

# Energy Contribution and Nutrient Composition of Breakfast and Their Relations to Overweight in Free-living Individuals: A Systematic Review<sup>1–3</sup>

Valentina Rosato,<sup>4</sup> Valeria Edefonti,<sup>4\*</sup> Maria Parpinel,<sup>6</sup> Gregorio Paolo Milani,<sup>7</sup> Alessandra Mazzocchi,<sup>5</sup> Adriano Decarli,<sup>4,8</sup> Carlo Agostoni,<sup>5</sup> and Monica Ferraroni<sup>4</sup>

<sup>4</sup>Branch of Medical Statistics, Biometry and Epidemiology “G. A. Maccacaro” and <sup>5</sup>Pediatric Clinic, Fondazione Istituto di Ricovero e Cura a Carattere Scientifico (IRCCS) Ca’ Granda Ospedale Maggiore Policlinico, Department of Clinical Sciences and Community Health, University of Milan, Milan, Italy; <sup>6</sup>Institute of Hygiene and Epidemiology, Department of Medical and Biological Sciences, Università degli Studi di Udine, Udine, Italy; <sup>7</sup>Pediatric Emergency Department, Fondazione IRCCS Ca’ Granda Ospedale Maggiore Policlinico, Milan, Italy; and <sup>8</sup>Fondazione IRCCS Istituto Nazionale dei Tumori Foundation, Milan, Italy

## ABSTRACT

Previous systematic reviews on the relation between overweight or obesity and breakfast focused on the frequency of consumption and only partially accounted for breakfast nutritional profiles. Given the central role of these factors, we conducted a systematic review of the literature on this putative relation, with a specific focus on breakfast energy intake and/or breakfast composition. Among the 814 articles identified from the literature search in PubMed, 19, mostly cross-sectional, studies met the inclusion criteria (i.e., studies providing a quantitative estimate of the relation between any measure of weight, overweight, and obesity and breakfast energy intake or breakfast macronutrient composition). We excluded studies in subjects with acquired metabolic disorders, such as diabetes or impaired glucose tolerance. Of the 16 studies that evaluated the amount of energy intake at breakfast, 4 found that a lower energy intake at breakfast was significantly associated with obesity in children, adolescents, and adults, whereas 2 partially overlapping studies found that a higher energy intake was significantly associated with a higher body mass index in children. Of the 8 studies investigating breakfast composition, 3 suggested that a breakfast characterized by a higher amount of carbohydrates and a lower amount of fat is significantly related to normal weight in adults, whereas the others reported mixed results. In conclusion, there is some evidence that a lower energy intake at breakfast is related to obesity, although the studies are few and heterogeneous. Studies on the nutrient composition of breakfast have shown inconsistent results. *Adv Nutr* 2016;7:455–65.

**Keywords:** breakfast, breakfast energy intake, breakfast composition, obesity, overweight

## Introduction

Obesity is one of the most important causes of preventable morbidity and mortality in developed countries, with adverse psychosocial and economic consequences. In 2014, ~40% of adults worldwide were overweight and 13% were obese; >40 million children under the age of 5 y were overweight or obese in 2013 (1). Obesity has major genetic determinants,

but environmental factors are also strongly related to its development (2). Among them, diet and physical activity are the main contributors.

Much research has investigated the role of breakfast consumption on obesity. This issue is of specific interest in childhood and adolescence because overweight or obese children have a higher risk of being obese in adulthood (3) and, consequently, a higher risk of hypertension, diabetes, and heart disease (4). Several observational studies have shown a tendency for low or nonconsumers of breakfast to be overweight or obese, although findings were not always well supported and the heterogeneity of various sources makes comparisons difficult (2, 5–11). However, the vast majority of these investigations focused on the effects of frequency of breakfast occasions (in terms of number of occasions per week or in categories) and, if at all, provided

<sup>1</sup>Supported by contributions from the Italian Association for Cancer Research (AIRC grant IG10415) and the Italian Ministry of University, Education, and Research (PRIN 2009 X8YCBN) and partly supported by the Italian Ministry of Health (IRCCS grant).

<sup>2</sup>Author disclosures: V Rosato, V Edefonti, M Parpinel, GP Milani, A Mazzocchi, A Decarli, C Agostoni, and M Ferraroni, no conflicts of interest. The supporting organizations had no role in the design, implementation, analysis, or interpretation of data.

<sup>3</sup>Supplemental Material, Supplemental Table 1, and Supplemental Figure 1 are available from the “Online Supporting Material” link in the online posting of the article and from the same link in the online table of contents at <http://advances.nutrition.org>.

\*To whom correspondence should be addressed. E-mail: [valeria.edefonti@unimi.it](mailto:valeria.edefonti@unimi.it).

only a partial account of energy intake at breakfast and breakfast composition.

Because energy imbalance (between intake and expenditure) and diet composition seem to be independent determinants in the etiology of obesity, studies specifically focusing on breakfast energy intake and/or breakfast composition are expected to reveal new aspects of the putative association between breakfast habits and overweight/obesity. Moreover, these studies may provide comparable data from different countries, which typically have different breakfast habits.

The aim of the present systematic review is to summarize the available evidence for the relation between overweight/obesity and breakfast characteristics, considering the specific role of energy intake from breakfast and/or the nutrient composition of breakfast. Because obesity is an increasing worldwide problem and breakfast habits are a modifiable factor, we expect results from this review to represent the starting point for the development of future public health messages.

## Methods

### Search strategy

We carried out a systematic search through MEDLINE via PubMed to identify articles on the relation between breakfast characteristics (energy intake and/or nutrient composition) and overweight/obesity in humans that were published in English up to November 2014. The following key terms were used: (breakfast OR “breakfast composition” OR “daily meal distribution”) and (“energy intake” OR “energy contribution” OR “energy expenditure” OR quality OR energy OR skipping) and (obesity OR overweight OR “body mass index” OR “insulin sensitivity” OR “glycemic index”). We followed the guidelines from the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) group (12). Two authors (VR and VE) independently selected the articles and retrieved and assessed those that were potentially relevant. The reference lists of the identified articles and of other systematic reviews focusing on similar topics were also reviewed. Discrepancies in article selection were resolved by involving a third researcher (CA).

### Inclusion and exclusion criteria

**Participants.** Studies in subjects of all ages and both sexes were included. We excluded studies in subjects with acquired metabolic disorders, such as diabetes or impaired glucose tolerance.

**Outcome measures.** Studies that referred to any measure of weight, overweight, or obesity (weight in kilograms, weight changes, waist circumference, waist-to-height ratio, BMI) were included. We excluded studies that reported outcome measures at baseline but not at the end of the study experiment or studies that investigated the effect of breakfast on proxies of the outcome, such as perception of weight, appetite, and satiety or blood surrogates, such as ghrelin concentration.

**Exposure measures.** We included studies that provided quantitative estimates of total energy intake at breakfast (including absolute intakes of total energy and/or percentages of daily energy intake provided by breakfast) or breakfast macronutrient composition (e.g., protein, fiber, carbohydrate, sugar, fat, cholesterol, SFAs) for different breakfast treatments. The definition of breakfast was the first food or meal consumed during the day, although some studies on school breakfast programs did not explicitly ask for previous intakes (e.g., at home, on the bus). Original information on energy intake at breakfast has been consistently expressed in kilocalories throughout the present study. Studies were included regardless of the content of the meal (e.g., drinks, eggs); however, when studies provided separate analyses on breakfast energy including or excluding beverages, we reported results on the former analysis. We excluded studies that compared breakfast with a “no breakfast” option unless

several breakfast treatments, with specified energy or composition, were simultaneously available and compared with one another (other exclusion criteria are described in the **Supplemental Material**).

**Relation between outcome and exposure measures.** Studies that provided data on any form of relation between obesity and energy intake at breakfast or breakfast composition were included. This included results derived from different statistical approaches, such as descriptive statistics and tests, correlation analysis, multiple regression models, and ANOVA. We excluded studies that did not provide quantitative results of any kind but only histogram-like representations of the results. We also excluded studies that provided indirect information on the relation between breakfast characteristics and weight, through regression models carried out in strata of obese and normal-weight subjects. Finally, we chose to include all of the studies that met the inclusion criteria, and we did not exclude any study on the basis of study quality.

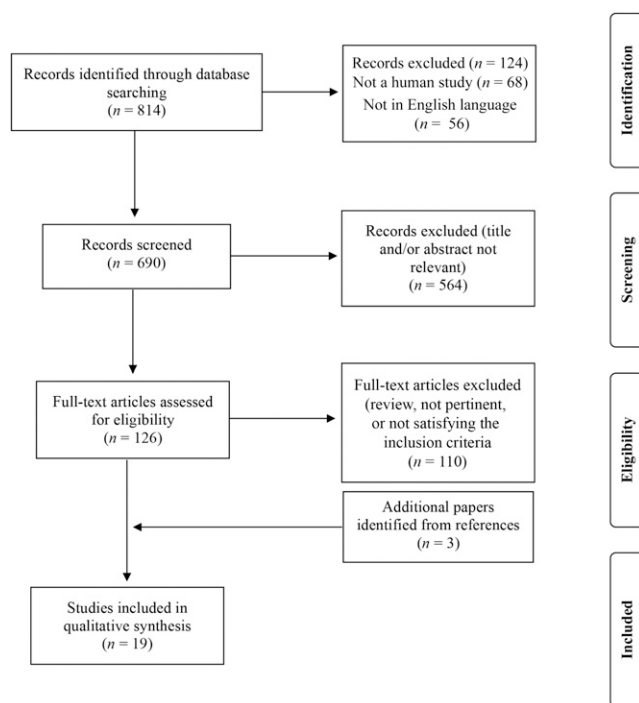
## Results

### Study selection

From the literature search of the PubMed database, we identified 814 articles of which 690 were retained when we limited our search to “humans” ( $n = 68$  removed) and “English” language ( $n = 56$  removed). After the exclusion of 564 articles that were not relevant based on title and/or abstract, 126 articles remained and their full texts were retrieved for detailed evaluation. In addition to 25 reviews, 85 original research articles were excluded because they were not pertinent or did not satisfy the inclusion criteria previously indicated. The most frequent reasons for exclusion were the absence of information on the composition of the breakfast (e.g., information on the consumption or frequency of breakfast, without extra details on energy intake or macronutrient composition of the available breakfast options) or the absence of an appropriate outcome measure (e.g., perception of weight). Three additional articles were identified from manual searches of reference lists of selected original research and review articles. Therefore, 19 articles based on ~30,000 subjects were included in our systematic review (**Supplemental Table 1, Figure 1**).

### Characteristics of the included studies

Among the selected 19 studies (13–31) (**Supplemental Table 1**), 1 was a cohort study (13), 2 were intervention trials (14, 15), and the remaining studies were cross-sectional studies or surveys (16–31). The studies were published between 1996 and 2013 (13–15, 17–31), with the exception of 1 study that was published in 1988 (16). The studies were mainly conducted in Europe, including Spain (17, 19, 20, 23, 28), the United Kingdom (13, 15, 18, 31), France (16, 25), and Finland (14), but some of the studies were conducted in the United States (22, 24, 26, 27, 29, 30) and 1 study was conducted in Iran (21). The studies examined subjects of different ages: 10 studies enrolled children or adolescents (16, 19–21, 23, 25–28, 30), 8 recruited adults of different ages (13–15, 17, 22, 24, 29, 31), and 1 study enrolled 4 age-specific subgroups of subjects (18). The sex of recruited subjects was not stated in 6 studies (13, 16, 25, 27, 28, 30). Ten studies defined strict exclusion criteria (e.g., presence of chronic or endocrine diseases) (14, 15, 17, 19, 20, 22–24,



**FIGURE 1** Flowchart of the study selection process in the systematic review.

28, 29). In most of the studies, the anthropometric data were measured and recorded by trained staff (13–17, 19–24, 26–28, 30, 31), in 2 studies they were self-reported (25, 29), and in 1 study this information was not reported (18). Finally, 7 of the 19 included studies were sponsored by food companies (14, 15, 19, 20, 22, 24, 27).

**Overview of the main results.** Table 1 shows the main results of the 19 studies included in the present review. Among them, 11 studies investigated the relation between overweight/obesity measures and energy intake at breakfast only (13, 16, 18, 19, 21, 23–26, 28, 30), 3 studies reported the relation with breakfast composition only (15, 27, 31), and 5 addressed both characteristics (14, 17, 20, 22, 29). Among the 16 studies investigating the effect of energy intake, 8 investigated the effect of absolute energy intake of breakfast (kcal) (14, 20, 22–24, 26, 29, 30) and 8 investigated the effect of the percentage of energy from breakfast to overall daily energy intake (13, 16–19, 21, 25, 28). Absolute values of breakfast energy intake ranged from 164 [mean of the low-energy breakfast group (23)] to 591 kcal [mean of the high-energy breakfast group (23)]. The percentage of energy from breakfast ranged from 10% (21) to 50% (13), but a reference value of 20% was occasionally fixed a priori to indicate an adequate/inadequate breakfast (19).

**Energy intake at breakfast and overweight/obesity.** Ten of the 16 studies that investigated the effect of energy intake at breakfast showed a negative relation with obesity: a lower energy intake at breakfast was associated with greater weight/BMI (13, 16–18, 20, 22, 23, 25, 28, 29). Among the

10 studies, 1 was a cohort study (13) and the remaining ones were cross-sectional studies or surveys. Three studies used interviewer-administered dietary assessment instruments (16, 22, 23) and 7 used self-reported (13, 17, 18, 20, 25, 28, 29) dietary assessment instruments, mainly food diaries (17, 18, 20, 25, 28, 29). Seven studies used multiple regression models with various outcomes (13, 16–18, 20, 22, 25), 2 used tests of significance (23, 28), and 1 did not perform any test (29). Two studies were sponsored by industry (20, 22). In 4 studies, the negative association was statistically significant (13, 16, 18, 22), although in 1 study the result was significant for adolescents only (18). Two partially overlapping cross-sectional US studies adopted regression models for multilevel data to show a significant positive relation between energy intake at breakfast and BMI in children: a higher energy intake at breakfast was associated with a higher BMI (26, 30). Two other studies, which included the only available trial on energy intake at breakfast (6 wk for each of the 2 trial periods), showed no significant association between energy intake at breakfast and obesity (14, 24).

Finally, 2 cross-sectional studies carried out separate analyses in strata of sex and found inconsistent results. An Iranian study in adolescents showed a significantly lower energy intake at breakfast in overweight/obese girls but no significant difference in normal-weight boys (21), and a Spanish study showed that a higher percentage of obese boys but a lower percentage of girls consumed an inadequate breakfast (characterized by <20% of total daily energy intake), although without a significant effect of sex and percentage of total energy intake (19).

With regard to different age groups and the association between energy intake at breakfast and overweight/obesity, of the 7 cross-sectional/survey studies in children aged 2–13 y [of which 1 study reported both overall and separate results for children aged 3–6 and 7–11 y (25)], 1 study (14%) reported an inverse association (16), 2 partially overlapping studies (29%) reported a positive association (26, 30), whereas the remaining 4 studies (57%) reported no significant associations (19, 20, 23, 25). In particular, 2 studies (100%) in 2- to 6-y-old children found no significant association (19, 25). Of the 5 studies in 7- to 13-y-old children, 1 study (20%) found an inverse association (16), 2 studies (40%) found no significant inverse association (20, 25), and the 2 partially overlapping studies (40%) showed a positive association (26, 30). One study (100%) in children of different ages (3–12 y) found no significant inverse association (23). Among the 3 cross-sectional studies in adolescents (aged 10–17 y), 1 study in adolescents aged 13–14 y reported an inverse association (18); 1 study in adolescents aged 10–19 y (50%) reported an inverse association in females, but not in males (21); and another study in 12- to 17-y-olds showed a nonsignificant inverse association (28). Among the 7 studies in adults (>19 y of age), 1 cohort study (13) and 1 large survey (22) (29%) reported an inverse association, 1 cross-sectional study (14%) reported a descriptive inverse association (29), and the remaining 4 studies, including 1 trial

**TABLE 1** Main results of the studies evaluating the effect of energy intake at breakfast and breakfast composition on overweight/obesity<sup>1</sup>

First author, publication year, country (reference)	Definition of breakfast	Definition of overweight/obesity	Statistical methods	Results	Impact of BF EI on outcome <sup>2</sup>
Cohort studies					
Purslow, 2008, United Kingdom (13)	Percentage of BF EI	BMI at baseline; weight change (gain) over the course of follow-up	Descriptive statistics; linear regression: regression coefficients adjusted by age, sex, social class, baseline BMI, smoking, physical activity, fruit and vegetable intake, total EI, plasma vitamin C, follow-up time	On baseline data, higher proportion of BF EI is associated with lower BMI (consumers of 22–50% BF EI had a mean BMI of 26.0, consumers of 0–11% BF EI had a mean BMI of 26.3; <i>P</i> -trend = 0.018) Significant negative association between percentage of BF EI and weight gain over the course of ~4 y of follow-up (weight reduction in kg of 0.021 for 1% BF EI increase; <i>P</i> -trend = 0.004)	↓ S
Trials					
Kleemola, 1999, Finland (14)	Cereal BF for women: 210 kcal, 4 g P, <1 g fat, 51 g CHO, 3 g fiber; cereal BF for men: 280 kcal, 6 g P, <1 g fat, 68 g CHO, 4 g fiber (cereals were consumed with skimmed milk, fat-free sour milk products or fruit juices) Control group: usual dietary habits The following values refer to the (observed) baseline—end of study: period 1 (first 6 wk): cereal BF: 425–420 kcal, 53–77% CHO, 13–14% SFAs; controls: 385 kcal, 54% CHO, 13% SFAs; period 2 (next 6 wk, after washout): cereal BF: 360–407 kcal, 51–78% CHO, 12–4% SFAs; controls: 363–399 kcal, 57–55% CHO, 11% SFAs	Weight in kg; weight change between trial periods	Descriptive statistics; ANOVA	No significant difference in mean body weight change between the 2 BF groups (cereal vs. usual dietary habits; <i>P</i> = 0.47 for period 1, <i>P</i> = 0.16 for period 2)	↔
Lattimore, 2010, United Kingdom (15)	Cereal BF: 392 kcal, 13.5 g P, 7.4 g fat, 66.3 CHO, 3.2 g fiber, 37.7 g sugar Muffin BF: 400 kcal, 4.0 g P, 14.5 g fat, 61.4 CHO, 1.6 g fiber, 49.7 g sugar Isoenergetic BF	Weight change	Student's <i>t</i> test	No significant difference in body weight change in either group (all <i>P</i> > 0.05 from baseline to 1 wk later, at completion of the study)	—

(Continued)

TABLE 1 (Continued)

First author, publication year, country (reference)	Definition of breakfast	Definition of overweight/obesity	Statistical methods	Results	Impact of BF EI on outcome <sup>2</sup>
Cross-sectional studies/surveys Bellisle, 1988, France (16)	BF EI: 418.9 kcal (18.6%) in lean, 422.9 kcal (19.1%) in slim, 455.5 kcal (19.2%) in average, 389.1 kcal (17.7%) in fat, 385.1 kcal (15.7%) in O children	Five subgroups of different body compositions: mean BMI (kg/m <sup>2</sup> ) of 13.6 for lean ( <i>n</i> = 37), 14.4 for slim ( <i>n</i> = 40), 16.3 for average ( <i>n</i> = 172), 19.4 for fat ( <i>n</i> = 42), and 22.0 for O ( <i>n</i> = 48) children	Student's <i>t</i> test, ANOVA	Significant lower percentage of BF EI in O than in lean ( <i>P</i> = 0.034) or slim ( <i>P</i> = 0.002) or average ( <i>P</i> = 0.002) children; no difference in BF EI percentage between fat children and other body-composition groups. Among small-BF eaters (<96 kcal), 0% in lean, 2.5% in slim, 4.1% in average, 2.4% in fat, and 4.2% in O children	↓ S
Ortega, 1996, Spain (17)	BF EI: 19.9% (<80 y) and 22.6% (≥80 y) in N vs. 17.4% (<80 y) and 19.3% (≥80 y) in OW/O Percentage of BF intakes: protein: 22.6% (<80 y) and 22.2% (≥80 y) in N vs. 21.2% (<80 y) and 21.3% (≥80 y) in OW/O Fiber: 15.3% (<80 y) and 11.7% (≥80 y) in N vs. 9.6% (<80 y) and 11.5% (≥80 y) in OW/O Percentage of BF EI in OW/O	OW/O: BMI ≥25	Descriptive statistics; linear regression analysis adjusted by age, sex, and place of residence	BF EI: 19.9% (<80 y) and 22.6% (≥80 y) in N vs. 17.4% (<80 y) and 19.3% (≥80 y) in OW/O ( <i>P</i> > 0.05) An adequate BF (>20% daily energy expenditure) was reported in 55% of N and 38% of OW/O ( <i>P</i> < 0.05). Significantly lower percentage of fiber intake in OW/O than in N	↓
Summerbell, 1996, United Kingdom (18)	Percentage of BF EI	BMI Mean BMI based on I vs III tertile of percentage of BF EI—adolescent: 21.7 vs. 18.6; working age: 23.2 vs. 21.8; middle-aged: 25.7 vs. 23.5; elderly: 22.6 vs. 23.4; all: 22.8 vs. 22.6	ANOVA, linear regression (no adjustment provided)	Lower percentage of BF EI was significantly associated with a higher (mean) BMI in adolescents (tertile 1 vs. 3 of percentage of BF EI: 21.7 vs. 18.6; <i>P</i> < 0.05) Significant negative association between percentage of BF EI and BMI among adolescents in continuous linear regression model (average reduction of 0.0095, <i>P</i> < 0.05, considering valid dietary data only) No significant association for the other age groups	↓ S in adolescents
Ortega, 1998, Spain (19)	Percentage of BF EI: <20% BF EI (inadequate BF), ≥20% BF EI (adequate BF)	OW/O: BMI >75th percentile	Descriptive statistics; ANOVA (adjusted by sex)	In boys, 31.6% vs. 25.0% inadequate vs. adequate BF eaters were O; in girls, 16.7% vs. 19.2% inadequate vs. adequate BF eaters were O (not significantly different in boys or girls)	↓ in M ↑ in F

(Continued)

TABLE 1 (Continued)

First author, publication year, country (reference)	Definition of breakfast	Definition of overweight/obesity	Statistical methods	Results	Impact of BF EI on outcome <sup>2</sup>
Ortega, 1998, Spain (20)	BF EI: 462 (M) and 359 (F) kcal in N vs. 409 (M) and 302 (F) kcal in OW/O CHO: 64.7 (M) and 51.3 (F) g in N vs. 55.3 (M) vs. 40.2 (F) g in OW/O P: 12.8 (M) and 10.9 (F) g in N vs. 12.3 (M) and 10.0 (F) g in OW/O Fat: 18.7 (M) and 13.6 (F) g in N vs. 16.9 (M) and 12.4 (F) g in OW/O Fiber: 5.2 (M) and 4.7 (F) g in N vs. 4.4 (M) and 4.2 (F) g in OW/O CHL: 35.7 (M) and 28.3 (F) mg in N vs. 32.7 (M) and 27.1 (F) mg in OW/O	OW/O: BMI > 75th percentile (age- and sex-specific percentile)	Descriptive statistics; ANOVA (adjusted by sex), ANCOVA (adjusted by the degree of under- or overestimation of intake)	Energy supplied by BF (measured as a percentage of total EI) was lower in O (18.6% in M and 16.3% in F) than in N (19.4% in M and 18.3% in F), but was nonsignificant; no significant difference in BF composition	↓
Azizi, 2001, Iran (21)	BF EI <sup>3</sup> : 388 (14.7%, M) and 280 kcal (13.0%, F) in N vs. 391 (12.9%, M) and 219 kcal (10.0%, F) in OW/O	OW and O defined according to recommended BMI cutoffs for adolescents (85th and 95th percentiles for OW and O, respectively)	Student's <i>t</i> test and Pearson correlation	Significantly lower BF EI in OW/O (219 kcal) vs. N (280 kcal) girls ( $P < 0.01$ ); significantly negative correlation between BMI and BF EI in girls ( $r = -0.18$ , $P < 0.01$ ); no significant difference in percentage of BF EI between OW/O and N boys	↓ S in F ↔ in M
Song, 2005, United States (22)	RTEC BF: 222 kcal, 2 g fat, 90 g CHO, 5 g fiber Non-RTEC BF <sup>3</sup> : 466 kcal, 17 g fat, 52 g CHO, 3 g fiber	BMI ≥ 25	Linear and logistic regression. Regression coefficients adjusted by age, ethnicity, sex (when appropriate), smoking, EI	Consumers of RTEC BF were less likely to be OW than non-RTEC BF consumers ( $\beta = -0.95$ , $P = 0.002$ ; OR: 0.75; 95% CI: 0.62, 0.91), although the association was restricted to women ( $\beta = -1.37$ , $P = 0.002$ ; OR: 0.70; 95% CI: 0.52, 0.94) compared with men ( $\beta = -0.56$ , $P = 0.229$ ; OR: 0.99; 95% CI: 0.67, 1.49), with both linear and logistic regression models	↓ S overall ↓ S in F ↓ in M
Torres, 2007, Spain (23)	Low-energy BF (mean $\pm$ SD: 164.2 $\pm$ 31.9 kcal); high-energy BF (591.0 $\pm$ 101.2 kcal)	OW: BMI ≥ 90th percentile for children of the same age and sex; O: BMI ≥ 95th percentile for children of the same age and sex	Descriptive statistics and Pearson correlation	No significant difference in percentage of obesity related to BF EI (10.2% vs. 8.0% for lowest vs. highest energy BF group) No significant correlation between total EI and OW	↓

(Continued)



TABLE 1 (Continued)

First author, publication year, country (reference)	Definition of breakfast	Definition of overweight/obesity	Statistical methods	Results	Impact of BF EI on outcome <sup>2</sup>
Kant, 2008, United States (24)	Tertiles of ED of all BF foods and beverages and corresponding mean BF EI: first tertile ( $\leq 1.05$ kcal/g); 389 kcal; second tertile ( $>1.05$ – $2.12$ kcal/g); 548 kcal; third tertile ( $\geq 2.12$ kcal/g); 446 kcal	O: BMI $\geq 30$	Linear and logistic regression; regression coefficients adjusted by age, race/ethnicity, poverty-income ratio, education, leisure-time physical activity, smoking, survey wave, non-BF EI, total EI, history of weight loss, and self-image	A continuous increase in ED was associated with an increase in mean BMI in the linear model ( $\beta = 0.38$ , $P = 0.001$ ) but was inversely associated with O in the logistic model ( $\beta = -0.12$ , $P = 0.02$ ) in men No association for women	↓ in M with linear model ↑ in M with logistic model ↔ in F
Lloret, 2008, France (25)	Percentage of BF EI—3–6 y: BF EI: 19.7% in N, 20.0% in OW; 7–11 y: BF EI: 20.1% in N, 19.3% in OW	OW/O: BMI $\geq 25$	Chi-square test; final logistic regression model on the 2 age groups together; ORs adjusted by age, sex, leisure physical activity, sedentary behavior, and total EI	No significant difference in the percentage of BF EI between OW and N ( $P = 0.79$ for 3–6 y, $P = 0.41$ for 7- to 11-y group) Nonsignificant negative association between tertiles (BMI: $<16.5$ , 16.5–22.4, $>22.4$ ) of percentage of BF EI and BMI (second tertile—OR: 0.63; 95% CI: 0.38, 1.03; third tertile—OR: 0.76; 95% CI: 0.47, 1.21; $P$ -trend = 0.23)	↓
Baxter, 2010, United States (26)	Average observed BF EI—BF EI: 248 kcal in N, 261 kcal in OW, 302 kcal in O, and 281 kcal in severely O	BMI (in continuous and in the following categories: $<5$ th, 5th to $<85$ th, 85 to $<95$ th, 95th to $<99$ th, $\geq 99$ th percentile)	Mixed-effects linear regression model with school as random effect; regression coefficients adjusted by sex, age, school year, BF participation, BF location, lunch participation, combined participation, average observed EI at BF, and average observed EI at lunch Pooled ordered logistic regression model for the BMI categories, with the same adjustment variables as before, but excluding age and sex	Significant positive association between BF EI and BMI: average increased BMI of $0.42$ kg/m <sup>2</sup> for any 100-kcal increase in BF EI ( $P = 0.045$ ) when BMI was entered in the regression model as a continuous outcome and 24% increased risk of being in the next higher BMI category (OR: 1.24; $P = 0.037$ ) when BMI was entered in the regression model as categorical outcome	↑ S

(Continued)

TABLE 1 (Continued)

First author, publication year, country (reference)	Definition of breakfast	Definition of overweight/obesity	Statistical methods	Results	Impact of BF EI on outcome <sup>2</sup>
Albertson, 2011, United States (27)	Based on tertiles of sugar content of cereals (g sugar/100 g) defined on day 1 recall of all waves—low-sugar: <17 g ( <i>n</i> = 578, 28.7% OW/O); medium-sugar: 17–33 g ( <i>n</i> = 495, 24.3% OW/O); high-sugar: >33 g ( <i>n</i> = 1874, 30.5% OW/O)	Different measures: BMI; BMI-for-age z scores; O: ≥85th percentile of BMI; waist-to-height ratio	Descriptive statistics; weighted regression (with adjustment by the survey design) adjusted by age group, sex, race/ethnicity, household income, total EI, calcium and sugar. Healthy Eating Index–2005 score	Mean BMI values for subjects eating low- (BMI = 20.07), medium- (BMI = 19.97), and high-sugar (BMI = 19.98) cereals were not significantly different from each other ( <i>P</i> > 0.05); however, they were significantly lower than that in non-cereal eaters (BMI = 21.62); the same pattern was observed for the other outcomes	—
Fernández Morales, 2011, Spain (28)	Percentage of BF EI: 13.2% in N, 11.36% in OW, 9.29% in O	Mean BMI of 21.43	Pearson correlation	Nonsignificant negative correlation between percentage BF EI and BMI ( <i>p</i> = −0.11, <i>P</i> = 0.30)	↓ (descriptive statistics)
Chu, 2012, United States (29)	Stratified analysis: the values refer to ≤5 to >5 min spent to prepare BF (for description of BF, see Results column)	OW/O: BMI ≥25 Mean BMI of 22 in N ( <i>n</i> = 357) and 32 in OW/O ( <i>n</i> = 436)	Descriptive statistics	BF EI: 3205–400.7 kcal in N, 342.3–487.7 kcal in OW/O by time spent in preparation Fat (% of EI): 18.32–28.35% in N, 18.94–33.45% in OW/O	↓ (descriptive statistics)
Paxton, 2012, United States (30); partially overlapping with (26)	Average observed BF EI	Different measures—BMI (raw values); BMI z scores; BMI (dichotomized, O: ≥95th percentile, not O: <95th percentile); BMI percentile categories (severely O: ≥99th; O: 95 to <99th; OW: 85 to <95th; UW/N: <85th percentile)	Marginal regression models using generalized estimating equations to account for the nested structure of children within schools; regression coefficients adjusted by sex, age, race, school year, BF participation, lunch participation, average observed EI for lunch and for BF and lunch combined	Significant positive association between BF EI and BMI (average BMI increase in kg of 0.58 for 100-kcal increase in BF EI; <i>P</i> < 0.01); similar results were observed for BMI z scores and BMI percentile categories	↑ S
Almoosawi, 2013, United Kingdom (31)	Substituting 5% of energy from CHO (or P) for a similar amount of energy from fat	Abdominal O: waist circumference >102 cm for M and >88 cm for F	Multivariate nutrient density model adjusted by sex, social occupation, region of residence, smoking, alcohol, recreational physical activity, and total daily EI	A decreased prevalence of abdominal O was significantly associated with increasing BF EI from CHO and simultaneously decreasing BF EI from fat (OR: 0.90; <i>P</i> < 0.001) but not with increasing BF EI from P and simultaneously decreasing BF EI from fat (OR: 1.03; <i>P</i> = 0.65)	—

<sup>1</sup> BF, breakfast; CHL, cholesterol; CHO, carbohydrate; ED, energy density; EI, energy intake; F, females; M, males; N, normal weight; O, obese; OW, overweight; P, protein; RTEC, ready-to-eat cereal; S, significant association; UW, underweight.

<sup>2</sup> To summarize the impact of energy intake from breakfast we used the following notation: ↓, negative relation (lower EI is associated with a higher weight); ↑, positive relation (higher EI is associated with a higher weight); ↔, no relation; —, indicated no information on energy intake but on breakfast composition only.

<sup>3</sup> We calculated the group-specific values of breakfast energy intake from the available data. We reported the corresponding percentage of energy intake in parentheses.



(57%), showed no association (14, 17, 18, 24) (**Supplemental Figure 1**).

**Breakfast composition and overweight/obesity.** Among the 8 available studies that investigated the effect of breakfast composition, 2 were trials (14, 15) and 6 were cross-sectional studies or surveys (17, 20, 22, 27, 29, 31). Five studies (14, 15, 22, 27, 31) assessed the specific effect of cereals at breakfast (14, 15, 22) or related issues (e.g., their sugar content or the substitution of energy from carbohydrates or protein with fat) (27, 31), whereas 3 studies assessed the effect of dietary habits in general (17, 20, 29). Two studies used interviewer-administered dietary assessment instruments (22, 27) and 6 studies used self-reported (14, 15, 17, 20, 29, 31) dietary assessment instruments, mostly diary food records (14, 17, 20, 29, 31). Six studies used multiple regression models (14, 17, 20, 22, 27, 31), and 5 were sponsored by industry (14, 15, 20, 22, 27).

In a large US survey, consumers of a ready-to-eat cereal (RTEC) breakfast were significantly less likely to be overweight than non-RTEC breakfast consumers, with the former breakfast being characterized by fewer calories (222 compared with 466 kcal), less fat (2 compared with 17 g), more carbohydrates (90 compared with 52 g), and more fiber (5 compared with 3 g) than the latter (22). Similarly, in a survey from the United Kingdom, a decreased prevalence of abdominal obesity at age 53 y was significantly associated with increasing energy intake at breakfast from carbohydrates and simultaneously decreasing energy intake from fat at age 43 y; however, the same was not true if the increased energy intake at breakfast was from protein (31). In a US survey that focused on sugar in cereals, the mean BMI of children and adolescents who consumed cereals with different sugar contents at breakfast (<17, 17–33, or >33 g/100 g) was not significantly different across groups, although it was significantly lower than that of non-cereal eaters (27). In a Spanish survey in elderly individuals, obese subjects had a significantly lower percentage of fiber intake than did normal-weight individuals (17); however, in a Spanish survey in schoolchildren from the same authors, no significant difference was found in breakfast composition between normal-weight and overweight subjects (20). Finally, in 2 European trials (14, 15), no significant difference in body weight change was observed between a breakfast option based on cereals and other types of breakfast (including the subject's usual diet) over 6 wk (14) and an isoenergetic muffin-based breakfast during 1 wk (15).

## Discussion

In the present review, we identified 19 studies, mainly conducted in Europe in the past decade, that provided quantitative estimates on the effect of the amount of energy intake at breakfast or of breakfast composition on various measures of overweight or obesity, mainly BMI. Of the 16 studies that investigated the effect of the amount of energy intake at breakfast, 4 found that a lower absolute percentage of energy intake at breakfast was significantly associated

with obesity (13, 16, 18, 22). Conversely, 2 other partially overlapping studies found that a higher energy intake was significantly associated with a higher BMI in children aged 9–10 y (26, 30). The conflicting results may be due, at least in part, to heterogeneity in the age of the participants.

Of the 8 studies that investigated the effect of breakfast composition, 3 surveys suggested that a breakfast characterized by a lower amount of fat and a higher amount of carbohydrates is significantly associated with normal weight among children and adolescents (27) and adults (22, 31), whereas the other studies reported mixed results (14, 15, 17, 20, 29). However, there were insufficient quantity and consistency among studies to draw firm conclusions, and most of the studies were cross-sectional.

**Strengths and limitations.** Although most of the included studies were carried out in well-nourished subjects from developed countries, some heterogeneity emerged with regard to participant age. Half of the studies were in children and adolescents, and the other half were in adults. However, further analyses showed consistent results in the 2 subgroups. Similarly, some heterogeneity existed with regard to the sex of the participants.

In addition, only a few studies acknowledged the importance of potentially relevant confounding factors such as socioeconomic status (SES)—or its proxies (e.g., social class and occupation, income, education) (13, 19, 20, 24, 27, 31)—and physical activity (13, 24, 25, 31), although these factors may have a substantial effect on weight (32). In detail, among the 10 studies that presented results from regression models of any kind, 5 provided an adjustment for SES and/or physical activity (13, 24, 25, 27, 31).

A limitation of the studies included in our systematic review is that measured outcomes and exposures may suffer from underreporting. A differential underreporting of weight and food intakes between obese and normal-weight subjects, as well as between children and adolescents/adults, cannot be excluded (21, 25). Potential bias due to underreporting in frequency and consumed amounts may have an impact on the identified relation/associations. Three of the included studies assessed this effect, with mixed results (18, 20, 24). However, a reassuring aspect is that most of the studies ( $n = 16$ ; 84%) recruited trained personnel to measure the anthropometric variables of interest, thus limiting the risk of potential underreporting related to the outcome of interest.

Most of the available studies ( $n = 16$ ; 84%) referred to BMI as the main outcome of interest, thus improving comparability of results across studies. Moreover, some of the studies ( $n = 8$ ; 50%) referred to BMI in a continuous scale and consistently proposed results from linear regression models. Unfortunately, when results were presented for different BMI categories, various cutoffs were adopted across studies.

Moreover, differences were found in the dietary assessment methods used for the collection of dietary information. FFQs, 24-h dietary recalls, food diaries with different reference

periods, and diet histories were used across the different studies. Only a few studies were based on validated dietary assessment methods (13, 15, 18, 23). Records from self-reported and interviewer-administered dietary instruments were also allowed. This may limit the effective comparability of study-specific exposure variables.

With regard to study design, almost all of the studies included in the present review were cross-sectional. If, in principle, this limits heterogeneity, it is also an important limitation of our review, because no causal relation may be assessed from a similar design. Moreover, reverse causation is a potential issue of this study design: although quantitative estimates are calculated, there is no way to attribute a temporal direction to the relation between exposure and outcome, and therefore to assess causality. This makes the evidence from these studies relatively weak. However, it is difficult to conceive and design trials on similar topics. In addition, it is also worth noting that the 2 available trials included in the review were from Europe, focused on the effect of cereals, and showed null results. However, although 1 trial (14) had a potentially sufficient follow-up to observe a weight change (6 wk for each of the 2 trial periods, with a washout period in-between), the other one (15), which had a duration of 1 wk, likely had a very low possibility of showing important modifications in body weight.

In summary, among the selected studies, only 1 study (13), the only cohort study included in the review, was a “high-quality” study. It presented all of the following characteristics: based on a large sample size, used a validated dietary questionnaire, measured anthropometric variables, and included model adjustment for SES and physical activity. This study from the EPIC (European Prospective Investigation into Cancer and Nutrition)–Norfolk, which was based on almost 7000 adults aged 40–75 y, found a significant negative association between percentage of breakfast energy intake and weight gain over the course of ~4 y of follow-up (weight reduction in kg: of 0.021 for a 1-percentage-point increase;  $P$ -trend = 0.004). No study on breakfast nutrient composition had all of these characteristics.

In addition, of the 19 studies included in the present review, 7 were funded by food companies (i.e., Kellogg’s, Danone, PepsiCo, and General Mills); none of the included studies were funded by other sources only. The sponsorship seems not to have affected the results. Indeed, of the 7 sponsored studies, 4 reported null results for breakfast energy intake and/or breakfast nutrient composition.

**Possible mechanisms.** Although obesity has known genetic determinants, environmental factors—in particular diet—may play a role in its development. When energy intake is higher than energy expenditure, and therefore requirements, the amount of energy stored increases, with a corresponding increase in body fat. This potentially leads to obesity. Identifying a sensible amount (percentage) of energy intake at breakfast may contribute to avoiding energy imbalance and thus to preventing overweight/obesity. The composition of breakfast per se may be a relevant factor in obesity development. Some studies shared the hypothesis that a higher percentage of energy from carbohydrates at breakfast (instead

of fat) may have positive effects on satiation immediately after a meal, as well as on sustained satiety during the entire day and, in the long term, on weight gain (14, 17, 20). This hypothesis is also at the origin of several studies that reported specifically on the effect of RTEC breakfast consumption, in which a lower intake of cholesterol and a higher intake of fiber, in addition to a lower intake of fat, may protect against weight gain, (14, 17, 31). However, not all carbohydrates are equal: a breakfast high in refined sugars could have a different effect on weight than a breakfast high in whole grains, the former being related to a higher obesity risk than the latter (33).

Obese individuals are more likely to have less “satisfactory” breakfast habits than normal-weight individuals. This might be a reflection of an overall inadequate diet. For instance, obese individuals may have less-varied diets, with variety being negatively correlated with obesity (17). Similarly, patterns of food selection are related to food preferences and may be similar across eating events in the day (24). However, it is also conceivable that an inadequate breakfast contributes to worse food choices over the rest of the day and, in this regard, to an increased risk of obesity in the long term. An obese individual may compensate for an insufficient amount of energy from breakfast by consuming foods higher in energy over the rest of the day and/or by consuming high-fat snacks during the morning, thus deriving more energy from fat than from protein or carbohydrates (34). In addition, an inadequate breakfast may also be associated with a reduced level of physical activity which, in turn, is related to the development of overweight/obesity (35).

**Summary of findings.** In conclusion, there is some evidence from observational studies that energy intake at breakfast may be associated with overweight/obesity in children, adolescents, and adults. In particular, most of the studies found that a lower energy intake at breakfast may be associated with overweight/obesity. Future research—in particular, from large, long-term randomized trials—should focus on improving the comparability of study-specific results via standardization of exposures, outcomes, and relevant confounding factors.

## Acknowledgments

VR and VE collected the existing literature and selected the included studies under the supervision of CA; VR wrote the manuscript under the supervision of VE, who contributed to the Methods and Conclusions sections; AD and MF provided useful suggestions on summarizing the design and statistical analysis of the included studies; MP, GPM, and AM provided useful suggestions on summarizing details of the available breakfast options; and CA conceived the systematic review. All authors read and approved the final manuscript.

## References

1. World Health Organization. Obesity and overweight. Fact sheet no. 311. Updated January 2015. [cited 2016 Mar 15]. Available from: <http://www.who.int/mediacentre/factsheets/fs311/en/>.
2. Casazza K, Brown A, Astrup A, Bertz F, Baum C, Brown MB, Dawson J, Durant N, Dutton G, Fields DA, et al. Weighing the evidence of common beliefs in obesity research. *Crit Rev Food Sci Nutr* 2015;55:2014–53.

3. Hernández Rodríguez M. Alimentación del niño preescolar y escolar [Diet and nutrition for the preschool and school-age child]. In: Hernández Rodríguez M, editor. *Infant diet*. 3rd ed. Madrid: Díaz de Santos; 2001. p. 73–8 (in Spanish).
4. Freedman DS, Mei Z, Srinivasan SR, Berenson GS, Dietz WH. Cardiovascular risk factors and excess adiposity among overweight children and adolescents: the Bogalusa Heart Study. *J Pediatr* 2007;150:12–7, e2.
5. de la Hunty A, Gibson S, Ashwell M. Does regular breakfast cereal consumption help children and adolescents stay slimmer? A systematic review and meta-analysis. *Obes Facts* 2013;6:70–85.
6. Mesas AE, Munoz-Pareja M, Lopez-García E, Rodríguez-Artalejo F. Selected eating behaviours and excess body weight: a systematic review. *Obes Rev* 2012;13:106–35.
7. Timlin MT, Pereira MA. Breakfast frequency and quality in the etiology of adult obesity and chronic diseases. *Nutr Rev* 2007;65:268–81.
8. Szajewska H, Ruszczyński M. Systematic review demonstrating that breakfast consumption influences body weight outcomes in children and adolescents in Europe. *Crit Rev Food Sci Nutr* 2010;50:113–9.
9. Horikawa C, Kodama S, Yachi Y, Heianza Y, Hirasawa R, Ibe Y, Saito K, Shimano H, Yamada N, Sone H. Skipping breakfast and prevalence of overweight and obesity in Asian and Pacific regions: a meta-analysis. *Prev Med* 2011;53:260–7.
10. Williams PG. The benefits of breakfast cereal consumption: a systematic review of the evidence base. *Adv Nutr* 2014;5:636S–73S.
11. Casazza K, Fontaine KR, Astrup A, Birch LL, Brown AW, Bohan Brown MM, Durant N, Dutton G, Foster EM, Heymsfield SB, et al. Myths, presumptions, and facts about obesity. *N Engl J Med* 2013;368:446–54.
12. Moher D, Liberati A, Tetzlaff J, Altman DG. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *BMJ* 2009;339:b2535.
13. Purslow LR, Sandhu MS, Forouhi N, Young EH, Luben RN, Welch AA, Khaw KT, Bingham SA, Wareham NJ. Energy intake at breakfast and weight change: prospective study of 6,764 middle-aged men and women. *Am J Epidemiol* 2008;167:188–92.
14. Kleemola P, Puska P, Vartiainen E, Roos E, Luoto R, Ehnholm C. The effect of breakfast cereal on diet and serum cholesterol: a randomized trial in North Karelia, Finland. *Eur J Clin Nutr* 1999;53:716–21.
15. Lattimore P, Walton J, Bartlett S, Hackett A, Stevenson L. Regular consumption of a cereal breakfast. Effects on mood and body image satisfaction in adult non-obese women. *Appetite* 2010;55:512–21.
16. Bellisle F, Rolland-Cachera MF, Deheeger M, Guillaud-Bataille M. Obesity and food intake in children: evidence for a role of metabolic and/or behavioral daily rhythms. *Appetite* 1988;11:111–8.
17. Ortega RM, Redondo MR, Lopez-Sobaler AM, Quintas ME, Zamora MJ, Andres P, Encinas-Sotillos A. Associations between obesity, breakfast-time food habits and intake of energy and nutrients in a group of elderly Madrid residents. *J Am Coll Nutr* 1996;15:65–72.
18. Summerbell CD, Moody RC, Shanks J, Stock MJ, Geissler C. Relationship between feeding pattern and body mass index in 220 free-living people in four age groups. *Eur J Clin Nutr* 1996;50:513–9.
19. Ortega RM, Requejo AM, Navia B, Lopez-Sobaler AM, Quintas ME, Andres P, Redondo MR, Lopez-Bonilla MD, Rivas T. The relationship between the consumption of an inadequate breakfast and energy profile imbalance in preschool children. *Nutr Res* 1998;18:703–12.
20. Ortega RM, Requejo AM, Lopez-Sobaler AM, Quintas ME, Andres P, Redondo MR, Navia B, Lopez-Bonilla MD, Rivas T. Difference in the breakfast habits of overweight/obese and normal weight schoolchildren. *Int J Vitam Nutr Res* 1998;68:125–32.
21. Azizi F, Allahverdian S, Mirmiran P, Rahmani M, Mohammadi F. Dietary factors and body mass index in a group of Iranian adolescents: Tehran Lipid and Glucose Study–2. *Int J Vitam Nutr Res* 2001;71:123–7.
22. Song WO, Chun OK, Obayashi S, Cho S, Chung CE. Is consumption of breakfast associated with body mass index in US adults? *J Am Diet Assoc* 2005;105:1373–82.
23. Torres MD, Carmona I, Campillo C, Perez G, Campillo JE. Breakfast, plasma glucose and beta-hydroxybutyrate, body mass index and academic performance in children from Extremadura, Spain. *Nutr Hosp* 2007;22:487–90.
24. Kant AK, Andon MB, Angelopoulos TJ, Rippe JM. Association of breakfast energy density with diet quality and body mass index in American adults: National Health and Nutrition Examination Surveys, 1999–2004. *Am J Clin Nutr* 2008;88:1396–404.
25. Lioret S, Touvier M, Lafay L, Volatier JL, Maire B. Are eating occasions and their energy content related to child overweight and socioeconomic status? *Obesity (Silver Spring)* 2008;16:2518–23.
26. Baxter SD, Hardin JW, Guinn CH, Royer JA, Mackelprang AJ, Devlin CM. Children's body mass index, participation in school meals, and observed energy intake at school meals. *Int J Behav Nutr Phys Act* 2010;7:24.
27. Albertson AM, Thompson DR, Franko DL, Holschuh NM. Weight indicators and nutrient intake in children and adolescents do not vary by sugar content in ready-to-eat cereal: results from National Health and Nutrition Examination Survey 2001–2006. *Nutr Res* 2011;31:229–36.
28. Fernández Morales I, Aguilar Vilas MV, Mateos Vega CJ, Martínez Para MC. Breakfast quality and its relationship to the prevalence of overweight and obesity in adolescents in Guadalajara (Spain). *Nutr Hosp* 2011;26:952–8.
29. Chu YL, Addo OY, Perry CD, Sudo N, Reicks M. Time spent in home meal preparation affects energy and food group intakes among midlife women. *Appetite* 2012;58:438–43.
30. Paxton AE, Baxter SD, Tebbis JM, Royer JA, Guinn CH, Devlin CM, Finney CJ. Nonsignificant relationship between participation in school-provided meals and body mass index during the fourth-grade school year. *J Acad Nutr Diet* 2012;112:104–9.
31. Almoosawi S, Prynne CJ, Hardy R, Stephen AM. Time-of-day of energy intake: association with hypertension and blood pressure 10 years later in the 1946 British Birth Cohort. *J Hypertens* 2013;31:882–92.
32. Timlin MT, Pereira MA, Story M, Neumark-Sztainer D. Breakfast eating and weight change in a 5-year prospective analysis of adolescents: Project EAT (Eating Among Teens). *Pediatrics* 2008;121:e638–45.
33. Rampersaud GC, Pereira MA, Girard BL, Adams J, Metz JD. Breakfast habits, nutritional status, body weight, and academic performance in children and adolescents. *J Am Diet Assoc* 2005;105:743–60; quiz: 61–2.
34. Ashwell M. An examination of the relationship between breakfast, weight and shape. *Br J Nurs* 2010;19:1155–9.
35. EFSA Panel on Dietetic Products, Nutrition and Allergies. Scientific opinion on dietary reference values for energy EFSA J 2013;11:3005.