REVIEW ARTICLE
Effects of eating breakfast on children and adolescents: A systematic review of potentially relevant outcomes in economic evaluations

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Abstract
Background: Breakfast is often described as the most important meal of the day. Several studies have focused on examining if breakfast habits have any short-term effects on school attendance, academic achievement, and general health in children and adolescents. Informed decisions of whether to promote eating breakfast or not require a more long-term perspective.

Objective: The aim of this study was to conduct a systematic review of scientific publications studying the effects identified as potentially relevant for the economic evaluation of eating breakfast in children and adolescents.

Design: A systematic literature review was conducted. Studies were identified by searching the electronic databases PubMed, CINAHL, Web of Science, and PsycINFO between January 2000 and October 2017. The inclusion criteria applied were published articles from peer-reviewed journals with full text in English, quantitative studies collecting primary data with school-aged children, and adolescents aged from 6 to 18 years as participants, performed entirely or partly in countries with advanced economies, except Japan and Taiwan.

Results: Twenty-six studies fulfilled the inclusion criteria, and studies that were judged to be of at least moderate quality were included in the analysis. The results of the review of eating breakfast studies showed positive and conclusive effects on cognitive performance, academic achievement, quality of life, well-being, and on morbidity risk factors.

Conclusions: The overall assessment of the studies indicated positive effects of eating breakfast. How the identified effects influence societal costs and an individual’s quality-adjusted life years require further research.

Keywords: children; adolescents; youth; breakfast; effects; review

Popular scientific summary
• The article reviews the potential study outcomes for the economic evaluation of long-term effects of eating breakfast in children and adolescents.
• The studies showed positive and conclusive effects on cognitive performance, academic achievement, quality of life, well-being, and on morbidity risk factors.
• How the identified effects influence societal costs and an individual’s quality-adjusted life years require further research.
• Development of simulation models to estimate the long-term costs and effects of eating breakfast should be considered.

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As societal resources are scarce, and needs are endless, choices between health interventions must be made. Several published reviews have examined varying short-term effects of eating breakfast on children and adolescents (6, 13–15). However, informed decisions of whether to promote eating breakfast or not require a more long-term perspective. Economic evaluation seeks to identify, quantify, and compare the long-term costs and effects of different interventions for well-founded and informed decision-making. The costs are weighed against the health effects measured in such a way that it corresponds to a value, usually quality-adjusted life years (QALYs). This measure should ideally encapsulate the impact of an intervention on a person’s length of life and the impact on their health-related quality of life. To our knowledge, it remains unstudied which short-term effects of breakfast eating that may serve as parameters for modeling long-term effects of eating breakfast in economic evaluations. As a starting point for future economic assessments, our intention was to review study outcome measures and identify those that could transform into long-term QALY’s.

The aim of this study was to conduct a systematic review of scientific publications studying effects identified as potentially relevant for the economic evaluation of eating breakfast in children and adolescents.

**Methods**

**Search methods for identification of studies**

Studies were identified by searching the electronic databases PubMed, CINAHL, Web of Science, and PsycINFO between January 2000 and October 2017.

To capture all relevant articles published in the field, two different search strategies were constructed (see Table 1).

**Selection of studies**

One of the authors (ML) conducted the search in October 2017. Initially, two of the authors (ML and NEV) read all titles and abstracts of the identified studies to determine the relevance of each article. If title and abstract met with the inclusion criteria, the study proceeded to the next stage of the review process. Studies with insufficient information in title and abstract were also proceeded to the next stage of the review process. After this selection, all authors (ML, L-AL, and NEV) read the remaining studies in full text, in order to confirm the inclusion eligibility and conduct the quality assessment.

The inclusion criteria applied in the review were determined before the initial search. The criteria are presented as follows:

- Published articles from peer-reviewed journals with full text in English.
- Studies collecting primary data.
- Quantitative studies.
- Study participants in the age of 6 to 18 years.
- Studies performed entirely or partly in countries listed by Central Intelligence Agency (CIA) as advanced economies, except Japan and Taiwan (16).
- Studies using clear definitions of eating and not eating breakfast.

**Review of quality**

In pairs, the authors read the articles in full to assess both eligibility and scientific quality. If the two authors who made the initial assessment did not agree, the third author will also read the article. The scientific quality assessment was based on the following criteria: adequate control group(s), randomization, sufficient statistical power, control of confounders, sufficient descriptions of experimental design, relevance of outcome measures, and consistency between reported results and conclusions (17, 18).

During the selection process, the authors assessed the relevance of the outcome measures (i.e. study effects). Study effects deemed to have the potential to be transformed into long-term effects were selected and categorized into four topics: academic achievement, quality of life and well-being, morbidity risk factors, and cognitive

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**Table 1. Search strategies**

| Search strategy 1 | Search strategy 2 |
|-------------------|-------------------|
| **Breakfast**     | **School**        |
| **AND**           | **Search strategy 1** |
| **Children OR Adolescents OR Teen OR Youth OR Students OR Kids OR Pupils** | **Breakfast** |
| **AND**           | **AND**           |
| **Behavior OR Mental OR Learning OR Effect OR Cognitive OR Academic OR Achievement OR Performance OR Well-being OR Quality of life OR Health** | **Children OR Adolescents OR Teen OR Youth OR Students OR Kids OR Pupils** |

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performance. Studies focusing on the association between adiposity, obesity, overweight, and eating breakfast were excluded, because the topic has already been studied thoroughly. Studies using other outcome measures were also excluded.

In order not to let the results of the study affect the quality assessment, this was done separately without, as far as possible, reading the study results. The criteria for quality assessment varied with different study types. The quality of the studies was rated as high, moderate, or low. A study rated “high quality” had to fulfill all the quality criteria. Studies of moderate quality fulfilled several of the criteria. Finally, low-quality studies either failed to meet several of the criteria or had major shortcomings in certain criteria. Studies rated as being of high or moderate quality were included in the further analysis. The low-quality studies were excluded. They are presented with a comment in Appendix 1. Table 2 contains the following information from the included studies: reference, participant characteristics (number, age, gender), study design, study purpose, outcomes, authors conclusions, and the scientific quality assessment.

**Result compilation**

A compilation of the study results based on statistical inference is presented in Table 3. A study was deemed positive if it had at least one statistically significant positive outcome measure, a study was deemed negative if it had at least one statistically significant negative outcome, and a study was deemed “no effect” if it showed no statistically significant results. A two-tailed p-value of 0.05 was considered statistically significant.

**Result of the search**

The flow chart presented in Fig. 1 illustrates the work process. Database searches identified 5,200 articles. After the removal of duplicates, 2,958 unique articles remained. Exclusion based on information given in title and abstract resulted in the removal of 2,908 articles. The full-text reading of the articles resulted in the additional exclusion of 16 articles that did not meet the inclusion criteria, and eight articles were excluded because of low quality (19–26) (see Appendix 1). Finally, 26 articles met the inclusion criteria and remained for further analysis.

**Results**

The 26 studies included in the analysis are summarized in Table 2.

All studies were published between 2003 and 2017. The countries represented were the UK (seven studies); the United States (three studies); Canada, Norway, Australia, and Sweden (two studies each); and Denmark, Germany, Italy, and the Netherlands (one study each). Four studies were multinational. Nineteen of the included studies were observational. Four of these were also longitudinal with follow-up periods of 27 years in two studies, 21 years and 6 months in one study each. Five studies employed randomization. One study was a cluster-randomized controlled trial, three studies employed randomized crossover designs, and one study used a cluster-randomized crossover design. One study was a non-randomized controlled trial, and one study employed a separate-group design.

The number of participants included in the studies varied from 29 to 28,608. Based on the predetermined inclusion criteria, the age range of all children and adolescents included in the studies were from 6 to 18 years. Four of the studies had participants with a mean age below 10 years (27–30), the remaining 22 focused on studying participants with a mean age of 10 or more years (5, 31–51).

The studies included a variety of outcome measures and instruments. The outcome measures that met inclusion criteria were grouped into four categories. Nine studies comprise the category of morbidity risk factors associated with eating or not eating breakfast (29–37). Eight studies form the academic achievement category, with outcome measures that study links between breakfast and academic achievement (5, 28, 43–48). Six studies analyzed the association between breakfast eating and cognitive disorders, comprising the category of cognitive performance (27, 38–40, 49, 50). Finally, the quality of life and/or well-being category is made up of three studies, analyzing links between breakfast eating and QoL and/or well-being (41, 42, 51). No study concerning the cost-effectiveness of eating breakfast was found. Table 3 shows the compilation of the study results.

**Morbidity risk factors**

All of the nine studies with morbidity risk factors as outcomes were observational studies. Five of the studies examined the association between breakfast consumption and the metabolic syndrome. Marlatt et al. found that higher levels of breakfast consumption were significantly associated with lower risk for insulin resistance as well as other risk factors for metabolic syndrome (32). This is in line with what both Sese et al. and Wennberg et al. concluded in their studies (34, 36, 37). The two studies conducted by Wennberg et al. were longitudinal with 27 years of follow-up. In both studies, they found an association between poor breakfast habits and future risk of developing metabolic syndrome. Hallstrom et al. studied the association between breakfast consumption and cardiovascular disease risk factors. Their results indicated that adolescents who regularly consumed breakfast had higher cardiorespiratory fitness and lower total adiposity (31). Significant effects of breakfast consumption on blood lipid levels, blood pressure, or insulin resistance were found in overweight/obese male participants, while no significant effects were found among female participants.
| First author (year), country | Participants | Study design | Study purpose | Outcomes | Author conclusion | Scientific quality assessment |
|-----------------------------|--------------|--------------|---------------|----------|------------------|-----------------------------|
| Hallstrom et al. (2013), SE, ES, BE, DE, FR GR, IT, AU (31) | 2,929 | 14.7 years | 53% | Cross-sectional, observational | To examine the association between breakfast consumption and cardiovascular disease (CVD) risk factors in European adolescents. | Cardiorespiratory fitness, Physical activity, Serum triacylglycerol (TAG), Total cholesterol (TC), High-density lipoprotein-cholesterol (HDL-C), Low-density lipoprotein-cholesterol (LDL-C), Glucose | Findings regarding European adolescents confirm previous data indications: adolescents who consume breakfast regularly have lower body fat content than other peers. Results also show that regular breakfast consumption (BC) is associated with higher cardiorespiratory fitness and (especially in male adolescents) with a healthier cardiovascular profile and negation of the effect of excess adiposity on TC and LDL-C. | Moderate |
| Marlatt et al. (2016), US (32) | 367 | 14.7 years | 49% | Observational | To evaluate the relationship between both breakfast and fast food consumption on selected biomarkers and important cardiovascular and metabolic risk factors among healthy adolescents, and further examine the relationship between these dietary behaviors and the known risk factor clustering that occurs with the metabolic syndrome. | Body mass index (BMI), Percent body fat (PBF), S-, DBP, L-, HDL, Triglyceride (TG), Glucose, Insulin, Homeostasis Model Assessment-Insulin Resistance Index (HOMA-IR), metabolic syndrome (MetS) cluster score | The finding suggests that fast food and BC are associated with some metabolically important chronic disease risk factors in healthy adolescents. | Moderate |
| Moschiano et al. (2012), IT (33) | 800 | 10≤ years | 40.6% | Observational | To assess the possible association between headache and specific habits and lifestyle factors. | Headache | Evidence of clear association between headache and irregular intake of meals (especially irregular breakfast) and sleep disturbance with significant differences when comparing subjects with and without headache. | Moderate |
| Papoutsou et al. (2014), CY, GR, BE, ES (29) | 8,863 | 2 < 10 years | 48.8% | Cross-sectional, Observational | To investigate the relationship between breakfast routine and CVD risk factors in a multinational sample. | Blood glucose, TC, LDL-C, HDL-C, TG, Physical activity (PA) | Daily BC contributes to controlling school-aged children’s weight and lipid profile. It promotes higher PA. | Moderate |
Table 2. (Continued)

| First author (year), country | Participants | Study design | Study purpose | Outcomes | Author conclusion | Scientific quality assessment |
|-----------------------------|-------------|--------------|---------------|----------|-------------------|-----------------------------|
| Sese et al. (2012), ES, GB, FR, BE, DE, AU, HU, GR (34) | 826 | 14.8 years | Observational | To examine the associations of food behaviors and preferences with markers of insulin resistance and clustered metabolic risk factors score after controlling for potential confounders, including body fat in European adolescents. | TG, TC, HDL-C, Blood glucose, School Breakfast Program (SBP), HOMA-IR | The results of this study indicate that insulin resistance and a clustered metabolic risk factors score are positively associated with food behaviors and preferences. Skipping breakfast explains part of the insulin resistance variance. | Moderate |
| Smith et al. (2010), AU (30) | 2,184 | N/A | Longitudinal, observational; follow-up period: 21 years. | To examine longitudinal associations of breakfast skipping in childhood and adulthood with cardiometabolic risk factors in adulthood. | Mean weight, Circumference, Cardiometabolic risk factors | Participants skipping breakfast in both childhood and adulthood had larger waist circumferences, higher BMIs, and poorer cardiometabolic profiles than did those who reported eating breakfast at both time points. | Moderate |
| Walter (2014), US (35) | 13,570 | 11–17 years | Cross-sectional | To study how lifestyle behaviors (skipping meals, water intake, tobacco use, alcohol use, and physical activity) and illness-related factors (depression, somatic complaints, insomnia, and obesity) work together to predict headache in an adolescent population. | Recurrent headache | Lifestyle behaviors and illness-related factors are associated with adolescent headache. Skipping breakfast three or more times was one of them. | Moderate |
| Wennberg et al. (2015), SE (36) | 889 | 16 years | Longitudinal, observational; follow-up period: 27 years. | To analyze whether poor breakfast habits in adolescence predict the metabolic syndrome and its components in adulthood. | Metabolic syndrome, Central obesity, High fasting glucose | Poor breakfast habits in adolescence predicted the metabolic syndrome in adulthood. Of the metabolic syndrome components, poor breakfast habits in adolescence predicted central obesity and high fasting glucose in adulthood. | Moderate |
| Wennberg et al. (2016), SE (37) | 889 | 16 years | Longitudinal, observational; follow-up period: 27 years. | To investigate whether irregular eating of meals in adolescence predicts the metabolic syndrome and its components in adulthood, and if any specific meal is of particular importance. | Metabolic syndrome | Irregular eating of meals in adolescence predicted the metabolic syndrome in adulthood, but not independently of BMI and lifestyle in adolescence. Poor breakfast in adolescence was the only specific meal associated with future metabolic syndrome, even after adjustments. | Moderate |
| First author (year), country | Participants | Study design | Study purpose | Outcomes | Author conclusion | Scientific quality assessment |
|-----------------------------|--------------|--------------|---------------|----------|-------------------|-----------------------------|
| Cognitive performance       |              |              |               |          |                   |                             |
| Cooper et al. (2011), GB (50) | 96           | 13.3 years   | 62.5%         |          | BC improved the accuracy of responses on the visual search and Stroop tests. BC also improved response times on the more complex levels of the Sternberg paradigm, but did not have consistent effects on response times on the other tests conducted. BC was particularly beneficial for the more cognitively demanding tasks, whereas the simpler tasks could be performed to a similar level following breakfast omission. | Moderate |
| Defeyter and Russo (2013), GB (49) | 40           | 14.2 years   | 52.5%         |          | Overall, it appeared that after breakfast, participants felt more alert, satiated, and content. Only in the recall task did performance appear to be significantly modulated by the interactive combination of the effect of BC and task difficulty, with improved performance at time two when the task was harder. | Moderate |
| Hjorth et al. (2016), DK (27) | 710–828      | 9.9 years    | 49%           |          | Normal weight children had higher cognitive performance compared to overweight/obese and underweight children. Daily BC was associated with higher cognitive performance in the d2-test, mathematics and/or sentence-reading test. | Moderate |
### Table 2. (Continued)

| First author (year), country | Participants | Study design | Study purpose | Outcomes | Author conclusion | Scientific quality assessment |
|-----------------------------|--------------|--------------|---------------|----------|-------------------|-------------------------------|
| Wesnes et al. (2003), GB (38) | 29 | 12 years | Randomized, four-way crossover design | To determine the extent to which breakfast cereals would help to prevent declines in cognitive function in school children. | Cognitive drug research (CDR) test: Word presentation, immediate word recall, picture presentation, simple reaction time, digit vigilance, choice reaction time, spatial and numeric working memory, delayed word recall, word and picture recognition (attention, working memory, episodic secondary memory) Bond and Lader (mood, alertness) | Skipping breakfast impairs attention and episodic memory, increasing in magnitude over the morning. Ingesting carbohydrates in the form of breakfast cereals reduces attention deficit by more than half and, for some aspects of memory (immediate word recall), prevents the deficit altogether. No benefits to attention or episodic memory with the glucose drink; in fact, greater initial impairment with the drink than with no drink or breakfast. Improvements in alertness and contentment did occur for 90 min following the glucose drink, but effects faded thereafter, whereas the benefits continued from the two cereals. | Moderate |
| Wesnes et al. (2012), GB (39) | 1,386 | 10.59 years | Controlled trial | To determine the extent to which breakfast cereals would help to prevent declines in cognitive function in school children. | Power of attention Response speed variability Digit vigilance task Choice reaction time task Picture recognition | Power of Attention, a score reflecting the ability to focus attention and avoid distraction, was slowed by 7% in those children who did not have breakfast. The ability to sustain attention was also compromised, 7% less targets being detected in the digit vigilance task while 23% more false alarms were made. The ability to correctly identify pictures was impaired by 9% and speed was slowed by 9%. Finally, the response speed variability was 10% greater in children who did not have breakfast. These scores reflect every aspect of cognitive performance assessed, showing a comprehensive difference between the two groups. | Moderate |
| Widenhorn-Müller (2008), DE (40) | 104 | 17.2 years | Randomized crossover design | To determine whether breakfast had effects on the cognitive performance and mood of high school students. | d2-Test (concentration speed and attention) Lern- und Gedächtnistest (LGT-3, learning capacity, immediate memory) Verfahren zur Erfassung des Gefühlszustandes (VGZ, mood assessment scale) | This crossover trial demonstrated positive short-term effects of breakfast on cognitive functioning and self-reported alertness in high school students. | Moderate |
Table 2. (Continued)

| First author (year), country | Participants | Study design | Study purpose | Outcomes | Author conclusion | Scientific quality assessment |
|-----------------------------|--------------|--------------|---------------|----------|-------------------|-------------------------------|
| **Quality of life and well-being** | | | | | | |
| Page et al. (2009), US, SK, HU, RO, CZ (41) | 1,121 | Cross-sectional | To investigate self-rated health (SRH) in Central and Eastern European (CEE) adolescents and determine its association with psychosocial functioning and other dimensions of adolescent health. | Self-Rated Health R-UCLA Loneliness Scale Beck Hopelessness Scale Cheek and Buss Shyness Scale MacArthur Scale of Subjective Social Status – Youth Version Self-Rated Happiness | Self-rated Health appears to be associated with psychosocial functioning and other dimensions of adolescent health in CEE youth. Eating breakfast was one of 12 significant predictors of SRH. | Moderate |
| Richards and Smith (2016), GB (42) | 2,307 | Longitudinal study with two cross-sections; follow-up period: 6 months. | To investigate the effects of consuming energy drinks and missing breakfast on stress, anxiety, and depression in a cohort of secondary school children. | The Diet and Behavior Scale (DABS) Exercise frequency questionnaire Self-Assessed Mental Health (Wellbeing Process Questionnaire [WPQ]-items) | The current study has provided evidence to suggest that high stress, anxiety, and depression levels in adolescents are associated with breakfast omission. The relationship is unlikely to be causal in nature and there may be bi-directional mechanisms involved, with mental health also influencing whether or not breakfast is consumed. | Moderate |
| Smith (2010), GB (51) | 213 | Separate groups design | To examine the effects of consuming different breakfast cereals on parents’ perceptions of the alertness, cognitive function and other aspects of the well-being of their children. | Questionnaire measures of well-being (alertness, cognitive difficulties, anxiety, depression, emotional distress, fatigue, somatic symptoms, positive/negative mood, symptoms, bowel problems). | Breakfast cereal consumption by children is associated with greater well-being. | Moderate |
| **Academic achievement** | | | | | | |
| Boschloo et al. (2012), NL (43) | 605 | Cross-sectional | To investigate whether adolescents who habitually skip breakfast have lower end-of-term grades than adolescents who eat breakfast daily. | BC Attention Problem Scale School performance—arithmetic mean of subjects Dutch, mathematics and English. | Study shows that breakfast skipping and school performance are related, partially mediated by attention. No causal conclusions drawn. | Moderate |
| Burrows et al. (2017), AU (44) | 4,245 | Observational | To conduct secondary analysis to examine associations between a range of dietary behaviors and children’s academic achievement. | Dietary behaviors National Assessment Program Literacy and Numeracy (NAPLAN) (reading, writing, spelling, grammar/punctuation, numeracy) | The findings demonstrate the association between dietary behaviors and higher academic achievement. Breakfast was only significantly associated with the academic domain of writing. | Moderate |
| Faught et al. (2017), CA (48) | 28,608 | Observational | To characterize the associations between health behaviors and self-reported academic achievement. | Questionnaire (academic achievement, PA, healthy eating habits, sleep, screen time, body weight [BW], status, socioeconomic status [SES]) | The present findings demonstrate that lifestyle behaviors are associated with academic achievement. | Moderate |
| First author and country | Participants | Study design | Study purpose | Outcomes | Author conclusion | Scientific quality assessment |
|--------------------------|--------------|--------------|---------------|----------|-------------------|-------------------------------|
| **Lien (2007), NO (45)** | 7,305 | Cross-sectional survey | To examine the relationship between mental distress, academic performance and regular breakfast consumption across gender and immigration status. | Average grade for mathematics, written Norwegian, English and social science. Hopkins Symptoms Checklist (10-Item Version) (HSCL-10) (mental distress) | The implications of skipping breakfast on mental distress and academic performance are stronger for boys than girls and stronger for Norwegians than immigrants. | Moderate |
| **Littlecott et al. (2016), GB (5)** | 3,093 (baseline), 3,055 (follow-up) | Observational | To examine the link between breakfast consumption in 9- to 11-year-old children and educational outcomes obtained 6–18 months later. | Educational outcomes: scholastic assessment test (SAT)-scores | Significant positive association between self-reported BC and educational outcomes. | Moderate |
| **Ptomey et al. (2016), US (28)** | 698 | Cluster-randomized controlled trial | To determine whether breakfast consumption or content affects academic achievement measured by standardized tests. | Wechsler individual achievement test (3-components) (WIAT-III) | Both BC and breakfast content may be associated with improved standardized test performance in elementary school students. | Moderate |
| **Sampasa-Kanyinga & Hamilton (2017), CA (47)** | 9,912 | Observational | To investigate the association between breakfast consumption and school connectedness and to extend previous research on the association between breakfast consumption and academic achievement. | School connectedness (questionnaire) Academic performance (good marks: 70%–100%, poor marks: <70%) | Provides supporting evidence for the association between regular BC and higher school connectedness and academic performance. | Moderate |
| **Stea and Torstveit (2014), NO (46)** | 2,432 | Cross-sectional study | To examine the associations between several lifestyle habits and academic achievement in adolescent girls and boys. | Self-reporting questionnaire (dietary, PA, smoking, and snuffing habits, academic achievement) | Regular meal pattern, intake of healthy food items and being physically active were all associated with increased odds of high academic achievement, whereas the intake of unhealthy food and beverages, smoking cigarettes and snuffing were associated with decreased odds of high academic achievement. | Moderate |
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regardless of weight status. Two studies examined the association between breakfast skipping and headache (33, 35). Both found that irregular breakfast eating is associated with headache.

**Cognitive performance**

Various number of instruments and tests were used to measure cognitive performance among the seven studies included. All of them found that eating breakfast has positive effects on cognitive performance. Wesnes et al. concluded in both their studies that breakfast improved children’s attention (38, 39). Cooper et al. found that eating breakfast had particularly beneficial effects when study participants faced more cognitively demanding tasks (50). They also measured self-reported tension and calmness between the breakfast and no breakfast groups, but found no difference. In addition, they found that breakfast consumption improved response time measured with Sternberg paradigm, a memory-scanning task for short-term memory testing. This effect was not possible to confirm with other similar tests measuring response time. Wesnes et al. also showed that breakfast affects response speed variability. Participants who had breakfast showed lower response speed variability. Hjorth et al. and Widenhorn-Müller used the d2-test to measure selective and sustained attention and visual scanning speed. Hjorth et al. found a positive interaction between breakfast consumption and d2-test results (27). Widenhorn-Müller showed beneficial effects of breakfast on short-term memory and mood but not on sustained attention (40).

**Quality of life and well-being**

The three included studies used different measurements to study the association between breakfast consumption and QoL and/or well-being. However, the results are consistent. Page et al. found that eating breakfast was one of

| First author | Cognitive performance | Academic achievement | Morbidity risk factors | QoL/well-being |
|--------------|-----------------------|----------------------|-----------------------|---------------|
| Hallström et al. (31) | N/A | N/A | + | N/A |
| Marlatt et al. (32) | N/A | N/A | + | N/A |
| Moschiano et al. (33) | N/A | N/A | + | N/A |
| Papoutsou et al. (29) | N/A | N/A | + | N/A |
| Sese et al. (34) | N/A | N/A | + | N/A |
| Smith et al. (30) | N/A | N/A | + | N/A |
| Walter (35) | N/A | N/A | + | N/A |
| Wennberg et al. (36) | N/A | N/A | + | N/A |
| Wennberg et al. (37) | N/A | N/A | + | N/A |
| Cooper et al. (50) | + | N/A | N/A | N/A |
| Defeeyer and Russo (49) | + | N/A | N/A | N/A |
| Hjorth et al. (27) | + | N/A | N/A | N/A |
| Wesnes et al. (38) | + | N/A | N/A | N/A |
| Wesnes et al. (39) | + | N/A | N/A | N/A |
| Widenhorn-Müller (40) | +/- | N/A | N/A | N/A |
| Page et al. (41) | N/A | N/A | + | N/A |
| Richards and Smith (42) | N/A | N/A | + | N/A |
| Smith (51) | N/A | N/A | + | N/A |
| Boschloo et al. (43) | + | + | N/A | N/A |
| Burrows et al. (44) | N/A | + | N/A | N/A |
| Faught et al. (48) | N/A | + | N/A | N/A |
| Lien (45) | N/A | + | N/A | + |
| Littlecott et al. (5) | N/A | + | N/A | N/A |
| Pomey et al. (28) | N/A | + | N/A | N/A |
| Sampasa-Kanyinga & Hamilton (47) | N/A | + | N/A | N/A |
| Stea and Torstveit (46) | N/A | + | N/A | N/A |
| Number of studies indicating positive effects | 7 (100%) | 8 (100%) | 9 (100%) | 4 (100%) |
| Number of studies indicating negative effects | 1 (14%) | 0 (0%) | 0 (0%) | 0 (0%) |
| Number of studies indicating no effects | 0 (0%) | 0 (0%) | 0 (0%) | 0 (0%) |

+ = positive effect, − = negative effect, 0 = no effect, N/A = not applicable.
the 12 significant predictors of self-rated health measures (41). Richards and Smith provided evidence showing that stress, anxiety, and depression were associated with skipping breakfast (42). Nevertheless, they highlighted the possibility that mental health might influence whether a person consumes breakfast or not. Smith et al. also found that breakfast consumption is linked to increased well-being (51).

**Academic achievement**

All the eight studies that investigated breakfast consumption and academic achievement found positive associations between breakfast consumption and academic achievement. In a study conducted by Lien in Norway, the implications of skipping breakfast on mental distress and academic achievement were stronger for boys than girls and stronger for native Norwegians than immigrants (45). Burrows et al. concluded that dietary behavior overall was associated with higher academic achievement, but that breakfast was only significantly associated with the domain writing (44).

**Discussion**

This review set out to find relevant outcome measures of eating breakfast on children and adolescents, for use in economic evaluations. The studies included focused mainly on studying the effects of eating versus not eating breakfast, and they were divided into four categories of study outcomes, namely morbidity risk factors, cognitive performance, quality of life and well-being, and academic achievement. All studies included in the analysis met the inclusion criteria of this review and were judged to be of at least moderate quality. Consequently, the excluded studies either failed to meet the inclusion criteria or had a low study quality rating.

There was a notable variation in the study design. In general, studies were either of observational or experimental design. Even though, randomized control trial is

![Flow chart of the work process: PRISMA 2009 Flow Diagram.](image-url)
the only study design for drawing causal relationship, the observational study still is important to identify associations. Whether children eat breakfast or not and whether it has any substantial effect on study outcomes might very well be derived from a large number of unobserved influential factors, such as the children’s social environment and parental support. Thus, assigning the effects of eating breakfast to its sole nutritional value may be problematic.

The review showed associations between eating breakfast and cognitive performance, academic achievement, quality of life, well-being, and morbidity risk factors. When results are consistently positive, different forms of bias need to be discussed. There is always a risk of publication bias that could contaminate this type of review, which could have overestimated the strength of the evidence (52). In addition, reformulations of initial study hypothesis to better suit data might affect results. This is known as HARKing—hypothesizing after the results are known (53). Also, the lack of control for confounders may have affected the results. As it is not possible to adjust for all confounders, it is difficult to establish a clear causal link between intervention and outcome (54). Studies that examine the association between breakfast and weight/obesity have been thoroughly studied and reviewed before. Therefore, such studies were excluded from this review. However, despite the exclusion of the weight/obesity effects of eating breakfast in this review, it should be noted that it is relevant to include weight/obesity in the economic evaluations of breakfast.

To only include studies performed entirely or partly in countries listed by the CIA as advanced economies, except Japan and Taiwan, restricts the relevance of results to these countries. The potential exclusion of relevant studies from other nations is thus one limitation. In the assessment of study quality, the risk of incorrect classification is contingent. Although, by proactively disregarding the study results in the articles included when performing quality assessment, the authors took measures to limit the risk of study quality misclassification. Our interest in finding and valuing effects that can be attributed to breakfast eating emanates from the question of the cost-effectiveness of breakfast interventions. Our study cannot answer that question, but shows that breakfast eating is associated with effects that could be used in economic evaluations, especially when using decision analytic modeling, calculating the long-term cost and effects of intervention. For instance, improved cognitive performance and academic achievements may influence long-term effects on an individual’s productivity through improved school results, grades, and higher education. Further, this gives higher human capital, which can be reflected in higher income, both for the individual and for society. Improvements in quality of life and well-being will have an immediate effect on the QALY weight of a child or adolescent but also, if the effects are sustained, on long-term QALY gain. Finally, the health effects mediated by a reduction of long-term morbidity risk factors, such as obesity, will contribute to lower morbidity/mortality and a reduction in healthcare costs. In order to answer the questions regarding the cost-effectiveness of breakfast and interventions promoting breakfast eating, we need to know more about how the identified effects influence the societal cost and the individual’s QALY gain. There is also a need to develop models that can simulate breakfast and breakfast interventions’ long-term costs and effects. In this study, we have started that work by identifying important model parameters.

Conclusions

The overall assessment of the studies indicated positive associations between eating breakfast and study outcomes that measure cognitive performance, academic achievement, quality of life and well-being, and morbidity risk factors in high-income nations. How these outcomes influence societal costs and individuals’ QALYs require further research.

Conflict of interest and funding

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References

1. Riby L, Smith M, Foster JK. Nutrition and mental performance: a lifespan perspective. Basingstoke: Palgrave Macmillan; 2012.
2. Blondin SA, Anzman-Frasca S, Djang HC, Economos CD. Breakfast consumption and adiposity among children and adolescents: an updated review of the literature. Pediatr Obes 2016; 11(5): 333–48. doi: 10.1111/jpo.12082.
3. Dye L, Adolphus K, Lawton C. Associations between habitual school-day breakfast consumption frequency and academic achievement in British adolescents. Ann Nutr Metab 2015; 67: 372.
4. Kennedy S, Ryan L, Clegg ME. Associations between breakfast consumption, attitudes towards breakfast and physical activity in adolescents. Proc Nutr Soc 2015; 74(Oct1):E99. doi: 10.1017/ S0029665115001147.
5. Littlecott HJ, Moore GF, Moore L, Lyons RA, Murphy S. Association between breakfast consumption and educational outcomes in 9–11-year-old children. Public Health Nutr 2016; 19(9): 1575–82. doi: 10.1017/S1368946215002669.
6. Adolphus K, Lawton CL, Dye L. The effects of breakfast on behavior and academic performance in children and adolescents. Front Hum Neurosci 2013; 7: 425. doi: 10.3389/fnhum.2013.00425.
7. Lazzeri G, Pammolli A, Azzolini E, Simi R, Meoni V, de Wet DR, et al. Association between fruits and
vegetables intake and frequency of breakfast and snacks consumption: a cross-sectional study. Nutr J 2013; 12:123. doi: 10.1186/1475-2891-12-123.
8. Huang CJ, Hu HT, Fan YC, Liao YM, Tsai PS. Associations of breakfast skipping with obesity and health-related quality of life: evidence from a national survey in Taiwan. Int J Obesity 2010; 34(4): 720–5.
9. Ahadi Z, Qorbani M, Kelishadi R, Ardalan G, Motlagh ME, Asayesh H, et al. Association between breakfast intake with anthropometric measurements, blood pressure and food consumption behaviors among Iranian children and adolescents: the CASPIAN-IV study. Public Health 2015; 129(6): 740–7. doi: 10.1016/j.puhe.2015.03.019.
10. Mahoney CR, Taylor HA, Kanarek RB, Samuel P. Effect of breakfast composition on cognitive processes in elementary school children. Physiol Behav 2005; 85(5): 635–45. doi: 10.1016/j.physbeh.2005.06.023.
11. Siega-Riz AM, Popkin BM, Carson T. Trends in breakfast consumption for children in the United States from 1965–1991. Am J Clin Nutr 1998; 67(4): 748s–56s. doi: 10.1093/ajcn/67.4.748s.
12. Moore GF, Tapper K, Murphy S, Lynch R, Raisanen L, Pimm C, et al. Associations between deprivation, attitudes towards eating breakfast and breakfast eating behaviours in 9–11-year-olds. Public Health Nutr 2007; 10(6): 582–9. doi: 10.1017/s1368980007699558.
13. Murray NG, Low BJ, Hollis C, Cross AW, Davis SM. Coordinated school health programs and academic achievement: a systematic review of the literature. J Sch Health 2007; 77(9): 589–600. doi: 10.1111/j.1746-1561.2007.00238.x.
14. Adolphus K, Lawton CL, Champ CL, Dye L. The effects of breakfast and breakfast composition on cognition in children and adolescents: a systematic review. Adv Nutr (Bethesda, Md) 2016; 7(3): 590–612s. doi: 10.3945/an.115.010256.
15. Burrows T, Goldman S, Pursey K, Lim R. Is there an association between dietary intake and academic achievement: a systematic review. J Hum Nutr Diet 2017; 30(2): 117–40. doi: 10.1111/jhn.12407.
16. National Foreign Assessment Center (U.S.), United States. Central Intelligence Agency. The world factbook. Washington, DC: Central Intelligence Agency. 2019 Mar [about 1 p.]. Available from: https://www.cia.gov/library/publications/the-world-factbook/appendix/appendix-b.html [cited 2019 Mar 12].
17. Egger M, Smith GD, Altman DG. Systematic reviews in health care: meta-analysis in context. 2nd ed. London: BMJ Books; 2001.
18. Riegelman R. Studying a study & testing a test: reading with anthropology. Cambridge, MA: Harvard University Press; 2012.
19. Adolphus K, Lawton M, Champion A-A, Dye L. The relationship between habitual breakfast consumption frequency and academic performance in British adolescents. Front Public Health 2015; 3: 68. doi: 10.3389/fpubh.2015.00068.
20. Benton D, Jarvis M. The role of breakfast and a mid-morning snack on the ability of children to concentrate at school. Physiol Behav 2007; 90(2–3): 382–5. doi: 10.1016/j.physbeh.2006.09.029.
21. Karatzi K, Moschonis G, Barouti A-A, Lionis C, Chrousos GP, Manios Y. Dietary patterns and breakfast consumption in relation to insulin resistance in children. The healthy growth study, Public Health Nutr 2014; 17(12): 2790–7. doi: 10.1017/S1368980013003327.
22. Kral TV, Heo M, Whiteford LM, Faith MS. Effects on cognitive performance of eating compared with omitting breakfast in elementary schoolchildren. J Dev Behav Pediatr 2012; 33(1): 9–16. doi: 10.1097/DBP.0b013e318232e2f35.
23. Lopez-Sobaler AM, Ortega RM, Quintas ME, Navia B, Requejo AM. Relationship between habitual breakfast and intellectual performance (logical reasoning) in well-nourished schoolchildren of Madrid (Spain). Eur J Clin Nutr 2003; 57 Suppl 1:S49–53. doi: 10.1038/sj.ejcn.1601815.
24. Maffezis C, Fornari E, Surano MG, Comencini E, Corradi M, Tommasi M, et al. Breakfast skipping in prepubertal obese children: hormonal, metabolic and cognitive consequences. Eur J Clin Nutr 2012; 66(3): 314–21. doi: 10.1038/j.ejcn.2011.206.
25. McIsaac JL, Kirk SF, Kuhle S. The association between health behaviours and academic performance in Canadian elementary school students: a cross-sectional study. Int J Environ Res Public Health 2015; 12(11): 14857–71. doi: 10.3390/ijerph12114857.
26. Overby NC, Ludemann E, Hoigaard R. Self-reported learning difficulties and dietary intake in Norwegian adolescents. Scand J Public Health 2013; 41(7): 754–60.
27. Hjortj MF, Sorenson LB, Andersen R, Dyssegaard CB, Ritz C, Tetens I, et al. Normal weight children have higher cognitive performance – Independent of physical activity, sleep, and diet. Physiol Behav 2016; 165: 398–404. doi: 10.1016/j.physbeh.2016.08.021.
28. Promea LT, Steger FL, Schubert MM, Lee J, Willis EA, Sullivan DK, et al. Breakfast intake and composition is associated with superior academic achievement in elementary schoolchildren. J Am Coll Nutr 2016; 35(4): 326–33. doi: 10.1080/07315724.2015.1048381.
29. Papoutsou S, Briassoulis G, Wolters M, Peples J, Iacovilli L, Eiben G, et al. No breakfast at home: association with cardiovascular disease risk factors in childhood. Eur J Clin Nutr 2014; 68(7): 829–34. doi: 10.1038/ejcn.2014.88.
30. Smith KJ, Gall SL, McNaughton SA, Blizzard L, Dwyer T, Venn AJ. Skipping breakfast: longitudinal associations with cardiometabolic risk factors in the childhood determinants of adult health study. Am J Clin Nutr 2010; 92(6): 1316–25. doi: 10.3945/ajcn.2010.30101.
31. Hallstrom L, Labayen I, Ruiz JR, Patterson E, Vereeken CA, Breidenassel C, et al. Breakfast consumption and CVD risk factors in European adolescents: the HELENA (Healthy Lifestyle in Europe by Nutrition in Adolescence) Study. Public Health Nutr 2013; 16(7): 1296–305. doi: 10.1017/s1368980012000973.
32. Marlltt KL, Farbakhsh K, Dengel DR, Ltye L. Breakfast and fast food consumption are associated with selected biomarkers in adolescents. Prev Med Rep 2016; 3: 49–52. doi: 10.1016/j.pmedr.2015.11.014.
33. Moschiano F, Messina P, D’Amico D, Grazzi L, Frediani F, Casucci G, et al. Headache, eating and sleeping behaviors and lifestyle factors in preadolescents and adolescents: preliminary results from an Italian population study. Neurol Sci 2012; 33 Suppl 1:S87–90. doi: 10.1007/s10072-012-1048-3.
34. Sese MA, Jimenez-Pavon D, Gilbert CC, Gonzalez-Gross M, Gottrand F, de Henauw S, et al. Eating behaviour, insulin resistance and cluster of metabolic risk factors in European adolescents: the HELENA Study. Appetite 2012; 59: 140–7. doi: 10.1016/j.appet.2012.04.011.
35. Walter S. Lifestyle behaviors and illness-related factors as predictors of recurrent headache in U.S. adolescents. J Neurosci Nurs 2014; 46(6): 337–50. doi: 10.1097/jn.0000000000000095.
36. Wennberg M, Gustafsson PE, Wennberg P, Hammarstrom A. Poor breakfast habits in adolescence predict the metabolic syndrome in adulthood. Public Health Nutr 2015; 18(1): 122–9. doi: 10.1017/s1368980013003509.
37. Wennberg M, Gustafsson PE, Wennberg P, Hammarstrom A. Irregular eating of meals in adolescence and the metabolic syndrome in adulthood: results from a 27-year prospective cohort. Public Health Nutr 2016; 19(4): 667–73. doi: 10.1017/s1368980015001445.
38. Wesnes KA, Pincock C, Richardson D, Helm G, Hails S. Breakfast reduces declines in attention and memory over the morning in schoolchildren. Appetite 2003; 41(3): 329–31. doi: 10.1016/j.appet.2003.08.008.
39. Wesnes KA, Pincock C, Scholey A. Breakfast is associated with enhanced cognitive function in schoolchildren. An internet based study. Appetite 2012; 59(3): 646–9. doi: 10.1016/j.appet.2012.08.008.
40. Widenhorn-Müller K, Hille K, Klenk J, Weiland U. Influence of having breakfast on cognitive performance and mood in 13- to 20-year-old high school students: results of a crossover trial. Pediatrics 2008; 122(2): 279–84. doi: 10.1542/peds.2007-0944.
41. Page RM, Simonek J, Ihasz F, Hantiu I, Uvacsek M, Kalabiska I, et al. Self-rated health, psychosocial functioning, and other dimensions of adolescent health in Central and Eastern European adolescents. Eur J Psychiatry 2009; 23(2): 101–14. doi: 10.4321/S0213-61632009000200004.
42. Richards G, Smith AP. Breakfast and energy drink consumption in secondary school children: breakfast omission, in isolation or in combination with frequent energy drink use, is associated with stress, anxiety, and depression cross-sectionally, but not at 6-month follow-up. Front Psychol 2016; 7: 106. doi: 10.3389/fpsyg.2016.00106.
43. Boschloo A, Ouwehand C, Dekker S, Lee N, de Groot R, Krabbendam L, et al. The relation between breakfast skipping and school performance in adolescents. Mind Brain Educ 2012; 6(2): 81–8. doi: 10.1111/j.1751-228X.2012.01138.x.
44. Burrows T, Goldman S, Olson RK, Byrne B, Coventry WL. Associations between selected dietary behaviours and academic achievement: a study of Australian school aged children. Appetite 2017; 116: 372–80. doi: 10.1016/j.appet.2017.05.008.
45. Lien L. Is breakfast consumption related to mental distress and academic performance in adolescents? Public Health Nutr 2007; 10(4): 422–8. doi: 10.1017/s136898007007258550.
46. Stea TH, Torstveit MK. Association of lifestyle habits and academic achievement in Norwegian adolescents: a cross-sectional study. BMC Public Health 2014; 14: 829. doi: 10.1186/1471-2458-14-829.
47. Sampaia-Kanyinga H, Hamilton HA. Eating breakfast regularly is related to higher school connectedness and academic performance in Canadian middle- and high-school students. Public Health 2017; 145: 120–3. doi: 10.1016/j.puhe.2016.12.027.
48. Faught EL, Gleddie D, Storey KE, Davison CM, Veugelers PJ. Healthy lifestyle behaviours are positively and independently associated with academic achievement: an analysis of self-reported data from a nationally representative sample of Canadian early adolescents. PLoS One 2017; 12(7):e0181938. doi: 10.1371/journal.pone.0181938.
49. Defeuyter MA, Russo R. The effect of breakfast cereal consumption on adolescents' cognitive performance and mood. Front Hum Neurosci 2013; 7: 789. doi: 10.3389/fnhum.2013.00789.
50. Cooper SB, Bandelow S, Nevill ME. Breakfast consumption and cognitive function in adolescent schoolchildren. Physiol Behav 2011; 103(5): 431–9. doi: 10.1016/j.physbeh.2011.03.018.
51. Smith AP. An investigation of the effects of breakfast cereals on alertness, cognitive function and other aspects of the reported well-being of children. Nutr Neurosci 2010; 13(5):230–6. doi: 10.1179/147683010x12611460764642.
52. Song F, Parekh S, Hooper L, Loke YK, Ryder J, Kwok CS, et al. Dissemination and publication of research findings: an updated review of related biases. Health Technol Assess 2010; 14(8): 1–220. doi: 10.3310/hta14080.
53. Minarić A, Horvat M, Smolčić VŠ. Dealing with the positive publication bias: why you should really publish your negative results. Biochem Med 2017; 27(3): 447–52. doi: 10.11613/BM.2017.030201.
54. Skelly AC, Dettori JR, Brodt ED. Assessing bias: the importance of considering confounding. Evid Based Spine Care J 2012; 3(1): 9–12. doi: 10.1055/s-0031-1298595.

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Appendix 1

Studies that were excluded because of low quality and reasons for exclusion are presented in Table A1.

Table A1. Excluded studies because of low quality, with reasons for exclusion

| Exclusion no. | First author (year) | Title                                                                 | Reason for low-quality rating |
|---------------|---------------------|-----------------------------------------------------------------------|-------------------------------|
| 1             | Adolphus et al. (2015) (19) | The relationship between habitual breakfast consumption frequency and academic performance in British adolescents | 1, 6                          |
| 2             | Benton and Jarvis (2007) (20) | The role of breakfast and a mid-morning snack on the ability of children to concentrate at school | 1, 3, 5                      |
| 3             | Karatzi et al. (2014) (21) | Dietary patterns and breakfast consumption in relation to insulin resistance in children: The healthy growth study | 1, 7                          |
| 4             | Kral et al. (2012) (22) | Effects on cognitive performance of eating compared with omitting breakfast in elementary schoolchildren | 1, 3, 5                      |
| 5             | López-Sobaler et al. (2003) (23) | Relationship between habitual breakfast and intellectual performance (logical reasoning) in well-nourished schoolchildren of Madrid (Spain) | 2                             |
| 6             | Maffeis et al. (2012) (24) | Breakfast skipping in prepubertal obese children: Hormonal, metabolic and cognitive consequences | 5                             |
| 7             | McIsaac et al. (2015) (25) | The association between health behaviors and academic performance in Canadian elementary school students: A cross-sectional study | 1, 6                          |
| 8             | Overby et al. (2013) (26) | Self-reported learning difficulties and dietary intake in Norwegian adolescents | 1, 3                          |

Matters causing low-quality rating: (1) No RCT, (2) lack of adequate control group(s), (3) lack of control for confounders, (4) insufficiently described experimental design, (5) insufficient statistical power, (6) non-relevant outcome measures, and (7) non-consistency between reported results and conclusions.