women* Heavy consumers 0.75[a] Non-consumers 0.77[b] *Men* Heavy consumers 0.91[c] Non-consumers 0.92[d]

Values with different superscripts are significantly different to each other.

Table 8 Summary of comparisons of increased breakfast cereal consumption and outcome measures related to weight in adults

Comparison of increased breakfast cereal consumption and:	Significant positive relationship	Non significant positive relationship	Non significant negative relationship	Significant negative relationship	Overall direction of relationship
Increased energy intakes	2	2	1		1/5 negative
Increased BMI			1	3	4/4 negative
Increased risk of BMI > 25			1	4	5/5 negative
Increased weight loss in RCT		1	1		1/2 positive
Decreased weight gain in prospective study				1	1/1 negative
WHR				2	2/2 negative

BMI, body mass index; RCT, randomised controlled trial; WHR, waist–hip ratio.

This survey measured the diets of 2705 children aged 10–15 years using 7-day weighed intakes. They found that children who ate breakfast cereals had significantly lower BMIs than those who did not. Children who ate the most breakfast cereals had significantly higher energy intakes than non-consumers.

A further study by Ortega *et al.* (1998) in 200 schoolchildren aged 9–13 years in Madrid found that overweight and obese children omitted breakfast more frequently than normal weight children and ate significantly less cereal. Overweight children had significantly lower energy intakes than normal weight children.

Prospective studies

Barton *et al.* (2005) examined the association of breakfast cereal intake with BMI in a group of 2379 girls aged 9 and 10 years, followed up for a further 10 years (see Table 10). They assessed diet using an annual 3-day food record. They found that those who ate breakfast cereal more often in those three days had significantly lower BMI and a lower risk of overweight after controlling for age, family context, race, physical activity and energy intake. At all ages, breakfast cereal eaters were significantly leaner than girls who did not eat cereal. They did not report energy intakes.

The fact that the relationship with BMI remained after controlling for energy intake is interesting and suggests that the relationship might be mediated through some mechanism other than a reduction in energy intakes, possibly through an increase in energy expenditure.

Summary

As for adults, the evidence is consistent that children who eat breakfast cereals regularly tend to have a lower BMI and are less likely to be overweight than those who eat breakfast cereals infrequently (see Table 11).

Again, however, there is no evidence that children who consume breakfast cereals regularly have lower energy intakes than infrequent cereal consumers; but as in the studies in adults, the energy intakes findings are

Table 9 Cross-sectional studies of breakfast cereal consumption and body mass index (BMI) in children

Reference	Subjects	Age	Number	Method of dietary assessment	Category of breakfast cereal consumption	Daily energy intakes	Relationship between breakfast cereal consumption and weight
Albertson *et al.* (2003)	US Children	4–12 years	603	14-day food diaries	Tertiles of breakfast cereal consumption	Lowest 1726 kcal[a] Middle 1693 kcal[a] Highest 1681 kcal[a]	*BMI* *%BMI > 25* Lowest 19.3[a] 47.4%[a] Middle 17.9[b] 36.7%[b] Highest 16.7[c] 21.3%[b]
Gibson & O'Sullivan (1995)	British schoolchildren	10–15 years	2705	7-day weighed intake	4 categories of intake (portions/day) of breakfast cereals	*Girls 10–11 years* Non-consumers 1765 kcal[a] <1 portion 1781 kcal[a] 1 portion 1857 kcal[a] >1 portion 1996 kcal[b] *Boys 10–11 years* Non-consumers 1960 kcal[c] <1 portion 1997 kcal[c] 1 portion 2033 kcal[c] >1 portion 2152 kcal[d]	*BMI* *Girls 10–15 years* Non-consumers 19.9[a] <1 portion 18.7[b] 1 portion 18.8[b] >1 portion 18.7[b] *Boys 10–15 years* Non-consumers 19.6[c] <1 portion 18.2[d] 1 portion 18.4[d] >1 portion 18.7[b]
Ortega *et al.* (1998)	Spanish schoolchildren	9–13 years	200	7-day food record	Differences in breakfast cereal consumption between obese (BMI > 75th %) and non-obese (BMI < 75th %) children	*Girls* Obese 1265 kcal[a] Non-obese 1501 kcal[b] *Boys* Obese 1711 kcal[c] Non-obese 1933 kcal[d]	*Cereal intake* *Girls* Obese 26.4 g/day[a] Non-obese 37.0g/day[b] *Boys* Obese 44.4g/day[c] Non-obese 53.0g/day[d]

Values with different superscripts are significantly different to each other. BMI, body mass index.

Table 10 Prospective study of breakfast cereal consumption and BMI in children

Reference	Subjects	Age	Number	Length	Method of dietary assessment	Category of breakfast cereal consumption	Relationship with BMI
Barton *et al.* (2005)	Children in the National Heart, Lung and Blood Institute Growth and Health and Study	9–10 years at baseline	2379	10 years	Annual 3-day food records	Days eating breakfast cereal in the 3-day observation each year 0 day 1 day 2 days 3 days	–0.015 BMI/days eating cereal OR for overweight 0 days 1.00[a] 1 day 0.93[b] 2 days 0.90[b] 3 days 0.87[b]

Values with different superscripts are significantly different to each other.
BMI, body mass index; OR, odds ratio.

Table 11 Summary of comparisons of increased breakfast cereal consumption and outcome measures related to weight in children

Comparison of increased breakfast cereal consumption and:	Significant positive relationship	Non-significant positive relationship	Non-significant negative relationship	Significant negative relationship	Overall direction of relationship
Increased energy intakes	2		1		1/3 negative
Mean BMI				4	4/4 negative
Risk of BMI > 25				2	2/2 negative

BMI, body mass index.

all from cross-sectional studies. Prospective studies might show the opposite results.

Is there a causal relationship between breakfast cereals and BMI?

We considered whether the relationship between breakfast cereal consumption and weight had arisen owing to confounding by other factors or whether it was a causal relationship, mediated either through lower energy intakes (perhaps via lower energy density/greater satiety) or higher energy expenditures. These options are considered in more detail below.

Evidence of confounding

The most likely explanation for the inverse association between cereal consumption and BMI is that a third factor (*e.g.* lower energy intakes or higher energy expenditure) is associated with both exposure (higher cereal consumption) and outcome (lower BMI). Breakfast cereal eaters tend to take more exercise and also drink less alcohol than those who don't eat breakfast cereals regularly. Although these and other lifestyle factors were adjusted for in a number of the studies, it is possible that residual confounding remains.

The question of causality can only be addressed completely by a randomised trial. Unfortunately, the authors of the one included randomised trial did not analyse their results by treatment group alone, but only presented results stratified by previous breakfast habits. No significant differences were found between the groups in the amount of weight lost, although the group that lost the most weight were those who usually ate breakfast but skipped breakfast during the trial. This study provides little support, therefore, for the hypothesis that eating breakfast cereals regularly helps to maintain a healthy weight.

Evidence for an effect on energy intakes

One proposed mechanism by which regular breakfast cereal consumption might lead to lower BMI is through lower total energy intakes through a reduction in snacking on high fat foods later in the day. The trial by Schlundt *et al.* (1992) found that breakfast skippers ate more unplanned impulsive snacks during the day than breakfast consumers. However, there is a lack of evidence of lower total energy intakes in regular consumers of breakfast cereals (see summary Tables 8 and 11). Although most studies found no significant difference in energy intakes, the

trend was for cereal consumers to consume more, rather than less, energy.

It is possible that these findings, which were all from cross-sectional studies, are because overweight people were skipping breakfast in an attempt to reduce their energy intakes. The one prospective study included in the review did not report energy intakes. Alternatively, energy intakes might have been under-reported by the overweight subjects. Summerbell *et al*. (1996) found that a relationship between greater energy intakes at breakfast and lower BMI disappeared when unreasonably low energy intakes were removed from the analysis.

Therefore, although there is no evidence to suggest that regular breakfast cereal consumers do have lower energy intakes than non-consumers, and much evidence to the contrary, lower energy intakes in regular breakfast consumers remains a possibility.

Evidence for an effect on energy expenditure

It is possible that the relationship is not mediated through reductions in energy intake but through some other mechanism which affects energy expenditure. Two studies (Barton *et al*. 2005; Song *et al*. 2005) both found an association with risk of being overweight even after controlling for energy intakes. Barton *et al*. (2005) proposed that increased calcium intakes associated with breakfast cereal intake might explain the observation. However, there is conflicting evidence for the hypothesis that calcium or dairy products play a role in regulating body fat. No relationship was seen in a recent prospective analysis of calcium intakes and weight gain in 23 500 men (Rajpathak *et al*. 2006) while others have found a relationship between calcium intakes and BMI (Zemel 2004). A recent systematic review and meta-analysis of 13 trials of calcium supplementation or dairy products and weight loss found no significant effect on weight loss after adjusting for differences in baseline weights between control and intervention groups (Trowman *et al*. 2006).

Alternatively, regular breakfast consumption might have effects on energy expenditure through an effect on the thermic effect of food and postprandial energy expenditure. Irregular meal frequency has been shown to lead to a lower postprandial energy expenditure compared with regular meal frequency, while the mean energy intake was not significantly different between the two (Farshchi *et al*. 2004). So, as it is possible that breakfast skipping is associated with a more irregular meal pattern than regular breakfast consumption, the consequent reduced postprandial energy expenditure might lead to weight gain in the long term. The stronger association with breakfast cereals specifically than breakfast *per se* might be due to lower energy intakes being provided by breakfast cereals than other forms of breakfast foods.

Conclusion

There is consistent evidence of an association between breakfast cereal consumption and a healthy weight, but limited evidence for any proposed mechanism that would point to it being a causal relationship.

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References

Albertson AM, Anderson GH, Crockett SJ *et al.* (2003) Ready-to-eat cereal consumption: its relationship with BMI and nutrient intake of children aged 4–12 years. *Journal of the American Dietetic Association* **103**: 1613–9.

Barton BA, Eldridge AL, Thompson D *et al.* (2005) The relationship of breakfast and cereal consumption to nutrient intake and body mass index: the National Heart, Lung, and Blood Institute Growth and Health Study. *Journal of the American Dietetic Association* **105**: 1383–9.

Bazzano LA, Song Y, Bubes V *et al.* (2005) Dietary intake of whole and refined grain breakfast cereals and weight gain in men. *Obesity Research* **13**: 1952–60.

Bertrais S, Polo Luque ML, Preziosi P *et al.* (2000) Contribution of ready-to-eat cereals to nutrition intakes in French adults and relations with corpulence. *Annals of Nutrition and Metabolism* **44**: 249–55.

Cho S, Dietrich M, Brown CJ *et al.* (2003) The effect of breakfast type on total daily energy intake and body mass index: results from the Third National Health and Nutrition Examination Survey (NHANES III). *Journal of the American College of Nutrition* **22**: 296–302.

Farshchi HR, Taylor MA & Macdonald IA (2004) Decreased thermic effect of food after an irregular compared with a regular meal pattern in healthy lean women. *International Journal of Obesity and Related Metabolic Disorders* **28**: 653–60.

Gibson SA & O'Sullivan KR (1995) Breakfast cereal consumption patterns and nutrient intakes of British schoolchildren. *Journal of the Royal Society of Health* **115**: 366–70.

Ortega RM, Requejo AM, Lopez-Sobaler AM *et al.* (1998) Difference in the breakfast habits of overweight/obese and normal weight schoolchildren. *International Journal for Vitamin and Nutrition Research* **68**: 125–32.

Pollitt E & Mathews R (1998) Breakfast and cognition: an integrative summary. *American Journal of Clinical Nutrition* **67**: 804S–813S.

Rajpathak SN, Rimm EN, Rosner B *et al.* (2006) Calcium and dairy intakes in relation to long-term weight gain in US men. *American Journal of Clinical Nutrition* **83**: 559–66.

Ruxton CH & Kirk TR (1997) Breakfast: a review of associations with measures of dietary intake, physiology and biochemistry. *British Journal of Nutrition* **78**: 199–213.

Schlundt DG, Hill JO, Sbrocco T *et al.* (1992) The role of breakfast in the treatment of obesity: a randomized clinical trial. *American Journal of Clinical Nutrition* **55**: 645–51.

Song WO, Chun OK, Obayashi S *et al.* (2005) Is consumption of breakfast associated with body mass index in US adults? *Journal of the American Dietetic Association* **105**: 1373–82.

Summerbell CD, Moody RC, Shanks J *et al.* (1996) Relationship between feeding pattern and body mass index in 220 free-living people in four age groups. *European Journal of Clinical Nutrition* **50**: 513–9.

Trowman R, Dumville JC, Hahn S *et al.* (2006) A systematic review of the effects of calcium supplementation on body weight. *British Journal of Nutrition* **95**: 1033–8.

Zemel MB (2004) Role of calcium and dairy products in energy partitioning and weight management. *American Journal of Clinical Nutrition* **79**: S907–12.

