UNITED STATES DEPARTMENT OF AGRICULTURE

Frequency of Meals and/or Snacking and Energy Intake: A Systematic Review

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Plain language summary

What is the question?
The question is: What is the relationship between frequency of meals and/or snacking and energy intake? The populations of interest for this question include children and adolescents (1 up to 19 years), and adults and older adults (19 years and older).

Why was this question asked?
This systematic review was conducted by the 2025 Dietary Guidelines Advisory Committee as part of the process to develop the *Dietary Guidelines for Americans, 2025-2030*.

How was this question answered?
The Committee conducted a systematic review to answer this question with support from the USDA Nutrition Evidence Systematic Review team.

What is the answer to the question?
Frequency of meals and/or snacking in children and adolescents

- A conclusion statement cannot be drawn about the relationship between frequency of meals and/or snacking in children and adolescents and energy intake because of substantial concerns with heterogeneity of exposures in a small body of evidence.

Breakfast in adults and older adults

- A conclusion statement cannot be drawn about the relationship between breakfast consumption in adults and total daily energy intake because of substantial concerns with consistency and generalizability in the body of evidence.
- A conclusion statement cannot be drawn about the relationship between breakfast consumption in older adults and energy intake because there is no evidence available.

Number of eating occasions in adults and older adults

- A conclusion statement cannot be drawn about the relationship between number of eating occasions per day in adults and older adults and energy intake because of substantial concerns with generalizability in a small body of evidence.

Snacking in adults and older adults

- A conclusion statement cannot be drawn about the relationship between snacking in adults and older adults and energy intake because of substantial concerns with generalizability in the body of evidence.

How up-to-date is this systematic review?
Conclusion statements from this review are based on articles published between January 2000 and May 2023.

Abstract

Background

This systematic review was conducted by the 2025 Dietary Guidelines Advisory Committee as part of the process to develop the *Dietary Guidelines for Americans, 2025-2030*. The U.S. Departments of Health and Human Services (HHS) and Agriculture (USDA) appointed the 2025 Dietary Guidelines Advisory Committee (Committee) in January 2023 to review evidence on high priority scientific questions related to diet and health. Their review forms the basis of their independent, science-based advice and recommendations to HHS and USDA, which is considered as the Departments develop the next edition of the *Dietary Guidelines*. As part of that process, the Committee conducted a systematic review with support from USDA's Nutrition Evidence Systematic Review (NESR) team to answer the following question: What is the relationship between frequency of meals and/or snacking and energy intake?

Methods

The Committee conducted a systematic review using the methodology of the USDA NESR team. The Committee first developed a protocol. The interventions/exposures were frequency of meals and/or snacking in young children, children, adolescents, adults, and older adults; definitions varied across studies and included occasion-based measures such as meals (e.g., breakfast), snacking, and number of eating occasions. The comparator was a different frequency of meals and/or snacking. The outcome was energy intake in young children, children, adolescents, adults, and older adults. Additional inclusion criteria were established for the following study characteristics: a) use randomized or non-randomized controlled trial, prospective or retrospective cohort, or nested case-control study designs, b) be published in English in peer-reviewed journals, c) be from countries classified as high or very high on the Human Development Index, and d) enroll participants with a range of health statuses. The review excluded studies that only examine frequency of intake of a single food, beverage or category of foods and/or beverages (e.g., frequency of cereal consumption, frequency of dairy consumption, frequency of snack foods).

NESR librarians conducted a literature search in PubMed, Embase, CINAHL, and Cochrane to identify articles published between January 2000 and May 2023. Two NESR analysts independently screened all electronic results and the reference lists of included articles based on the pre-determined criteria.

NESR analysts extracted data, from each included article, with a second analyst verifying accuracy of the extraction. Two NESR analysts independently conducted a formal risk of bias assessment, by study design, for each included article, then reconciled any differences in the assessment. The Committee qualitatively synthesized the evidence, according to the synthesis plan, with attention given to the overarching themes or key concepts from the findings, similarities and differences between studies, and factors that may have affected the results. The Committee developed conclusion statements and graded the strength of evidence based on its consistency, precision, risk of bias, directness and generalizability.

Results

Frequency of meals and/or snacking in children and adolescents

Conclusion statement and grade: A conclusion statement cannot be drawn about the relationship between frequency of meals and/or snacking in children and adolescents and energy intake because of substantial concerns with heterogeneity of exposures in a small body of evidence. (Grade: Grade Not Assignable)

Summary of the evidence:
- Five articles examined frequency of meals and/or snacking in children and adolescents. All were crossover randomized controlled trials.
- The articles varied in exposures and outcomes assessed. Three trials assessed breakfast consumption, 1 trial assessed snacking, and 1 trial assessed number of eating occasions. Three trials assessed energy intake at subsequent eating occasions as well as total daily energy intake, while the 2 other trials only measured energy intake at a subsequent eating occasion.

Breakfast in adults and older adults

Conclusion statement and grade: A conclusion statement cannot be drawn about the relationship between breakfast consumption in adults and total daily energy intake because of substantial concerns with consistency and generalizability in the body of evidence. (Grade: Grade Not Assignable)

Summary of the evidence:
- Nineteen articles examined breakfast in adults. Eighteen were randomized controlled trials and 1 was a prospective cohort study.
- The available evidence contributed mixed results and had many limitations including lack of diversity of the populations, different study designs, interventions, and durations as well as diversity in energy intake assessments.

Conclusion statement and grade: A conclusion statement cannot be drawn about the relationship between breakfast consumption in older adults and energy intake because there is no evidence available. (Grade: Grade Not Assignable)

Summary of the evidence:

- No articles examined breakfast in older adults.

Number of eating occasions in adults and older adults

Conclusion statement and grade: A conclusion statement cannot be drawn about the relationship between number of eating occasions per day in adults and older adults and energy intake because of substantial concerns with generalizability in a small body of evidence. (Grade: Grade Not Assignable)

Summary of the evidence:

- Six articles examined number of eating occasions in adults and older adults. Five were randomized controlled trials and 1 was a prospective cohort study.
- The articles were not generalizable to the overall U.S. population. The trials were narrowly focused on eating occasions in the context of weight loss or weight maintenance intervention trials in populations with overweight and/or obesity or in those who had previously lost weight and would not be generalizable to a free-living U.S. population.

Snacking in adults and older adults

Conclusion statement and grade: A conclusion statement cannot be drawn about the relationship between snacking in adults and older adults and energy intake because of substantial concerns with generalizability in the body of evidence. (Grade: Grade Not Assignable)

Summary of the evidence:

- Five articles examined snacking in adults and older adults. All were randomized controlled trials.
- There is not enough evidence available to answer this question and the evidence that is available is not generalizable to the overall U.S. population. The trials were narrowly focused on snacking in the context of weight loss intervention trials in participants with overweight and/or obesity and would not be generalizable to a free-living U.S. population.

Introduction

To prepare for the development of the *Dietary Guidelines for Americans, 2025-2030*, the U.S. Departments of Health and Human Services (HHS) (Appendix 1) and Agriculture (USDA) identified a proposed list of scientific questions based on relevance, importance, potential federal impact, and avoiding duplication, which were posted for public comment.* The Departments appointed the 2025 Dietary Guidelines Advisory Committee (Committee) in January 2023 to review evidence on the scientific questions. The Committee's review of the evidence forms the basis of the Scientific Report of the 2025 Dietary Guidelines Advisory Committee,† which includes independent, science-based advice and recommendations to HHS and USDA and is considered during the development of the next edition of the *Dietary Guidelines*.

The proposed scientific questions were refined and prioritized by the Committee for consideration in their review of the evidence. As part of that process, the following systematic review question was prioritized: What is the relationship between frequency of meals and/or snacking and energy intake? The Committee conducted a systematic review to address this question, with support from USDA's Nutrition Evidence Systematic Review (NESR) team (**Table 1**).

Table 1. Review history

Date	Description	Citation
May 2023	Systematic review protocol for the 2025 Dietary Guidelines Advisory Committee published online	Palacios C, Anderson CAM, Andres A, Fisher JO, Gardner CD, Giovannucci E, Hoelscher DM, Jernigan VBB, Odoms-Young A, Raynor HA, Stanford FC, Obbagy J, Callahan EH, Cole NC, Kingshipp BJ, Webster A, Higgins M, Butera G, Terry N. Frequency of Meals and/or Snacking and Energy Intake: A Systematic Review Protocol. May 2023. U.S. Department of Agriculture, Food and Nutrition Service, Center for Nutrition Policy and Promotion, Nutrition Evidence Systematic Review. Available at: https://nesr.usda.gov/protocols

Methods

The Committee used NESR's methodology to conduct this systematic review. NESR's methodology is described in detail in its methodology manual,‡ as well as in the Committee's Scientific Report.§ This section presents an overview of the specific methods used to answer the systematic review question: What is the relationship between frequency of meals and/or snacking and energy intake?

* *Dietary Guidelines for Americans*: Learn About the Process. 2022. Available at: https://www.dietaryguidelines.gov/work-under-way/learn-about-process

† 2025 Dietary Guidelines Advisory Committee. 2024. Scientific Report of the 2025 Dietary Guidelines Advisory Committee: Advisory Report to the Secretary of Health and Human Services and Secretary of Agriculture. U.S. Department of Health and Human Services. https://doi.org/10.52570/DGAC2025

‡ USDA Nutrition Evidence Systematic Review Branch. USDA Nutrition Evidence Systematic Review: Methodology Manual. February 2023. U.S. Department of Agriculture, Food and Nutrition Service, Center for Nutrition Policy and Promotion, Nutrition Evidence Systematic Review. Available at: https://nesr.usda.gov/methodology-overview

§ 2025 Dietary Guidelines Advisory Committee. 2024. Scientific Report of the 2025 Dietary Guidelines Advisory Committee: Advisory Report to the Secretary of Health and Human Services and Secretary of Agriculture. U.S. Department of Health and Human Services. https://doi.org/10.52570/DGAC2025

Develop a protocol

A systematic review protocol is the plan for how NESR's methodology will be used to conduct a specific systematic review and is established by the Committee, *a priori*, before any evidence is reviewed. The protocol is designed to capture the most appropriate and relevant body of evidence to answer the systematic review question. Development of the protocol involves discussion of the strengths and limitations of various methodological approaches relevant to the question, which then inform subsequent steps of the systematic review process. The protocol describes all of the methods that will be used throughout the systematic review process. Additionally, the protocol includes the following components, which are tailored to each systematic review question: the analytic framework, the inclusion and exclusion criteria, and the synthesis plan. The protocol was posted online (https://nesr.usda.gov/protocols) for the public to view and comment on.

Develop an analytic framework

An analytic framework visually represents the overall scope of the systematic review question and depicts the contributing elements that were examined and evaluated. It presents the core elements of each systematic review question, including the **P**opulation (i.e., those who experience the intervention/exposure and/or outcome), **I**ntervention and/or exposure (i.e., the independent variable of interest), **C**omparator (i.e., the alternative being compared to the intervention or exposure), and **O**utcome(s). The Committee identified key confounders based on their knowledge of nutrition and health research and experience as subject matter experts. Key confounders are participant characteristics, such as demographics, health status, and diet and lifestyle behaviors, and/or other factors related to both the intervention/exposure and the outcome of interest that may impact the relationships of interest. Key confounders were considered during review and evaluation of the evidence, particularly during the risk of bias assessment of non-randomized and observational studies.

Figure 1 is the analytic framework for the systematic review. The intervention or exposure of interest is the frequency of meals and/or snacking in young children, children, and adolescents (1 up to 19 years), and adults and older adults (19 years and older); frequency of meals and/or snacking included occasion-based measures such as meals (e.g., breakfast), snacking, and number of eating occasions, and were defined by individual study authors and therefore varied across studies. The comparator is a different frequency of meals and/or snacking. The outcome is energy intake in young children, children, adolescents, adults, and older adults. The key confounders are sex, age, physical activity, race and/or ethnicity, socioeconomic position, diet quality at baseline, and anthropometry in all populations; and smoking in adults and older adults.

Figure 1. Analytic framework for the systematic review question: What is the relationship between frequency of meals and/or snacking and energy intake?

Population	***Intervention/ exposure***	***Comparator***	***Outcome***	***Key confounders***
Young children, children, and adolescents (1 up to 19 years) Adults and older adults (19 years and older)	Frequency of meals and/or snacking*	Different frequency of meals and/or snacking	In young children, children and adolescents, adults and older adults: • Energy intake	• Sex • Age • Physical activity • Race and/or ethnicity • Socioeconomic position • Diet quality at baseline • Anthropometry • Smoking (adults, older adults)

* Definitions varied across studies and included occasion-based measures such as meals (e.g., breakfast), snacking, and number of eating occasions.

Synthesis organization:

I. ***Intervention/exposure:*** Meals (e.g., breakfast); Snacking; Number of eating occasions

   a. ***Population:*** Young children; Children; Adolescents; Adults; Older adults

      i. ***Outcome:*** Energy intake

Develop inclusion and exclusion criteria

The inclusion and exclusion criteria provide an objective, consistent, and transparent framework for determining which articles to include in the systematic review (**Table 2**). These criteria ensure that the most relevant and appropriate body of evidence is identified for the systematic review question, and that the evidence reviewed is:[*]

- Applicable to the U.S. population of interest
- Relevant to Federal public health nutrition policies and programs
- Rigorous from a scientific perspective

Table 2. Inclusion and exclusion criteria

Category	**Inclusion Criteria**	**Exclusion Criteria**
Study design	• Randomized controlled trials • Non-randomized controlled trials[†] • Prospective cohort studies • Retrospective cohort studies • Nested case-control studies	• Uncontrolled trials[‡] • Case-control studies • Cross-sectional studies • Ecological studies • Narrative reviews • Systematic reviews • Meta-analyses • Modeling and simulation studies
Publication date	• January 2000 – May 2023	• Before January 2000, after May 2023
Population: Study participants	• Human	• Non-human

[*]USDA Nutrition Evidence Systematic Review Branch. USDA Nutrition Evidence Systematic Review: Methodology Manual. February 2023. U.S. Department of Agriculture, Food and Nutrition Service, Center for Nutrition Policy and Promotion, Nutrition Evidence Systematic Review. Available at: https://nesr.usda.gov/methodology-overview

[†] Including quasi-experimental and controlled before-and-after studies

[‡] Including uncontrolled before-and-after studies

Category	Inclusion Criteria	Exclusion Criteria

Population: Life stage	• At intervention or exposure and outcome:
	  ○ Young children (12 up to 24 months)
	  ○ Children and adolescents (2 up to 19 years)
	  ○ Adults and older adults (19 years and older)
	  ○ Individuals during pregnancy
	  ○ Individuals during postpartum
		• At intervention or exposure and outcome:
		  ○ Infants (birth up to 12 months)

Population: Health status	• Studies that exclusively enroll participants not diagnosed with a disease[*]
	• Studies that enroll some participants:
	  ○ diagnosed with a disease;
	  ○ diagnosed with a disorder that affects feeding/eating or growth (e.g., autism spectrum disorder, attention-deficit/hyperactivity disorder, eating disorders);
	  ○ with severe undernutrition, failure to thrive/underweight, stunting, or wasting;
	  ○ receiving pharmacotherapy to treat obesity;
	  ○ pre- or post-bariatric surgery;
	  ○ and/or hospitalized for an illness, injury, or surgery
		• Studies that exclusively enroll participants:
		  ○ diagnosed with a disease;[†]
		  ○ diagnosed with a disorder that affects feeding/eating or growth (e.g., autism spectrum disorder, attention-deficit/hyperactivity disorder, eating disorders);
		  ○ with severe undernutrition, failure to thrive/underweight, stunting, or wasting;
		  ○ receiving pharmacotherapy to treat obesity;
		  ○ pre- or post-bariatric surgery;
		  ○ and/or hospitalized for an illness, injury, or surgery[‡]

Intervention/ Exposure	• Frequency of meals and/or snacking. Definitions will vary across studies and include occasion-based measures such as:
	  ○ Meals (e.g., breakfast)
	  ○ Snacking
	  ○ Number of eating occasions
	• Multi-component intervention in which the isolated effect of the intervention of interest on the outcome(s) of interest is provided or can be determined despite multiple components
		• Studies that only examine frequency of intake of a single food, beverage or category of foods and/or beverages (e.g., frequency of cereal consumption, frequency of dairy consumption, frequency of snack foods)
		• Multi-component intervention in which the isolated effect of the intervention of interest on the outcome(s) of interest is not provided or cannot be determined due to multiple components

Comparator	• Different frequency of meals and/or snacking	• N/A
Outcome(s)	• Energy Intake	• N/A
Publication status	• Peer-reviewed articles published in research journals	• Non-peer-reviewed articles, unpublished data or manuscripts, pre-prints, reports, editorials, retracted articles, and conference abstracts or proceedings
Language	• Published in English	• Not published in English

[*] Studies that enroll participants who are at risk for chronic disease were included

[†] Studies that exclusively enroll participants with obesity were included

[‡] Studies that exclusively enroll participants post-cesarean section were included

Category	Inclusion Criteria	Exclusion Criteria
Country[*]	• Studies conducted in countries classified as high or very high on the Human Development Index the year(s) the intervention/exposure data were collected	• Studies conducted in countries classified as medium or low on the Human Development Index the year(s) the intervention/exposure data were collected

Search for and screen studies

NESR librarians, in collaboration with NESR analysts and the Committee, used the analytic framework and inclusion and exclusion criteria to develop a comprehensive literature search strategy. The literature search strategy included selecting and searching the appropriate bibliographic databases, translating search using syntax appropriate for the databases being searched, and employing search refinements, such as search filters. The full literature search is documented in **Appendix 2**.

The results of all electronic database searches, after removal of duplicates, were screened independently by 2 NESR analysts using a step-wise process by reviewing titles, abstracts, and full-texts to determine which articles meet the inclusion criteria. Manual searching was conducted to find peer-reviewed published articles not identified through the electronic database search. These articles were also screened independently by two NESR analysts at the abstract and full-text levels.

Extract data and assess the risk of bias

NESR analysts extracted all essential data from each included article to describe key characteristics of the available evidence, such as the author, publication year, cohort/trial name, study design, population life stage at intervention/exposure and outcome, intervention/exposure and outcome assessment methods, and outcomes. One NESR analyst extracted the data and a second NESR analyst reviewed the extracted data for accuracy. Each article included in the systematic review underwent a formal risk of bias assessment, with 2 NESR analysts independently completing the risk of bias assessment using the tool that is appropriate for the study design.[†‡§]

Synthesize the evidence

The Committee described, compared, and combined the evidence from all included studies to answer the systematic review question.[**] Synthesis of the body of evidence involved identifying overarching themes or key concepts from the findings, identifying and explaining similarities and differences between studies, and

[*] The classification of countries on the Human Development Index (HDI) is based on the UN Development Program Human Development Report Office (http://hdr.undp.org/en/data) for the year the study intervention occurred or data were collected. If the study does not report the year(s) in which the intervention/exposure data were collected, the HDI classification for the year of publication is applied. Studies conducted prior to 1990 are classified based on 1990 HDI classifications. If the year is more recent than the available HDI values, then the most recent HDI classifications are used. If a country is not listed in the HDI, then the current country classification from the World Bank is used (The World Bank Country and Lending Groups, available from: https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-country-and-lending-groups)

[†] Sterne JAC, Savović J, Page MJ, et al. RoB 2: a revised tool for assessing risk of bias in randomised trials. *BMJ* 2019; 366: l4898.doi: 10.1136/bmj.l4898

[‡] Sterne JAC, Hernán MA, Reeves BC, et al. ROBINS-I: a tool for assessing risk of bias in non-randomized studies of interventions. *BMJ* 2016; 355; i4919; doi: 10.1136/bmj.i4919

[§] Higgins JPT, Morgan RL, Rooney AA, et al. A tool to assess risk of bias in non-randomized follow-up studies of exposure effects (ROBINS-E). *Environment International* 2024 (published online Mar 24); doi: 10.1016/j.envint.2024.108602.

[**] USDA Nutrition Evidence Systematic Review Branch. USDA Nutrition Evidence Systematic Review: Methodology Manual. February 2023. U.S. Department of Agriculture, Food and Nutrition Service, Center for Nutrition Policy and Promotion, Nutrition Evidence Systematic Review. Available at: https://nesr.usda.gov/methodology-overview

determining whether certain factors impact the relationships being examined, which includes potential causes of heterogeneity across all included evidence.

Extracted data and risk of bias assessments for all included studies were tabulated to visually display results and facilitate synthesis. During synthesis, the Committee considered the effect direction, magnitude, and statistical significance of the results reported across the articles included in the body of evidence. The evidence was synthesized qualitatively without meta-analysis of effect estimates, statistical pooling or conversion of data, or quantitative tests of heterogeneity.

The synthesis plan for this review was designed with the end-use in mind, to inform the Committee's advice to HHS and USDA regarding dietary guidance across life stages. The first level of synthesis organization was intended to be by frequency of meals and/or snacking categories (e.g., breakfast, snacking, number of eating occasions etc.). Then, within each of the frequency categories, the evidence was to be organized by similar populations based on the available evidence. Finally, the next level of organization was going to be according to similar outcomes. Based on the evidence that was included, we were not able to synthesize by every intended level of organization. When it was not possible to synthesize as planned, the overall category of frequency of meals and/or snacking was used. The organization that is presented in the report below are those where there was adequate evidence available.

Develop conclusion statements and grade the evidence

After the Committee synthesized the body of evidence, they drafted a conclusion statements. A conclusion statement is one or more summary statements carefully constructed to answer the systematic review question. Each conclusion statement reflects the evidence reviewed, as outlined in the analytic framework (e.g., PICO elements) and synthesis plan, and does not take evidence from other sources into consideration. Conclusion statements do not draw implications and should not be interpreted as dietary guidance. The Committee reviewed, discussed, and revised the conclusion statement until they reached agreement on wording that accurately reflected the body of evidence.

The Committee then graded the strength of the evidence underlying each conclusion statement. They did this using NESR's predefined criteria, based on 5 grading elements: consistency, precision, risk of bias, directness and generalizability of the evidence. Study design and publication bias were also considered.[*]

- Consistency: Consistency considers the degree of similarity in the direction and magnitude of effect across the body of evidence. This element also considers whether differences across the results can be explained by variations in study designs and methods.
- Precision: Precision considers the degree of certainty around an effect estimate for a given outcome. This element considers measures of variability, such as the width and range of confidence intervals, the number of studies, and sample sizes, within and across studies.
- Risk of bias: Risk of bias considers the likelihood that systematic errors resulting from the design and conduct of the studies could have impacted the accuracy of the reported results across the body of evidence.
- Directness: Directness considers the extent to which studies are designed to directly examine the relationship among the interventions/exposures, comparators, and outcome(s) of primary interest in the systematic review question.
- Generalizability: Generalizability considers whether the study participants, interventions and/or exposures, comparators, and outcomes examined in the body of evidence are applicable to the U.S. population of interest for the review.

[*] Spill MK, English LK, Raghavan R, et al. Perspective: USDA Nutrition Evidence Systematic Review Methodology: Grading the Strength of Evidence in Nutrition- and Public Health-Related Systematic Reviews. Adv Nutr. 2022 Aug 1;13(4):982-991. doi: 10.1093/advances/nmab147

The Committee assigned a grade to each conclusion statement (i.e., strong, moderate, limited, or grade not assignable). The grade communicates the strength of the evidence supporting a specific conclusion statement to decision makers and stakeholders. A conclusion statement can receive a grade of Strong, Moderate, or Limited, and if insufficient or no evidence is available to answer a systematic review question, then no grade is assigned (i.e., Grade Not Assignable) (**Table 3**). The overall grade is not based on a predefined formula for scoring or tallying ratings of each element. Rather, each overall grade reflects the expert group's thorough consideration of all of the grading elements, as they each relate to the specific nuances of the body of evidence under review.

Table 3. Definitions of NESR grades

Grade	Definition
Strong	The conclusion statement is based on a strong body of evidence as assessed by consistency, precision, risk of bias, directness, and generalizability. The level of certainty in the conclusion is strong, such that if new evidence emerges, modifications to the conclusion are unlikely to be required.
Moderate	The conclusion statement is based on a moderate body of evidence as assessed by consistency, precision, risk of bias, directness, and generalizability. The level of certainty in the conclusion is moderate, such that if new evidence emerges, modifications to the conclusion may be required.
Limited	The conclusion statement is based on a limited body of evidence as assessed by consistency, precision, risk of bias, directness, and generalizability. The level of certainty in the conclusion is limited, such that if new evidence emerges, modifications to the conclusion are likely to be required.
Grade Not Assignable	A conclusion statement cannot be drawn due to either a lack of evidence, or evidence that has severe limitations related to consistency, precision, risk of bias, directness, and generalizability.

Recommend future research

The Committee identified and documented research gaps and methodological limitations throughout the systematic review process. These gaps and limitations are used to develop research recommendations that describe the research, data, and methodological advances that are needed to strengthen the body of evidence on a particular topic. Rationales for the necessity of additional or stronger research are also provided with the research recommendations.

Peer review

This systematic review underwent external peer review in a process coordinated by staff from the National Institutes of Health (NIH). NIH staff identified potential peer reviewers through outreach to a variety of professional organizations to select academic reviewers from U.S. colleges and universities across the country with a doctorate degree, including MDs, and expertise specific to the questions being reviewed. All peer reviewers were external to the *Dietary Guidelines* process, and therefore, current Committee members or Federal staff who supported the Committee or the development of the *Dietary Guidelines* were not eligible to serve as peer reviewers.

The peer review process was anonymous and confidential in that the peer reviewers were not identified to the Committee members or NESR staff, and in turn, the reviewers were asked not to share or discuss the review with anyone. Peer reviewers were made aware that per USDA, Food and Nutrition Service (FNS) agency policy, all peer reviewer comments would be summarized and made public, but comments would not be attributed to a specific reviewer.

Peer review occurred after draft conclusion statements were discussed by the full Committee at its third, fourth, fifth, and sixth public meetings. NIH staff assigned and distributed the reviews to at least 2 peer reviewers based on area of expertise. Following peer review, the Committee reviewed and discussed comments and made revisions to the systematic review, as needed, based on the discussion.

Health equity considerations

The Committee was charged by HHS and USDA to review all scientific questions with a health equity lens to ensure that the next edition of the *Dietary Guidelines* is relevant to people with diverse racial, ethnic, socioeconomic, and cultural backgrounds. The Committee made a number of health equity considerations throughout the NESR systematic review process. The Committee's Scientific Report[*] includes a more detailed discussion of their approach to applying a health equity lens to their review of evidence, but examples include consideration of key confounders relevant to health equity and assessment of generalizability of the evidence.

Results

Literature search and screening results

The literature search was conducted to identify all potentially relevant articles for 3 systematic reviews assessing frequency of meals and/or snacking and different outcomes (alignment with the *Dietary Guidelines for Americans* (diet quality)[†]; growth, body composition, and risk of obesity[‡]; and energy intake), however this report is specific to the outcome of energy intake. The literature search (**Appendix 2**) yielded 31,399 search results after the removal of duplicates (see **Figure 2**). Dual-screening resulted in the exclusion of 27,732 titles, 2,821 abstracts, and 704 full-texts articles. Reasons for full-text exclusion are in **Appendix 3**. No additional articles were identified from the manual search. The body of evidence on frequency of meals and/or snacking and energy intake included 39 articles.

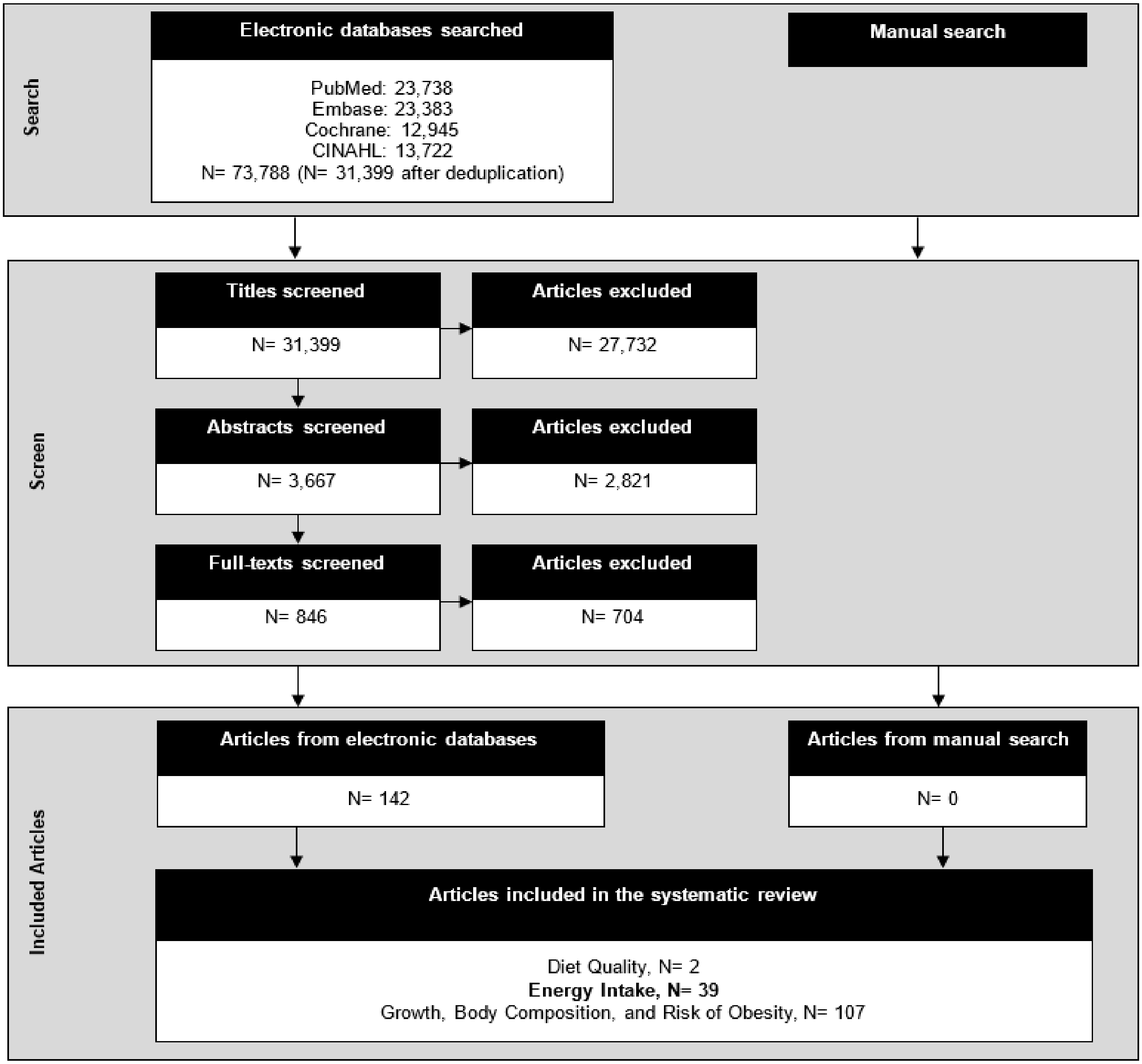
- Frequency of meals and/or snacking in children and adolescents: 5 articles[1-5]
- Breakfast in adults and older adults: 26 articles[6-31]
- Number of eating occasions in adults and older adults: 6 articles[32-37]
- Snacking in adults and older adults: 5 articles[32-34,38,39]

[*] 2025 Dietary Guidelines Advisory Committee. 2024. Scientific Report of the 2025 Dietary Guidelines Advisory Committee: Advisory Report to the Secretary of Health and Human Services and Secretary of Agriculture. U.S. Department of Health and Human Services. https://doi.org/10.52570/DGAC2025

[†] Palacios C, Andres A, Odoms-Young A, et al. *Frequency of Meals and/or Snacking and Consuming a Dietary Pattern That is Aligned With the Dietary Guidelines for Americans: A Systematic Review*. U.S. Department of Agriculture, Food and Nutrition Service, Center for Nutrition Policy and Promotion, Nutrition Evidence Systematic Review; 2025. https://doi.org/10.52570/NESR.DGAC2025.SR09

[‡] Palacios C, Raynor HA, Anderson CAM, et al. *Frequency of Meals and/or Snacking and Growth, Body Composition, and Risk of Obesity: A Systematic Review*. U.S. Department of Agriculture, Food and Nutrition Service, Center for Nutrition Policy and Promotion, Nutrition Evidence Systematic Review; 2025. https://doi.org/10.52570/NESR.DGAC2025.SR16

Figure 2. Literature search and screen flowchart



Frequency of meals and/or snacking in children and adolescents

Description of the evidence

Five articles examined the relationship between frequency of meals and/or snacking in children and adolescents and energy intake.[1-5] All included articles were crossover randomized trials. Included articles are summarized in **Table 8**, which encompasses each articles' definition of the specific category of frequency of meals and/or snacking being assessed in. Risk of bias assessments for each article are summarized in **Table 9**.

Population

Two articles were conducted in the U.S.[1,2] and 3 articles[3-5] were conducted in the UK. Sample size of study groups ranged from N=11 up to N=38. All trials were conducted in children with mean ages ranging from approximately 8.5 years to 13 years. Two articles were conducted only in females[4,5] while the other 3 included both males and females.

Two articles from the U.S. reported data on race and/or ethnicity: 83% White[2]; 76% African American, 19% White, 5% Mixed race[1]. None of the articles reported a measure of socioeconomic position. All articles included participants with varying baseline weight status, except for an article[1] that only included children within the category of normal BMI-for-age.

Intervention/exposure and comparator

Three articles[1,4,5] analyzed breakfast consumption, 1 article[3] assessed snacking, and 1 article[2] assessed number of eating occasions. The duration of the trials ranged from 1 day to 7 days (with a range of 2-day to 28-day washout periods).

Breakfast

In the 3 trials that assessed breakfast consumption, all compared those who consumed breakfast compared to those who did not consume breakfast.[1,4,5] Kral and colleagues[1] assessed breakfast consumption in a lab setting, looking only at single meal (with a 1-week washout period). The breakfast that was offered consisted of ready-to-eat breakfast cereal, 1% milk, banana, and orange juice. Zakrzewski-Fruer and colleagues conducted a study in the school setting and offered breakfast consisting of ready-to-eat cereal, semi-skimmed milk, and orange juice.[4] Zakrzewski-Fruer and colleagues assessed breakfast consumption at home and the offered breakfast consisted of ready-to-eat cereal with semi-skimmed milk, orange or apple juice, and optional raisins.[5]

Snacking

The included trial[4] that assessed snacking was a multi-component 1-day crossover trial with 4 conditions, all completed in a temporary lab setup within the school:

1. Control condition: no snack and no exercise
2. Snack: mid-morning snack
3. Exercise: moderate-intensity exercise
4. Snack + Exercise: mid-morning snack and moderate intensity exercise

Energy content of the offered snacks ranged from 1000-1033 kJ (239-247 kcal), carbohydrate ranged from 51-55%, protein from 11-12% and fat from 33-37%.

Number of eating occasions

The included trial that assessed number of eating occasions per day compared groups that consumed 2 isocaloric meal patterns, but in either 5 occasions (8am, 10am, 12pm, 2pm, 5pm) or 3 occasions (8am, 12pm, 5pm).[2] The following foods were offered at each study visit: Cheerios®; 2% milk; banana; wheat toast; butter;

cinnamon sugar; string cheese; chocolate chip granola bar; mandarin oranges; peanut butter; Premium® saltine crackers; apple juice; skim milk; Kraft® macaroni & cheese; Lit'l Smokies®; green beans; apple slices; Kool-Aid®, sugar-free; baby carrots; ranch dressing; chocolate milk, 1% fat; vanilla wafers; Hershey's Kisses®; canned peaches; juice pack; cottage cheese, 2% fat; whole milk; breaded chicken breast tenders; barbecue sauce; mashed potatoes; whipped margarine; chicken gravy; peas; and fruit punch.

Outcome

Among the 3 trials that assessed breakfast consumption, energy intake was assessed on the same day that each of the breakfast interventions took place. In one of the articles, energy intake at the subsequent lunch was measured in the lab by weighing all foods and beverages before and after the meal; while energy intake throughout the rest of the day was measured using a food record filled out by parental report.[1] In the other 2 articles, energy intake was measured by food diaries combined with digital photographs of the foods and beverages consumed.[4,5] Energy intakes (kcal) throughout the test day were reported at lunch[1], during the remainder of the day/post breakfast[1,4,5], and as total daily energy intake.[1,4,5] Additionally, Kral and colleagues[1] also reported all three outcome timepoints as energy density (kcal per gram).

In the one trial that assessed snacking, participants were offered pizza during lunch to eat ad libitum at the lab. Energy intake from lunch was calculated by weighing the plate before and after the food was consumed.[3]

The trial that assessed number of eating occasions per day measured energy intake from an offering of ad libitum ice-cream 2 hours following the last feeding on the same day as the intervention.[2]

Synthesis of the evidence

Five trials assessed frequency of meals and/or snacking and energy intake in children: 3 assessed breakfast, 1 assessed snacking, and 1 assessed the number of eating occasions per day.

Breakfast

Two out of 3 trials reported that children who consumed breakfast had higher total daily energy intakes on the day of testing compared to children who did not consume breakfast.[1,4] The other trial reported no difference in total daily energy intake between breakfast groups.[5]

One of the trials that reported a significant difference in total daily energy intake, reported that adolescent girls who ate breakfast had lower post-breakfast energy intake compared to girls who did not eat breakfast, indicating that the calories consumed at the randomized breakfast lead to the total daily energy intake result.[4] The other trial reported no other differences in energy intake at lunch or throughout the remainder of the day.[1]

Snacking

In the trial where adolescents were randomized to 4 conditions (control, mid-morning snack, exercise, or mid-morning snack and exercise), there were no between group differences in energy intake at an ad libitum lunch later that same day.[3] There was a higher mean difference in energy intake relative to energy expenditure in those that had a mid-morning snack and moderate-intensity exercise compared to when participants only had exercise and no snack.

Number of eating occasions

In an energy-controlled trial, children with obesity consumed more calories from an offering of ice cream after eating 5 meals that day compared to 3 meals, whereas children with normal weight consumed fewer calories from an offering of ice cream after eating 5 meals that day compared to 3 meals.[2]

Conclusion statement and grade

The 2025 Dietary Guidelines Advisory Committee was not able to develop a conclusion statement to answer the question, “What is the relationship between frequency of meals and/or snacking and energy intake?” based on their review of evidence in children and adolescents (**Table 4**). While the literature search was comprehensive, a search of the gray literature was not done, which may increase the possibility of publication bias. However, there were too few studies to thoroughly evaluate publication bias and it is unknown if the influence of publication bias contributed to the lack of articles available for inclusion in this body of evidence.

Table 4. Conclusion statement and grade for frequency of meals and/or snacking in children and adolescents and energy intake

Conclusion Statement	**A conclusion statement cannot be drawn about the relationship between frequency of meals and/or snacking in children and adolescents and energy intake because of substantial concerns with heterogeneity of exposures in a small body of evidence.**
Grade	Grade Not Assignable
Body of Evidence	5 articles: all crossover RCT
Rationale	Only a small number of articles met inclusion criteria for this review, and they varied in exposures and outcomes assessed: • 3 trials assessed breakfast consumption, 1 trial assessed snacking, and 1 trial assessed number of eating occasions. • 3 trials assessed energy intake at subsequent eating occasions as well as total daily energy intake, while the 2 other trials only measured energy intake at a subsequent eating occasion.

Breakfast in adults and older adults

Description of the evidence

Twenty-six articles examined the relationship between breakfast consumption in adults and older adults and energy intake.[6-31] Twenty-five articles[6-29,31] included data from randomized controlled trials and 1 article[30] reported data from a prospective cohort study. Six of the trial articles presented data from the same established trial project (Bath Breakfast Study), but examined different measures of frequency, outcomes, timepoints and/or subsets of participants.[7-12] Seven articles from 4 unique trials were parallel-arm designs[7-9,12,19,20,23] and 18 articles from 17 unique trials were crossover designs.[6,10,11,13-18,21,22,24-29,31] Evidence for breakfast in adults and older adults and energy intake is summarized in **Table 10**, which encompasses each articles' definition of breakfast consumption. Risk of bias assessments are summarized in **Table 11** (RCT) and **Table 12** (observational).

Population

The prospective cohort study was conducted in the U.S. in a predominantly White sample of participants (N=178; mean age 52 years; 73% female) with overweight/obesity and metabolic syndrome.[30] The article was a secondary analysis of an RCT comparing the American Heart Association diet to a high-fiber diet.

Among trials, sample size of study groups ranged from N=10 to N=54. The majority of articles included young adult populations in their 20s.[6,13-29,31] Six studies included adults with mean ages ranging from 35 to 44 years.[7-12] Several trials exclusively enrolled those at high-risk for diet-related chronic disease, with 100% participants with overweight or obesity.[8,9,11,20,21,23,27,30] Seven trials reported a mean BMI ≥25 kg/m^2. [8,9,11,20,21,23,27] The majority of the trials were conducted in the U.K.,[6-18,24,26,28] 7 studies were conducted in the U.S.,[19-23,27,31] 1 each in Italy and Japan.[25,29] Multiple articles represented data from the Bath Breakfast Study, but it examined different subsets of participants.[7-12]

Information on race and/or ethnicity was not reported in 22 studies.[6-19,21,22,24-26,28,29,31] however, 2 articles indicated participant heritage from the country of conduct (e.g., Japan and Italy).[25,29] Three trials reported data on race and/or ethnicity: 61% Caucasian, 35% African American, 4% Other[20]; 58% Caucasian, 13% Black, 8% Asian, 8% Indian, 13% Hispanic[23]; 72% Caucasian, 22% African American, 6% Asian (88% Non-Hispanic)[27]. The majority of the articles did not report any measure of socioeconomic position.[6-17,19-21,23-28,31] Education was only reported in 4 articles,[18,22,29,30] 2 of which were being conducted in university students.[22,29] One article also reported a measure of income and employment status.[30]

Intervention/exposure and comparator

The prospective cohort study measured breakfast consumption (defined as any food/beverage, excluding water, at the first eating episode no later than 10:00am) at baseline using three 24-hour recalls.[30]

Among trials, all articles compared breakfast consumption to no breakfast consumption. The majority of articles compared breakfast consumption to no breakfast consumption dichotomously.[6-13,15,17-19,24,27,29-31] Nine articles examined multiple categories of breakfast consumption (compared to a group that did not eat breakfast), in which the breakfast consumption groups differed by another component, such as nutritional content (e.g., high-protein versus normal-protein[20,21]; high-carbohydrate versus high-fiber[22]; protein-based versus carbohydrate-based[23]), specific foods (bread versus muesli versus rice[25]; whole-food breakfast versus low-calorie placebo breakfast[26]), amount (20 grams versus 40 grams[28]), or physical activity level (breakfast combined with exercise or rest[14,16]). Trial duration ranged from 1 day to 12 weeks; most trials were 1 day,[6,10,11,13,14,16,17,22,26-29] 7 trials were 1-2 weeks,[15,18,21,23-25,31] 5 trials were 4-6 weeks,[7-9,12,19] and 1 trial[20] was 12 weeks.

Outcome

Articles were included if they examined any measure of energy intake, and therefore there was some heterogeneity in the reported outcomes. The prospective cohort study reported change in total energy intake (representing kilocalories per day) over 1 year measured from three 24-hour dietary recalls.[30]

Among trials, the majority of articles measured energy intake by weighing the food before and after consumption.[6-14,16,17,21,22,25-28,31] Few studies used 24-hour diet records or food diaries.[15,18-20,23,24,29] The following outcomes were reported in the included trials:

- Energy intake during an ad libitum lunch following breakfast in controlled feeding settings.[6,8,10-14,16,22,25,26,28,29]
- Energy intake at breakfast and lunch combined following breakfast in controlled feeding settings[6,10,11,14,16,22,26]
- Energy intake consumed after lunch following breakfast and lunch in controlled feeding settings[13,22,27-29,31]
- Total daily energy intake[7,9,13-15,17-25,27-29,31]

Synthesis of the evidence

While it is useful to evaluate the extent to which breakfast skipping may influence energy intake at subsequent meals and snacks, effects of breakfast consumption on total daily energy intake are most relevant to the systematic review question. Therefore, the synthesis of trials, conclusion statements, and grading were based on the articles that included a measure of total daily energy intake. The results in the body of evidence were mixed and had many limitations. There was serious heterogeneity in the direction and the significance of the results in the included articles. Additionally, variation in participant characteristics and study methodology made the articles difficult to compare and synthesize. Duration of trials may explain some inconsistencies seen across the body of evidence, and additional long-term studies are needed.

Prospective cohort study

The one included prospective cohort study reported no association between baseline breakfast consumption and change in total daily energy intake over a 1-year follow-up.[30]

Some limitations noted included that the paper did not account for anthropometry, the exposure assessment method was not validated, and exposure data was only assessed at baseline leading to a concern that changes in exposure status occurred over 1-year follow-up. There was no information on non-completers and no preregistered data analysis plan.

Randomized controlled trials

Total daily energy intake

Total daily energy intake was examined in 18 trials. [7,9,13-15,17-25,27-29,31] While 2 of the trial articles were from the same project, they report results from different groups of participants and will be referred to as separate trials for the remainder of the synthesis.[7,9]

Nine of the 18 trials reported that those who consumed breakfast ate more total daily calories compared to those who did not consume breakfast.[7,13,14,17,19,21,22,24,29] The duration of these trials were short (5 were 1 day;[13,14,17,22,29] 2 were 1 week;[21,24] 2 were 4[19] or 6 weeks[7]). One of these trials was in participants with overweight and/or obesity.[21] The majority of trials were in young adults, with the oldest population having a mean of 36 years.[7] Three articles were exclusively in females[19,21,29] and 3 were exclusively in males.[13,14,17] Two articles included only usual breakfast skippers[19,21] and 3 were in usual breakfast eaters.[13,19,29] The foods that were consumed as part of the breakfast interventions varied across these articles and are reported in the summary table. Three trials did not provide food or instruct participants to eat specific breakfast foods,[7,19,24] 4 trials provided milk and cereal-, oats-, or grain-based breakfasts,[13,14,17,22] 1 included comparisons to both a high-protein breakfast ("egg and beef-rich") as well as a ready-to-eat-cereal-based breakfast,[21] and 1 article provided a breakfast of rice, ham, eggs, and salad.[29] The majority of the outcomes were calculated using weighed food intake,[7,13,14,17,21,22] which was the most accurate measurement of total energy intake, with only 3 studies using 24-hour recalls, food diaries, or purchased food labels and photographs.[19,24,29]

Seven of the 18 trials reported no differences in total energy intake between those who consumed breakfast compared to those who did not consume breakfast.[9,18,23,25,27,28,31] The duration of these trials were also short, with the longest being 6 weeks,[9] 2 were 1 day,[27,28] and 4 were about 1 week.[18,23,25,31] All but one of these studies were in participants in their 20s, [4]and 2 studies were conducted in participants with overweight or obesity.[9,27] The breakfasts that were offered varied substantially, with 4 focusing on cereal and milk or high-carbohydrate options (1 of which also offered eggs[27]),[18,25,27,28] 1 offered high-protein options,[31] 1 included comparisons to both a high protein and a high-carbohydrate breakfast,[23] and 1 did not provide or instruct what foods to consume during breakfast.[9] Three articles were exclusively in women,[23,27,28] and 1 was exclusively in men.[25] The majority of outcomes included weighing the foods to determine total daily energy intake,[9,25,27,28,31] with only 2 studies incorporating other methods.[18,23]

Two out of 18 articles reported that those who consumed breakfast ate fewer total daily calories compared to those who did not consume breakfast.[15,20] Both of these articles were longer in duration at 12 weeks and 14 weeks; however, both articles measured energy intake using 3-day food records or 24 hour recalls which were interpreted as a less accurate method compared to weighed food intakes. One article was conducted in healthy weight young women (mean age 25.5 years) who consumed breakfast regularly, while the other was in breakfast skipping young adults (mean age of 19 years) with overweight and/or obesity. The breakfasts foods provided in these two trials were different, one with whole-grain cereal with milk and the included comparisons to both a high-protein breakfast ("egg and pork-rich") as well as a ready-to-eat-cereal-based breakfast.

Energy intake from subsequent meals and/or snacks

The synthesis and conclusion statements in this systematic review are focused on total daily energy intake; however, additional shorter-term energy intake outcomes were included and considered in discussions.

Energy intake during an ad libitum lunch following breakfast in controlled feeding settings: Thirteen trials (11 crossovers) examined breakfast intake in relation to energy intake after an ad libitum lunch.[6,8,10-14,16,22,25,26,28,29] Seven trials (including 2 parallel trials) found that there was no difference in energy consumed at lunch between those who consumed a standardized breakfast compared to those who did not.[8,11,12,14,16,25,28] Six trials found that those who consumed breakfast ate fewer calories at an ad libitum lunch compared to those who did not consume breakfast.[6,10,13,22,26,29] None of these trials reported higher energy intake at an ad libitum lunch between those who ate breakfast compared to those who did not eat breakfast.

Energy intake at breakfast and lunch combined following breakfast in controlled feeding settings: Seven of those same trials that measured energy intake from lunch only also presented results where they summed calories from lunch with calories from breakfast.[6,10,11,14,16,22,26] Six out of 7 trials presented results indicating that those who consumed breakfast ate more calories at lunch and breakfast compared to those who did not consume breakfast.[10,11,14,16,22,26]

Energy intake consumed after lunch following breakfast and lunch in controlled feeding settings: Six trials reported calories consumed after lunch (usually when participants had left the lab setting) – and none of those trials reported a difference in energy intake between those who consumed breakfast compared to those who did not consume breakfast.[13,22,27-29,31]

Summary

Overall, the results in the body of evidence were mixed and had many limitations, including the lack of diversity of the population, the different study designs and interventions as well as the diversity in energy intake assessments. These results suggest that additional standardized studies are needed in larger and longer trials to establish a conclusion statement. There was serious heterogeneity in the direction and the significance of the results in the 19 included articles that could not be explained by participant characteristics.[7,9,13-15,17-25,27-31] Trial populations were very specific and together may not be fully representative of the adult and older adult U.S. population. All were generally young adults with selection criteria such as only including males, females, college students, those who were physically active, usual breakfast consumers, usual breakfast skippers, lean, and/or those with overweight or obesity. There was also a concern that breakfast provided in the trials may not have been reflective of usual consumption patterns and timing of eating of the U.S. population.

Study duration may be an unexplained driver of the mixed results in the trials. The majority of trials (16 of 18) had shorter durations of less than 6 weeks,[7,9,13,14,17-19,21-25,27-29,31] many of which (9 of 16) reported that breakfast consumption led to higher total daily energy intake.[7,13,14,17,19,21,22,24,29] However, the two trials of longer duration, 12[20] and 14 weeks,[15] reported results in the opposite direction leading to a concern that many of the included trials may not have been long enough to capture metabolic adjustments to consistent breakfast consumption (or non-consumption) over time. Additionally, the one observational study with a 1-year follow-up reported no association between breakfast and total daily energy intake.[30] More studies of longer duration are needed to explain these differences in outcomes. It is likely that more research on this topic would lead to additional clarity on the inconsistencies found in this body of evidence.

Conclusion statements and grades

The 2025 Dietary Guidelines Advisory Committee was not able to develop conclusion statements to answer the question, “What is the relationship between frequency of meals and/or snacking and energy intake?” based on their review of evidence on breakfast consumption in adults and older adults and energy intake (**Table 5**). While the literature search was comprehensive, a search of the gray literature was not done, which may increase the possibility of publication bias. However, this body of evidence comprised of both large and small studies, including small studies with null findings, so there are few concerns of publication bias.

Table 5. Conclusion statements and grades for breakfast consumption in adults and older adults and energy intake

Conclusion Statement	**A conclusion statement cannot be drawn about the relationship between breakfast consumption in adults and total daily energy intake because of substantial concerns with consistency and generalizability in the body of evidence.**	**A conclusion statement cannot be drawn about the relationship between breakfast consumption in older adults and energy intake because there is no evidence available.**
Grade	Grade Not Assignable	Grade Not Assignable
Body of Evidence	19 articles: 18 RCT, 1 prospective cohort study	0 articles
Rationale	The available evidence contributed mixed results and had many limitations including lack of diversity of the populations, different study designs, interventions, and durations as well as diversity in energy intake assessments.	No articles met the inclusion criteria in older adults.

Number of eating occasions in adults and older adults

Description of the evidence

Six articles examined the relationship between number of eating occasions in adults and older adults and energy intake.[32-37] Study designs of the included articles were 5 randomized controlled trials (3 parallel-arm trials[32-34] and 2 crossover trials[36,37]), and 1 prospective cohort study.[35] Evidence for number of eating occasions in adults and older adults and energy intake is summarized in **Table 13**, which encompasses each articles' definition of number of eating occasions. Risk of bias assessments are summarized in **Table 14** (RCT) and **Table 15** (observational).

Three of the trials included in this body of evidence was also included in the snacking body of evidence.[32-34] The analyses that are discussed are the exact same, but the exposure categories are interpreted as number of eating occasions as opposed to snacking.

Population

Studies were conducted in Sweden,[33,35] U.S.,[32] Brazil,[34] Norway,[36] and Greece.[37] Sample size of study groups ranged from N=11 up to N=93.

The observational study was a secondary analysis of trial data conducted in participants who were enrolled in a 12-week weight loss intervention in postpartum women with overweight and obesity.[35] Four out of the 5 trials were conducted in participants with overweight/obesity and/or with impaired glucose tolerance or overt type 2 diabetes.[32-34,37] One trial was conducted in lean adults (BMI 24.0±0.6 kg/m^2 and fat mass 24.0±0.6%).[36]

Only one article reported race and/or ethnicity or a measure of socioeconomic position, and the participants were 94% White and 98% Non-Hispanic with 88% having at least some college and 78% married. Two of the articles enrolled only females while the other 4 included both males and females.

Intervention/exposure

Four out of the 5 trials compared 6 meals vs. 3 meals per day,[32-34,37] while the other compared 3 meals vs. 1 meal per day.[36] Three were hypocaloric weight loss trials,[32-34] and 2 were eucaloric trials.[36,37] All trials were lab based controlled trials. The duration of the parallel trials ranged from 12 weeks to 1 year. The duration of the 2 crossover trials were 11 days (with a 2-week washout period) and 12 weeks (washout period length was not reported).

The observational study compared change in continuous eating occasions per day and measured exposure using a 4-day diet record.[35]

Outcome

All trials reported total daily energy intake (kcal),[32-34,36,37] while the observational trial reported change in total daily energy intake.[35] The assessment methods for measuring energy intake varied:

- 3-day diet record[32,34,37]
- Dietary questionnaire about past 3 months[33]
- Food diaries[36]

The observational article measured followed participants for 12 weeks from 10 to 14 weeks postpartum to post-intervention (22 to 26 weeks postpartum).[35]

Synthesis of the evidence

Prospective cohort study

In an observational analysis in postpartum women with overweight and obesity undergoing a weight loss intervention, eating frequency was positively associated with an increase in total daily energy intake over 12 weeks.[35]

Randomized controlled trials

All 5 of the included trials reported no relationship between number of eating occasions and total daily energy intake in adults.[32-34,36,37] All 5 trials were either weight loss trials or weight maintenance trials where the number of eating occasions and energy intake parameters was highly controlled and not generalizable to the general free-living U.S. population.

Conclusion statement and grade

The 2025 Dietary Guidelines Advisory Committee was not able to develop a conclusion statement to answer the question, "What is the relationship between frequency of meals and/or snacking and energy intake?" based on their review of on number of eating occasions and energy intake in adults and older adults (**Table 6**). While the literature search was comprehensive, a search of the gray literature was not done, which may increase the possibility of publication bias. However, there were too few studies to thoroughly evaluate publication bias, and it is not likely a concern given that all but one of the 6 included articles reported null results.

Table 6. Conclusion statement and grade for number of eating occasions in adults and older adults and energy intake

Conclusion Statement	**A conclusion statement cannot be drawn about the relationship between number of eating occasions per day in adults and older adults and energy intake because of substantial concerns with generalizability in a small body of evidence.**
Grade	Grade Not Assignable
Body of Evidence	6 articles: 5 RCT, 1 prospective cohort study
Rationale	Only a small number of articles met inclusion criteria for this review and they were not generalizable to the overall U.S. population. The trials were narrowly focused on eating occasions in the context of weight loss or weight maintenance intervention trials in populations with overweight and/or obesity or in those who had previously lost weight and would not be generalizable to a free-living U.S. population.

Snacking in adults and older adults

Description of the evidence

Five articles examined the relationship between snacking in adults and older adults and energy intake.[32-34,38,39] All included studies were randomized controlled trials: 4 were parallel-arm trials[32-34,39] and 1 was a crossover trial.[38] Evidence for snacking in adults and older adults and energy intake is summarized in **Table 16**, which encompasses each articles' definition of snacking. Risk of bias assessments are summarized in **Table 17**.

Three of the trials included in this body of evidence was also included in the number of eating occasions body of evidence.[32-34] The analyses that are discussed are the exact same, but the exposure categories are interpreted as snacking as opposed to number of eating occasions.

Population

Studies were conducted in the U.S.[32,39] UK,[38] Brazil,[34] and Sweden.[33] Sample size of study groups ranged from N=8 up to N=93. The duration of the parallel trials ranged from 8 weeks to 1 year. The duration of the crossover trial was 7 days (with a ≥1 week washout period).[38]

Only one article reported race and/or ethnicity or a measure of socioeconomic position, and the participants were 94% White and 6% Black (98% Non-Hispanic) with 88% having at least some college and 78% married.[32] Four out of the 5 trials were conducted in participants with overweight/obesity,[34] one of which enrolled only females.[34] The other trial enrolled only males who were with normal weight.[38]

Intervention/exposure and comparator

Three out of the 5 trials were hypocaloric weight loss trials and compared 3 snacks and 3 meals per day compared to only 3 meals per day.[32-34,37] The other two trials had varied snacking exposures including a crossover trial that compared 3 isoenergetically-dense snacks high in protein, fat or carbohydrate to no snacking,[38] and the other that compared having a post-dinner snack compared to no intervention.[39]

Outcome

All trials reported total daily energy intake (kcal).[32-34,38,39] The assessment methods for measuring energy intake varied:

- 3 day diet record,[32,34]
- Dietary questionnaire about past 3 months,[33]
- Provided food was returned and used to calculate energy intake.[38,39] Food was weighed in one article in a lab-based setting,[38] and method for calculation was not reported in the other.[39]

Synthesis of the evidence

All 5 of the included trials reported no relationship between snacking and total daily energy intake in adults.[32-34,38,39] Four out of 5 of the trials were weight loss trials where snacking and energy intake parameters were highly controlled and not generalizable to the general free-living U.S. population.[32-34,39]

Conclusion statement and grade

The 2025 Dietary Guidelines Advisory Committee was not able to develop a conclusion statement to answer the question, "What is the relationship between frequency of meals and/or snacking and energy intake?" based on their review of evidence on snacking and energy intake in adults and older adults (**Table 7**). While the literature search was comprehensive, a search of the gray literature was not done, which may increase the possibility of publication bias. However, there were too few studies to thoroughly evaluate publication bias, and it is not likely a concern given that all 5 included articles reported null results.

Table 7. Conclusion statement and grade for snacking in adults and older adults and energy intake

Conclusion Statement	**A conclusion statement cannot be drawn about the relationship between snacking in adults and older adults and energy intake because of substantial concerns with generalizability in the body of evidence.**
Grade	Grade Not Assignable
Body of Evidence	5 articles: all RCT
Rationale	There is not enough evidence available to answer this question and the evidence that is available is not generalizable to the overall U.S. population. The trials were narrowly focused on snacking in the context of weight loss intervention trials in participants with overweight and/or obesity and would not be generalizable to a free-living U.S. population.

Summary of conclusion statements and grades

The 2025 Dietary Guidelines Advisory Committee answered the systematic review question, "What is the relationship between frequency of meals and/or snacking and energy intake?", with the following conclusion statements.* The grades reflect the strength of the evidence underlying the conclusion statements.

Children and adolescents

A conclusion statement cannot be drawn about the relationship between frequency of meals and/or snacking in children and adolescents and energy intake because of substantial concerns with heterogeneity of exposures in a small body of evidence. (Grade: Grade Not Assignable)

Adults and older adults

A conclusion statement cannot be drawn about the relationship between breakfast consumption in adults and total daily energy intake because of substantial concerns with consistency and generalizability in the body of evidence. (Grade: Grade Not Assignable)

A conclusion statement cannot be drawn about the relationship between breakfast consumption in older adults and energy intake because there is no evidence available. (Grade: Grade Not Assignable)

A conclusion statement cannot be drawn about the relationship between number of eating occasions per day in adults and older adults and energy intake because of substantial concerns with generalizability in a small body of evidence. (Grade: Grade Not Assignable)

A conclusion statement cannot be drawn about the relationship between snacking in adults and older adults and energy intake because of substantial concerns with generalizability in the body of evidence. (Grade: Grade Not Assignable)

* A conclusion statement is carefully constructed, based on the evidence reviewed, to answer the systematic review question. A conclusion statement does not draw implications and should not be interpreted as dietary guidance.

Research recommendations

The Committee identified the following research recommendations that describe the research, data, and methodological advances that are needed to strengthen the body of evidence on frequency of meals and/or snacking and energy intake.

1. Develop and support prospective and/or experimental research that examines the relationship between frequency of meals and/or snacking and total daily energy intake in all age groups, including older adults, which includes a target population reflective of the geographic, racial, and socioeconomic diversity in the U.S.
2. Include details about what foods were consumed and their quality by study participants when reporting results related to frequency of meals and/or snacking and energy intake
3. Develop definitions of eating occasions, meals, and snacks as well as frameworks and reporting standards to be used consistently in research in order to increase comparability across studies and aid in the development of guidance around this topic.
4. Support research with funding from Federal and other funding agencies that provides information on types, frequency, timing, and size of meals and/or snacks in order to increase the accuracy and precision of the assessment of meal and snack frequency patterns and the ability to assess the combined and independent effects of frequency and timing of eating.
5. Provide consistency in the operational definition of frequency across studies when developing the comparisons to be examined in articles (e.g., categories of frequency comparisons vs. continuous frequency).
6. Explore all different meals and snack frequency patterns as a 24-hour eating behavior rather than isolating a meal or a snack and consider longer intervention period and follow-up.
7. Conduct studies that have enough follow up to understand the long-term impact of meals/snacks frequency patterns on energy intake.
8. Measure and assess energy intake across an entire 24-hour period in order to capture the impact of frequency of meals and snacks on an entire days’ consumption and not only on the following meal or snack.

Table 8. Evidence examining the relationship between frequency of meals and/or snacking in children and adolescents and energy intake[a]

Study and Population Characteristics	Intervention, Comparator, and Outcome(s)	Results and Summary of Findings	Study Limitations
Kral, 2011[1] **RCT-Crossover, U.S.** Baseline N=21, Analytic N=21 (Attrition: 0%) **Study objective:** To test the effects of consuming breakfast compared with omitting breakfast on energy intake, percentage of calories from fat, and dietary energy density at subsequent meals in children aged between 8 and 10 y **Participant characteristics at baseline:** children 8-10y with normal BMI-for-age % • Age: Mean (SD): 9.2 (0.8) • Female: 71% • Race and/or ethnicity: White: 19%; African American: 76%; Mixed race: 5% • Socioeconomic position: NR • Anthropometry: Mean (SD): BMI-for-age %, 57.3 (29.4); 71% normal weight, 29% overweight • Physical activity: NR • Smoking: N/A • TEI: NR • Usual diet at baseline: Eat breakfast daily: 91% during week and 95% on weekend **Excluded from study or analysis:** BMI-for-age <5th% and >94th%; serious medical conditions known to affect food intake and body weight; any learning disability or visual or auditory impairment; any developmental, medical, or psychiatric conditions that might affect study compliance; any food allergies; or were taking medications known to affect food intake or body weight.	**Intervention:** Breakfast vs No Breakfast (NB) Children consumed breakfast in full over a period of 30 min in presence of a research assistant who waited in an adjacent room. Participants were allowed to drink water, if desired. Breakfast consisted of ready-to-eat breakfast cereal, 1% milk, banana, and orange juice (350 kcal, which comprised ~19% of children's daily estimated energy requirement). Duration: Single meal (1wk washout) Compliance: parents/caretakers were asked to complete a meal/snack report to ensure that they had complied with the study procedures. **Outcomes and assessment methods:** Children were served lunch at 11:45am and consumed ad libitum over a period of 20 min. Lunch consisted of pasta, tomato sauce, broccoli, applesauce, chocolate chip cookies, and 1% milk. Portion sizes remained constant across experimental conditions. • Energy intake during lunch: assessed by weighing all foods and beverages before and after the meal to determine the amount consumed by each child to the nearest 0.1g. • Energy intake throughout remainder of the day: assessed via parental-report. Parents were instructed to complete a food record capturing their child's food and beverage intake throughout the remainder of the day (away from lab). Parents received detailed training by a clinical research coordinator with written instructions and visual aids for portion size estimates. • Total daily energy intake: sum of calories consumed at breakfast, lunch, and during the remainder of the day. • Energy density of the food consumed at lunch (laboratory meal) and throughout the remainder of the day (self-reported intake), excluding beverages, was computed by dividing the total energy consumed from food by the total weight of food consumed.	**Energy intake at lunch (kcal)**, Mean (SE) NB: 593 (50) Breakfast: 634 (50) p=0.36 **Energy intake consumed through remainder of the day (kcal)**, Mean (SE) NB: 1237 (134) Breakfast: 1207 (134) p=0.85 **Total daily energy intake (kcal)**, Mean difference 362 more with breakfast consumption compared to NB p=0.04 **Energy density at lunch (kcal/g)**, Mean (SE) NB: 1.25 (0.06) Breakfast: 1.25 (0.06) p=0.91 **Energy density throughout remainder of the day (kcal/g)**, Mean (SE) NB: 2.08 (0.16) Breakfast: 2.16 (0.16) p=0.68	**Limitations:** • Methods for randomization and concealment NR • Not sufficiently powered • No preregistered data analysis plan **Funding:** General Mills Bell Institute of Health and Nutrition

Study and Population Characteristics	Intervention, Comparator, and Outcome(s)	Results and Summary of Findings	Study Limitations
Mehra, 2011[2] **RCT-Crossover, U.S.** Baseline N=35, Analytic N=35 (Attrition: 0%) **Study objective**: To determine the effect of feeding frequency on appetite in prepubertal children with normal weight and obesity. **Participant characteristics at baseline**: prepubertal children (6-10y) with normal weight or obesity • Age: Mean ~8.5y • Female: 53% • Race and/or ethnicity: White: 83% • Socioeconomic position: NR • Anthropometry: BMI%, Mean (SD), 56.67 (5.42) in lean and 97.76 (0.16) in obesity • Physical activity: NR • Smoking: N/A • TEI: ~1580 kcal in children with normal weight; ~2300 kcal in children with obesity • Usual diet at baseline: NR **Excluded from study or analysis:** diabetes or any other chronic disease; any syndrome involving abnormal metabolism or eating; use of steroids, stimulant medications, or any other medication known to increase or decrease appetite; signs of puberty on examination; <6 or >10y at first study visit	**Intervention**: 5 vs 3 meals per day Children were assigned to one of two isocaloric meal patterns (5-meal or 3-meal) and asked to consume the meal within 30min. The 5-meal pattern was 20% total daily energy needs at 8am, 10am, 12pm, 2pm and 5pm. The 3-meal pattern was 33% of total daily energy needs at 8am, 12pm, and 5pm. No additional foods or beverages including water were provided between meals. Children were asked to eat their last food no later than 8pm the night before coming into the lab. Duration: 1 day (2d-2wk washout) Compliance: "All subjects complied with the treatments and followed the protocol" **Outcomes and assessment methods:** • Same day as intervention • Children were offered ice cream ad libitum (up to a predetermined upper limit of 8 quarter-cup scoops) 2hr following the last feeding. Ice cream consumption was determined by the difference in weights of the bowls before and after consumption of the amount desired. Energy intake of ice cream was calculated.	**<u>Total ice cream consumed (kcal)</u>**, Mean (SE) Children with obesity (n=17): 73.0 (37.4) more after 5-meal compared to 3-meal Children with normal weight (n=18): 47.1 (27.8) less after 5-meal compared to 3-meal Group x Meal pattern interaction: p=0.014	**Limitations**: • Methods for randomization and concealment NR • No power calculation • No preregistered data analysis plan **Funding**: NIH; Iowa Affiliate of the Fraternal Order of the Eagles; VA Medical Affairs; Genentech Foundation

Study and Population Characteristics	Intervention, Comparator, and Outcome(s)	Results and Summary of Findings	Study Limitations
Varley-Campbell, 2017[3] **RCT-Crossover, UK** Baseline N=40, Analytic N=38 (Attrition: 5%) **Study objective**: To investigate whether an energy-controlled mid-morning snack, an increased energy expenditure from a moderate-intensity exercise session, or a combined protocol can alter acute subjective feelings of appetite, and whether acute lunchtime EI would be altered between conditions. **Participant characteristics at baseline**: adolescents • Age: Mean ~13y • Female: 47% • Race and/or ethnicity: NR • Socioeconomic position: NR • Anthropometry: BMI, Mean (SD), 15.3 (2.3) kg/m^2 in girls, 18.4 (2.1) in boys • Physical activity: EE 1 MJ for EX and EX+SN groups • Smoking: NR • TEI: Breakfast not included in EI (constant throughout). • Usual diet at baseline: External eating, Mean (SD), 2.01 (0.55) boys and 1.95 (0.41) girls **Excluded from study or analysis**: history of diabetes or other metabolic disorders known to affect intermediary metabolism	**Intervention:** Snacking: 1 of 4 conditions, all completed in a temporary lab setup within the school Control (CON): control condition of no snack and no exercise Snack (SN): mid-morning snack Exercise (EX): moderate-intensity exercise Snack + Exercise (SN+EX): mid-morning snack and moderate-intensity exercise Duration: 1 day (7-28d washout) Compliance: NR **Outcomes and assessment methods:** • Same day as intervention • Participants were given pizza to eat ad libitum during the duration of lunch break (40min). • Energy intake from lunch was calculated by weighing intake of each lunch plate. • Relative energy intake was calculated for each condition (EI + 1 MJ for SN and SN+EX conditions, and EI -1 MJ for EX and SN+EX conditions) to take daily energy balance into consideration.	**<u>Energy intake at lunch (kcal)</u>**, Mean (SE) Between group difference: data NR (figure only), p=0.202 Group x sex interaction: p=0.583 **<u>Relative energy intake (kcal)</u>**, Mean (SE) Between group difference: data NR (figure only), p<0.001 Group x sex interaction: p=0.583 **<u>Relative energy intake (kcal)</u>**, Mean difference (SEM) SN+EX vs EX: 191.2 (47.8) higher in SN+EX, p<0.05 SN vs CON: data NR, NS	**Limitations:** • Methods for randomization and concealment NR • No preregistered data analysis plan **Funding:** Kelloggs Ltd

Study and Population Characteristics	Intervention, Comparator, and Outcome(s)	Results and Summary of Findings	Study Limitations
Zakrzewski-Fruer, 2017[4] **RCT-Crossover, UK** Baseline N=49, Analytic N=40 (Attrition: 18%) **Study objective:** To compare the effect of three consecutive weekdays of breakfast omission with standardized breakfast consumption on free-living energy intake and physical activity in girls aged 11-15y. **Participant characteristics at baseline:** adolescent girls • Age: Mean (SD): 13.3 (0.8)y • Female: 100% • Race and/or ethnicity: NR • Socioeconomic position: NR • Anthropometry: Mean (SD): BMI 21.5 (5.0) kg/m^2 • Physical activity: MVPA ~7% of total wear time • Smoking: NR • TEI: NR Usual diet at baseline: Usual breakfast: Mean (SD), 183 (105) kcal/d **Excluded from study or analysis:** health-related issues identified from health screening questionnaire; unable to walk or wear a physical activity monitor on their wrist; did not attend breakfast intervention on all days; did not abstain from all foods and beverages until 10:30am (for breakfast skipping group); consumed <80% of recommended daily energy intake of breakfast intervention; did not record their diet and wear accelerometer as specified	**Intervention:** Breakfast vs No Breakfast (NB) The breakfast group consumed breakfast at school within 30 min (8:15-8:45am), which consisted of ready-to-eat cereal, semi-skimmed milk, and orange juice (500kcal, equating to ~22-26% of daily energy requirements). The NB group arrived at school in the fasted state and were provided with 375 mL water at school; they were instructed to consume no food or drink except water from 9pm the previous day to 10:30am the following morning). Duration: 3 consecutive weekdays (4d or 11d washout) Compliance: Excluded from analysis if non-compliant **Outcomes and assessment methods:** • Same day as intervention • Energy intake assessed using food diaries combined with digital photographs of all foods and beverages consumed	**Energy intake (kcal)**, Mean (SD) **Total daily** (8:00am-9pm): NB: 1257 (339) Breakfast: 1608 (295) p<0.0005 **Post-breakfast** (10:30am-9pm): NB vs breakfast: 115 (313) kcal higher in NB group p=0.025	**Limitations:** • No preregistered data analysis plan **Funding:** No external funding

Study and Population Characteristics	Intervention, Comparator, and Outcome(s)	Results and Summary of Findings	Study Limitations
Zakrzewski-Fruer, 2021[5] **RCT-Crossover, UK** Baseline N=23, Analytic N=11 (Attrition: 52%) **Study objective:** To compare the effects of seven days of breakfast consumption with breakfast omission on free-living physical activity energy expenditure in adolescent girls classified as habitual breakfast skippers. **Participant characteristics at baseline:** adolescent girls • Age: Mean (SD): 13.3 (0.8)y • Female: 100% • Race and/or ethnicity: NR • Socioeconomic position: NR • Anthropometry: Mean (SD): BMI 21.3 (3.2) kg/m^2 • Physical activity: NR • Smoking: NR • TEI: NR • Usual diet at baseline: Habitually skips breakfast: Mean (SD), 5 (1) days/wk **Excluded from study or analysis:** health-related issues identified from health screening questionnaire; unable to walk or wear a combined heart rate and accelerometer on their chest; classified as habitual breakfast consumers; did not consume their breakfast on all 7 days (breakfast group) or did not confirm verbally that they had not consumed energy-providing nutrients before 10:30am on all 7 days (NB group).	**Intervention:** Breakfast vs No Breakfast (NB) The breakfast group consumed a standardized breakfast at home before 9:00am; breakfast consisted of ready-to-eat cereal with semi-skimmed milk, orange or apple juice, and optional raisins. Food items were provided in pre-packaged containers with marked beakers to measure milk and juice. The NB group abstained from all energy-providing nutrients before 10:30am. Both groups could eat ad libitum from 10:30am onward. Breakfast was defined as consumption with 2-3hr of waking, typically no later than 10:00am. Duration: 7 consecutive days (7-10d washout) Compliance: Excluded from analysis if non-compliant **Outcomes and assessment methods:** • Same day as intervention Energy intake assessed using food diaries combined with digital photographs of all foods and beverages consumed	**Energy intake (kcal)**, Mean (95% CI) **Total daily intake** (wake time to bed time) NB: 975 (732, 1299) Breakfast: 1005 (755, 1339) p=NS **Post-breakfast intake** (10:30am-3:30pm, 3:30pm to bed time) NB: 484 (292, 803), 389 (235, 645) Breakfast: 413 (249, 684), 282 (170, 468) p=NS	**Limitations:** • Differences in attrition • Not sufficiently powered • No preregistered data analysis plan **Funding:** Nutrition Society Summer Studentship Scheme; National Institute for Health Research Leicester Biomedical Research Centre

[a] Abbreviations: BMI: body mass index; CON: control; d: day; EI: energy intake; EX: exercise; kcal: kilocalories; MJ: megajoule; MVPA: moderate to vigorous physical activity; NB: no breakfast; NR: not reported; NS: not significant; SE: standard error; SD: standard deviation; SN: snack; TEI: total energy intake; wk: week; y: year

Table 9. Risk of bias for randomized controlled trials examining frequency of meals and/or snacking in children and adolescents and energy intake[a]

Article	Randomization	Period and carryover effects	Deviations from intended interventions (per-protocol)	Missing outcome data	Outcome measurement	Selection of the reported result	Overall risk of bias
Kral, 2011[1]	SOME CONCERNS	LOW	LOW	LOW	LOW	SOME CONCERNS	SOME CONCERNS
Mehra, 2011[2]	SOME CONCERNS	LOW	LOW	LOW	LOW	SOME CONCERNS	SOME CONCERNS
Varley-Campbell, 2017[3]	SOME CONCERNS	LOW	LOW	LOW	LOW	SOME CONCERNS	SOME CONCERNS
Zakrzewski-Fruer, 2017[4]	LOW	LOW	LOW	LOW	LOW	SOME CONCERNS	SOME CONCERNS
Zakrzewski-Fruer, 2021[5]	LOW	LOW	LOW	HIGH	LOW	LOW	HIGH

[a] Possible ratings of low, some concerns, or high determined using the "Cochrane Risk-of-bias 2.0" (RoB 2.0) (August 2019 version)" (Sterne JAC, Savović J, Page MJ, et al. RoB 2: a revised tool for assessing risk of bias in randomised trials. *BMJ* 2019; **366**: l4898. doi:10.1136/bmj.l4898.)

Table 10. Evidence examining the relationship between breakfast consumption in adults and energy intake[a]

Study and Population Characteristics	Intervention, Comparator, and Outcome	Results	Study Limitations
RANDOMIZED CONTROLLED TRIALS			
Astbury, 2011[6] **RCT-Crossover, UK** Baseline N=12, Analytic N=12 (Attrition: 0%) **Study objective:** To compare the effects of consuming breakfast with omitting breakfast on energy intake at a lunchtime test meal, subjective appetite responses, and the metabolic and endocrine responses to foods consumed later in the day in men who regularly eat breakfast. **Participant characteristics at baseline:** male habitual breakfast eaters • Age: 24.3 (7.3)y • Female: 0% • Race and/or ethnicity: NR • Socioeconomic position: NR • Anthropometry: BMI 23.5 (1.7) kg/m^2 • Physical activity: NR • Smoking: NR • TEI: NR • Habitual diet at baseline: All habitually consumed breakfast (inclusion criteria) **Excluded from study or analysis:** aged <18 or >45y; BMI <19 or >25 kg/m^2; female; irregular breakfast eater (consuming ready-to-eat cereal or continental style breakfast on <5 of 7 d); history of serious disease or currently taking any medications; current dieters; those with a recent weight loss or gain (±3 kg in the past 6mo); restrained eaters (score >7 for restraint on Three Factor eating Questionnaire); those with symptoms of clinical depression	**Intervention:** Breakfast vs No Breakfast (NB) Breakfast: cereal and milk (10% of daily energy requirement) consumed within 20min; water ad libitum Breakfast provided included Rice Krispies (Kelloggs) and semi skimmed milk (1.7% fat; cereal:milk ratio was 30g:125 mL) equivalent to 10% of the participant's DER. Each breakfast contained 14, 14, and 72% energy from protein, fat, and carbohydrate, respectively. NB: no breakfast (water ad libitum) Both groups were given a 400mL preload (protein shake, 251 kcal) after breakfast. Duration: 1d (≥1wk washout) Compliance: NR **Outcomes and assessment methods:** • Same day as intervention • Participants were provided with an ad libitum pasta lunch in pre-weighed servings; participants voluntarily terminated the lunch meal. Energy intake was determined from the weight of food consumed.	<u>**Energy intake (kcal)**</u>, Mean (SEM) **Lunch** NB: 1377 (96) Breakfast: 1171 (109) p<0.01 **Breakfast + Preload + Lunch** NB: 1632 (96) Breakfast: 1625 (109) p=NS	**Limitations:** • Methods for randomization and concealment NR • No preregistered data analysis plan • Water/Beverages were not accounted for in exposure assessment **Funding:** Mars UK

Study and Population Characteristics	Intervention, Comparator, and Outcome	Results	Study Limitations
Betts, 2014[7] **RCT-Parallel, Bath Breakfast Project, UK** Baseline N=38, Analytic N=33 (Attrition: 13%) **Study objective:** To conduct a randomized controlled trial examining causal links between breakfast habits and all components of energy balance in free-living humans. **Participant characteristics at baseline:** lean adults • Age: 36 (11)y • Female: 64% • Race and/or ethnicity: NR • Socioeconomic position: NR • Anthropometry: BMI 22.4 (2.2) kg/m^2 • Physical activity: NR • Smoking: NR • TEI: ~2400 kcal/d • Habitual diet at baseline: 79% habitual breakfast consumers (>50 kcal intake within 2hr of waking on ≥4d/wk) **Excluded from study or analysis:** BMI <18 or >25 kg/m^2, not weight stable (>1 kg body mass within past 6mo), metabolic disorders, non-standard sleep-wake cycle (e.g., shift workers), anticipated changes in diet and/or physical activity habits during study period, pregnant or breastfeeding, condition or behavior deemed to pose undue personal risk or introduce bias into experiment	**Intervention:** Breakfast vs No Breakfast (NB) Breakfast (n=16): consumed ≥700 kcal before 11am daily, with at least half consumed within 2hr of waking Foods/calories consumed were self-selected, but given examples NR; ≥700 kcal NB (n=17): extended overnight fast by abstaining from ingesting energy-providing nutrients (i.e., plain water only) until 12pm each day Duration: 6wk Compliance: confirmed via self-report and continuous glucose monitoring **Outcomes and assessment methods:** • At baseline, 6wk • Energy intake estimated from directly weighed food diaries. Participants were provided with a set of food-weighing scales and trained by staff on how to record food intake.	<u>**Energy intake (kcal)**</u>, Mean (SE) Within group: baseline, 6wk NB: 2169 (490), 2214 (584) Breakfast: 2715 (565), 2745 (658) Between groups: p=0.01 at baseline p=0.02 at 6wk <u>**Energy intake over 6wk period (kcal)**</u>, Mean (SE) NB: 2191 (494) Breakfast: 2730 (573) p=0.007	**Limitations:** • Water/Beverages were not accounted for in exposure assessment **Funding:** Biotechnology and Biological Sciences Research Council

Study and Population Characteristics	Intervention, Comparator, and Outcome	Results	Study Limitations
Chowdhury, 2015[10] **RCT-Crossover, Bath Breakfast Project, UK** Baseline N=38, Analytic N=34 (Attrition: 11%) **Study objective:** To examine acute effects of extended morning fasting upon subsequent energy intake and metabolic/hormonal responses **Participant characteristics at baseline:** lean adults • Age: 36 (11)y • Female: 60% • Race and/or ethnicity: NR • Socioeconomic position: NR • Anthropometry: BMI 22.7 (2.5) kg/m^2 • Physical activity: NR • Smoking: NR • TEI: NR • Habitual diet at baseline: 77% habitual breakfast consumers (>50 kcal intake within 2hr of waking on ≥4d/wk) **Excluded from study or analysis:** aged <21 or >60y, BMI <18 or >25 kg/m^2, not weight stable (>1 kg body mass within past 6mo), metabolic disorders, non-standard sleep-wake cycle (e.g., shift workers)	**Intervention:** Breakfast vs No Breakfast (NB) Breakfast: corn flakes, 2% milk, toasted white bread, margarine, and fresh orange juice (469±57 kcal; 70% carbohydrate, 17% fat and 13% protein) consumed within 15 minutes. Overnight fasting duration was ≥11h. NB: no breakfast; unclear if participants were allowed water. Overnight fasting duration was ≥14.5h. Duration: 1d (3-28d washout) Compliance: NR **Outcomes and assessment methods:** • Same day as intervention • Participants were provided with ad libitum lunch 3hr after breakfast. Energy intake was measured based on volume consumed.	<u>**Energy intake (kcal)**</u>, Mean (SD) **Lunch** NB: 929 (317) Breakfast: 776 (349) p<0.01 **Breakfast + Lunch** NB: 929 (317) Breakfast: 1246 (380) p<0.001	**Limitations:** • Methods for randomization and concealment NR • Water/Beverages were not accounted for in exposure assessment **Funding:** Biotechnology and Biological Sciences Research Council

Study and Population Characteristics	Intervention, Comparator, and Outcome	Results	Study Limitations
Chowdhury, 2016a[9] **RCT-Parallel, Bath Breakfast Project, UK** Baseline N=23, Analytic N=22 (Attrition: 4%) **Study objective:** To examine causal links between breakfast habits and components of energy balance in free-living humans with obesity **Participant characteristics at baseline:** adults with obesity • Age: 44 (10)y • Female: 65% • Race and/or ethnicity: NR • Socioeconomic position: NR • Anthropometry: BMI 33.7 (4.9) kg/m^2 • Physical activity: NR • Smoking: NR • TEI: ~2600 kcal/d • Habitual diet at baseline: 61% habitual breakfast consumers (>50 kcal intake within 2hr of waking on ≥4d/wk) **Excluded from study or analysis:** aged <21 or >60y, not weight stable (>2% within past 6mo), shift workers, irregular menstrual cycle/contraceptive use (if relevant), anticipated changes in diet and/or physical activity habits during study period, pregnant or breastfeeding, condition or behavior deemed to pose undue personal risk or introduce bias into experiment	**Intervention:** Breakfast vs No Breakfast (NB) Breakfast (n=11): consumed ≥700 kcal before 11am daily, with at least half consumed within 2hr of waking NB (n=11): extended overnight fast by abstaining from ingesting energy-providing nutrients (i.e., plain water only) until 12pm each day. Foods/calories consumed were self-selected, but given examples NR; ≥700 kcal Duration: 6wk Compliance: confirmed via self-report and continuous glucose monitoring **Outcomes and assessment methods:** • At baseline, 6wk • Energy intake estimated from directly weighed food diaries. Participants were provided with a set of food-weighing scales and trained by staff on how to record food intake.	**<u>Energy intake (kcal/d)</u>**, Mean (SE) Within group: baseline, 6wk NB: 2459 (780), 2303 (792) Breakfast: 2820 (595), 2618 (833) Between groups: p=0.2 at baseline p=0.4 at 6wk **<u>Energy intake over 6wk period (kcal)</u>**, Mean (SE) NB: 2381 (777) Breakfast: 2719 (683) p=0.3	**Limitations:** • Water/Beverages were not accounted for in exposure assessment **Funding:** Biotechnology and Biological Sciences Research Council

Study and Population Characteristics	Intervention, Comparator, and Outcome	Results	Study Limitations
Chowdhury, 2016b[11] **RCT-Crossover, Bath Breakfast Project, UK** Baseline N=24, Analytic N=24 (Attrition: 0%) **Study objective:** To examine energy intake, as well as metabolic and hormonal responses to acute morning fasting in individuals with obesity **Participant characteristics at baseline:** adults with obesity • Age: 44 (10)y • Female: 16% • Race and/or ethnicity: NR • Socioeconomic position: NR • Anthropometry: BMI 33.5 (4.7) kg/m^2 • Physical activity: NR • Smoking: NR • TEI: NR • Habitual diet at baseline: 14% habitual breakfast consumers (>50 kcal intake within 2hr of waking on ≥4d/wk) **Excluded from study or analysis:** not weight stable (>2% within past 6mo), non-standard sleep-wake cycle (e.g., shift workers), metabolic disorders, taking medications known to affect appetite regulation, irregular menstrual cycle/contraceptive use (if relevant), anticipated changes in diet and/or physical activity habits during study period, pregnant or breastfeeding, condition or behavior deemed to pose undue personal risk or introduce bias into experiment	**Intervention:** Breakfast vs No Breakfast (NB) Breakfast: cereal, milk, toast, orange juice (521±94 kcal) consumed within 15 minutes NB: no breakfast; unclear if participants were allowed water Duration: 1d (3-28d washout) Compliance: NR **Outcomes and assessment methods:** • Same day as intervention • Participants were provided with ad libitum lunch 3hr after breakfast. Energy intake was measured based on volume consumed.	<u>**Energy intake (kcal)**</u>, Mean (SD) **Lunch** NB: 869 (354) Breakfast: 817 (325) p=0.1 **Breakfast + Lunch** NB < Breakfast: -469 (-393, -545) p<0.01	**Limitations:** • Methods for randomization and concealment NR • Water/Beverages were not accounted for in exposure assessment **Funding:** Biotechnology and Biological Sciences Research Council

Study and Population Characteristics	Intervention, Comparator, and Outcome	Results	Study Limitations
Chowdhury, 2018[12] **RCT-Parallel, Bath Breakfast Project, UK** Baseline N=31, Analytic N=31 (Attrition: 0%) **Study objective:** To examine if daily breakfast consumption or fasting until noon modifies the acute metabolic and appetitive responses to a fixed breakfast and ad libitum lunch **Participant characteristics at baseline:** lean adults • Age: ~35.5 (11)y • Female: 61% • Race and/or ethnicity: NR • Socioeconomic position: NR • Anthropometry: BMI ~22 kg/m^2 • Physical activity: NR • Smoking: NR • TEI: NR • Habitual diet at baseline: 81% habitual breakfast consumers (>50 kcal intake within 2hr of waking on ≥4d/wk) **Excluded from study or analysis:** BMI <18 or >25 kg/m^2, not weight stable (>1 kg body mass within past 6mo), metabolic disorders, non-standard sleep-wake cycle (e.g., shift workers), anticipated changes in diet and/or physical activity habits during study period, pregnant or breastfeeding, condition or behavior deemed to pose undue personal risk or introduce bias into experiment	**Intervention:** Breakfast vs No Breakfast (NB) Breakfast (n=15): consumed ≥700 kcal before 11am daily, with at least half consumed within 2hr of waking NB (n=16): extended overnight fast by abstaining from ingesting energy-providing nutrients (i.e., plain water only) until 12pm each day Duration: 6wk Compliance: NR **Outcomes and assessment methods:** • At baseline, 6wk • Participants were provided with ad libitum lunch 3hr after breakfast. Energy intake was measured based on volume consumed.	**Energy intake (kcal)**, Mean (SE) **Lunch** NB vs Breakfast: p>0.2 **Breakfast + Lunch** Within group: baseline, 6wk NB: 1150 (341), 1177 (422) Breakfast: 1291 (377), 1368 (461) p-value NR	**Limitations:** • Water/Beverages were not accounted for in exposure assessment **Funding:** Biotechnology and Biological Sciences Research Council

Study and Population Characteristics	Intervention, Comparator, and Outcome	Results	Study Limitations
Chowdhury, 2019[8] **RCT-Parallel, Bath Breakfast Project, UK** Baseline N=22, Analytic N=22 (Attrition: 0%) **Study objective:** To determine the effects of sustained morning fasting or breakfast consumption on metabolism, energy intake, and appetite in healthy adults with obesity **Participant characteristics at baseline:** adults with obesity • Age: 43.5 (10)y • Female: 64% • Race and/or ethnicity: NR • Socioeconomic position: NR • Anthropometry: BMI ~33 kg/m^2 • Physical activity: NR • Smoking: NR • TEI: NR • Habitual diet at baseline: 59% habitual breakfast consumers (>50 kcal intake within 2hr of waking on ≥4d/wk) **Excluded from study or analysis:** BMI<30 kg/m^2, not weight stable (>2% within past 6mo), non-standard sleep-wake cycle (e.g., shift workers), metabolic disorders, irregular menstrual cycle/contraceptive use (if relevant), anticipated changes in lifestyle during study period	**Intervention:** Breakfast vs No Breakfast (NB) Breakfast (n=11): consumed ≥700 kcal before 11am daily, with at least half consumed within 2hr of waking NB (n=11): extended overnight fast by abstaining from ingesting energy-providing nutrients (i.e., plain water only) until 12pm each day Duration: 6wk Compliance: NR **Outcomes and assessment methods:** • At baseline, 6wk • Participants were provided with ad libitum lunch 3hr after breakfast. Energy intake was measured based on volume consumed.	<u>**Energy intake (kcal)**</u>, Mean (SEM) **Lunch** Within group: baseline, 6wk NB: 735 (330), 750 (284) Breakfast: 893 (313), 779 (323) Group x trial interaction: p=0.13 **Breakfast + Lunch** Within group: baseline, 6wk NB: 1272 (331), 1286 (274) Breakfast: 1418 (350), 1305 (366) p-value NR	**Limitations:** • Water/Beverages were not accounted for in exposure assessment **Funding:** Biotechnology and Biological Sciences Research Council

Study and Population Characteristics	Intervention, Comparator, and Outcome	Results	Study Limitations
Clayton, 2015[13] **RCT-Crossover, UK** Baseline N=10, Analytic N=10 (Attrition: 0%) **Study objective:** To examine the effect of breakfast omission and consumption on subsequent energy intake and evening exercise performance 4hr after provision of an ad libitum lunch **Participant characteristics at baseline:** male habitual breakfast eaters • Age: 22 (3)y • Female: 0% • Race and/or ethnicity: NR • Socioeconomic position: NR • Anthropometry: BMI 23.5 (3.2) kg/m^2 • Physical activity: All recreationally active (<10hr/wk) • Smoking: NR • TEI: NR • Habitual diet at baseline: All habitual breakfast eaters **Excluded from study or analysis:** NR	**Intervention:** Breakfast vs No Breakfast (NB) Breakfast: standardized breakfast meal based on 25% of estimated daily energy requirements (733 ± 46 kcal) consumed in entirety within 30min; included crisped rice cereal, semi-skimmed milk, wholemeal toast, margarine, strawberry jam, orange juice, and water. NB: water only Duration: 1d (≥1wk washout) Compliance: NR **Outcomes and assessment methods:** • Same day as intervention • Participants were provided with an ad libitum lunch buffet around 12:30pm and an ad libitum pasta dinner around 7pm. Ad libitum water and low-energy squash were available upon request throughout the study period and were provided with each buffet meal. Meals were served in the lab and participants were given 30min to consume each meal. They were instructed not to eat or drink anything other than plain water until they went to bed. Energy intake was calculated by weighing the food before and after consumption.	**Energy intake (kcal)**, Mean (SD) **Lunch** NB: 1387 (434) Breakfast: 1188 (475) p<0.01 **Dinner** NB: 1406 (345) Breakfast: 1520 (390) p=0.052 **Lunch and dinner** NB: 2793 (452) Breakfast: 2708 (506) p=0.196 **Total at breakfast, lunch, and dinner** NB: 2793 (452) Breakfast: 3447 (539) p<0.05	**Limitations:** • Methods for randomization and concealment NR • No power calculation • No preregistered data analysis plan **Funding:** National Institute for Health Research Diet, Lifestyle, and Physical Activity Biomedical Research Unit (University Hospitals of Leicester and Loughborough University)

Study and Population Characteristics	Intervention, Comparator, and Outcome	Results	Study Limitations
Edinburgh, 2019[14] **RCT-Crossover, UK** Baseline N=12, Analytic N=12 (Attrition: 0%) **Study objective:** To investigate the role of carbohydrate availability during exercise on net energy balance over 24hr **Participant characteristics at baseline:** physically active young men • Age: 23 (3)y • Female: 0% • Race and/or ethnicity: NR • Socioeconomic position: NR • Anthropometry: BMI 23.6 (2.0) kg/m^2 • Physical activity: NR • Smoking: NR • TEI: NR • Habitual diet at baseline: NR **Excluded from study or analysis:** history of metabolic disease, any condition that may have posed undue personal risk to the participant or introduced bias to the study	**Intervention:** Breakfast/Rest (BR) vs Breakfast/Exercise (BE) vs Exercise/No Breakfast (NBE) BR: porridge breakfast (refined oats/semi-skimmed milk) followed by 3hr rest BE: porridge breakfast (refined oats/semi-skimmed milk) followed by 2hr rest and 1hr cycling NBE: no breakfast (water only) followed by 2hr rest and 1hr cycling The breakfast meals provided 431kcal, 65g CHO, 11g Fat, 19g PRO. Duration: 1d (7-30d washout) Compliance: NR **Outcomes and assessment methods:** • Same day as intervention • Participants were provided with a researcher-weighed ad libitum lunch and the remaining food was weighed to calculate energy intake at lunch. Participants were also provided with a free-living food package to eat ad libitum (in addition to water). The remaining food was weighed to calculate free-living energy intake.	<u>**Energy intake (kcal)**</u>, Mean difference (normalized 95% CI) **At lunch** NBE > BE: 166 (-27, 308), p=NS **Breakfast + lunch** NBE < BE: 265 (123, 407), p<0.01 **Free-living (after lunch)** NBE vs BE: data NR (figure only) **Breakfast + lunch + free-living** NBE < BE: 393 (276, 510), p<0.01	**Limitations:** • Water/Beverages were not accounted for in exposure assessment **Funding:** European Society for Clinical Nutrition and Metabolism; Rank Prize Funds

Study and Population Characteristics	Intervention, Comparator, and Outcome	Results	Study Limitations
Farshchi, 2005a[15] **RCT-Crossover, UK** Baseline N=10, Analytic N=10 (Attrition: 0%) **Study objective:** To investigate the effect of omitting breakfast on energy intake, resting energy expenditure, and circulating glucose, lipid, and insulin concentrations in lean healthy women. **Participant characteristics at baseline:** healthy, lean women • Age: 25.5 (5.7)y • Female: 100% • Race and/or ethnicity: NR • Socioeconomic position: NR • Anthropometry: BMI 23.2 (1.6) kg/m^2 • Physical activity: NR • Smoking: NR • TEI: NR • Habitual diet at baseline: All reported consuming breakfast regularly **Excluded from study or analysis:** aged <19 or >38y, irregular menstruation (if not taking oral contraceptive pill); pregnant or lactating; self-reported history of hypercholesterolemia, hyperglycemia, or any serious medical conditions; reported that they were dieting or experiencing depression	**Intervention:** Breakfast vs No Breakfast (NB) Breakfast: consumed whole-grain breakfast cereal with 2% milk between 7-8am. They also consumed a mid-morning snack, a 48g chocolate-covered cookie (Kit Kat; Nestlé) between 10:30-11am, and 2 additional meals and 2 snacks as usual. NB: did not consume breakfast. Unclear if they were allowed to drink water. They consumed a mid-morning snack, a 48g chocolate-covered cookie (Kit Kat; Nestlé) between 10:30-11am and the whole-grain breakfast cereal at 12pm, and 2 additional meals and 2 snacks as usual. Duration: 14d (2wk washout) Compliance: "All subjects reported having adhered to the appropriate meal patterns during the 2 interventions" **Outcomes and assessment methods:** • During the intervention • Total energy intake was assessed using 3d food intake records (2 weekdays and 1 weekend)	**<u>Total energy intake (kcal) during intervention period</u>**, Mean (SD) NB: 1756.69 (155.35) Breakfast: 1665.87 (141.01) p=0.001	**Limitations:** • Methods for randomization and concealment NR • Unclear if outcome assessors were aware of intervention assignment • No power calculation • No preregistered data analysis plan • Water/Beverages were not accounted for in exposure assessment **Funding:** Ministry of Health and Medical Education (Islamic Republic of Iran); School of Biomedical Sciences at the University of Nottingham

Study and Population Characteristics	Intervention, Comparator, and Outcome	Results	Study Limitations
Gonzalez, 2013[16] **RCT-Crossover, UK** Baseline N=12, Analytic N=12 (Attrition: 0%) **Study objective:** To examine the impact of breakfast and exercise on postprandial metabolism, appetite and macronutrient balance **Participant characteristics at baseline:** physically active males • Age: 23.2 (4.3)y • Female: 0% • Race and/or ethnicity: NR • Socioeconomic position: NR • Anthropometry: BMI 24.5 (2.0) kg/m^2 • Physical activity: All exercised >30min 5x/wk • Smoking: NR • TEI: NR • Habitual diet at baseline: NR **Excluded from study or analysis:** self-reported as physically inactive (<30min of moderate activity 5x/wk); restrained eaters (score of .11 on Three Factor Eating Questionnaire); any metabolic disorders or on medications	**Intervention:** Breakfast/Rest (BR) vs Breakfast/Exercise (BE) vs No Breakfast/Rest (NBR) vs No Breakfast/Exercise (NBE) BR: breakfast consumption followed by rest BE: breakfast consumption followed by exercise NBR: rest without breakfast (water only) NBE: exercise without breakfast (water only) Breakfast consisted of 72g oats and 360ml semi-skimmed milk and provided 444 kcal; 17 % protein, 60 % carbohydrate and 23 % fat. Duration: 1d (≥1wk washout) Compliance: NR **Outcomes and assessment methods:** • Same day as intervention • All participants received chocolate milk test drinks within 20 minutes of exercise termination (500 mL, 120 kcal). Participants were provided with a researcher-weighed ad libitum lunch and the remaining food was weighed to calculate energy intake at lunch.	**<u>Energy intake (kJ)</u>**, Mean (SE) **During lunch** Between group difference: data NR (figure only) p=0.78 **Breakfast + test drink + lunch** NBR < BR: p<0.001 NBE < BE: p<0.001	**Limitations:** • No power calculation • No preregistered data analysis plan • Water/Beverages were not accounted for in exposure assessment **Funding:** No external funding

Study and Population Characteristics	Intervention, Comparator, and Outcome	Results	Study Limitations
Griffiths, 2020[17] **RCT-Crossover, UK** Baseline N=12 (study 1); 11 (study 2), Analytic N=12 (study 1); 11 (study 2) (Attrition: 0%) **Study objective:** <u>Study 1</u>: To determine the appetite, acylated ghrelin and energy intake response to breakfast consumption and omission in acute normobaric hypoxia (fraction of inspired oxygen ~11.7%, 4300 m) and normoxia. <u>Study 2</u>: To determine the appetite, acylated ghrelin and energy intake response to carbohydrate supplementation after both breakfast consumption and omission in hypoxia. **Participant characteristics at baseline:** physically active males • Age: 23 (3)y • Female: 0% • Race and/or ethnicity: NR • Socioeconomic position: NR • Anthropometry: Study 1 Weight, 79.8 (13.1)kg; Study 2 Weight 76.6 (7.0)kg • Physical activity: All physically active • Smoking: All nonsmokers • TEI: NR • Habitual diet at baseline: NR **Excluded from study or analysis:** smokers, hypertensive, diabetes, thyroid disorder, sickle cell trait, food allergies, taking medication, travelled to an altitude of >1500m within previous 3mo; for Study 2, participants also were required to have a normal baseline 12 lead electrocardiogram	**Intervention:** Breakfast vs No Breakfast (NB) Breakfast group consumed standardized breakfast (rolled oats, semi-skimmed milk, orange juice; 535 kcal) NB group did not consume breakfast (unclear if water was allowed) Each breakfast/NB condition was done under normoxia and hypoxia conditions. In study 2, both groups consumed a carbohydrate (CHO) or placebo (PLA) beverage supplement 1hr after breakfast. Duration: 1d (≥1wk washout) Compliance: NR **Outcomes and assessment methods:** • Same day as intervention • Participants were provided with an ad libitum post-exercise lunch and water. Energy intake was determined by weighing food before and after consumption.	**<u>STUDY 1</u>** **<u>Energy intake (kcal)</u>**, Mean (SD) **Lunch** Hypoxia: NB vs Breakfast, p=0.40 Normoxia: NB vs Breakfast, p=0.99 **Total including breakfast** Hypoxia NB: 1293 (395) Breakfast: 1706 (489) p=0.02 Normoxia NB: 1590 (500) Breakfast: 2217 (489) p<0.01 **<u>STUDY 2</u>** **<u>Energy intake (kcal)</u>**, Mean (SD) **Lunch** NB-CHO: 1497 (615) NB-PLA: 1476 (531) Breakfast-CHO: 1480 (677) Breakfast-PLA: 1304 (471) p=0.26 **Total including breakfast and beverage supplement** NB-CHO: 1926 (615) NB-PLA: 1476 (531) Breakfast-CHO: 2443 (677) Breakfast-PLA: 1839 (471) NB-CHO < Breakfast-CHO: p<0.01 NB-PLA < Breakfast-PLA: p=0.02	**Limitations:** • Methods for randomization and concealment NR • No preregistered data analysis plan • Water/Beverages were not accounted for in exposure assessment **Funding:** No external funding

Study and Population Characteristics	Intervention, Comparator, and Outcome	Results	Study Limitations
Gwin, 2018[31] **RCT-Crossover, U.S.** Baseline N=19, Analytic N=13 (Attrition: 32%) **Study objective:** To examine the effects of consuming a high-protein breakfast compared with breakfast skipping on markers of appetite, satiety, food reward, and food intake in healthy young adults **Participant characteristics at baseline:** healthy young adults • Age: 23.5 (0.9)y • Female: 54% • Race and/or ethnicity: NR • Socioeconomic position: NR • Anthropometry: BMI 23.6 (0.6) kg/m^2 • Physical activity: NR • Smoking: All nonsmokers • TEI: NR • Habitual diet at baseline: 92% habitual breakfast consumers **Excluded from study or analysis:** age <20 or >32y; BMI <22 or >30 kg/m^2; smoker or user of tobacco products; generally unhealthy (as assessed by medical history questionnaire); 5pregnant or lactating in the past 6 mo; clinically diagnosed with an eating disorder; metabolic, hormonal, and/or neural conditions, diseases, or medications that influence metabolism or food intake; known bleeding disorders; currently or previously (in the past 6 mo) following a weight-loss or other special diet; weight loss or gain (>4.5 kg) in the past 6 mo; abnormal cognitive restraint; rating of <5 showing “neither like nor dislike” on a 9-point hedonic scale rating for the study breakfasts; clinically diagnosed with obstructive sleep apnea or insomnia; participates in shiftwork	**Intervention:** Breakfast vs No Breakfast (NB) Breakfast: pre-prepared (340kcal) high-protein breakfast meals consumed at home between 7-8:30am with 30 g protein, 36 g carbohydrate, 9 g fat; Foods consumed included waffles with applesauce dipping cup and scrambled eggs with Canadian bacon; scramble with peach cup; quesadilla with pineapple cup; and (testing day): French toast with syrup. NB: nothing to eat or drink (besides water) until 12pm Duration: 7d (3-7d washout) Compliance: >90% based on food inventory logs **Outcomes and assessment methods:** • On day 7 • Both groups were given a standardized lunch (500kcal) 5hr after breakfast. Participants were given a cooler containing various snacks to consume ad libitum, at home, throughout the evening. All food items were initially weighed and recorded. The participants were instructed to return all uneaten foods as well as all wrappers and containers from the snacks that were consumed. Any partially eaten, returned items were weighed accordingly to calculate free-living energy intake.	**Energy intake (kcal)**, Mean (SEM) **In the evening** NB: 2252 (366) Breakfast: 1938 (263) p=NS **Total including breakfast and lunch** NB: 2768 (365.5) Breakfast: 2798 (262.9) p=NS	**Limitations:** • Methods for randomization and concealment NR • High attrition and did not account for the impact of those lost to follow-up • Water/Beverages were not accounted for in exposure assessment **Funding:** Egg Nutrition Center

Study and Population Characteristics	Intervention, Comparator, and Outcome	Results	Study Limitations
Halsey, 2012[18] **RCT-Crossover, UK** Baseline N=49, Analytic N=49 (Attrition: 0%) **Study objective:** To experimentally compare the effects of eating or skipping breakfast on energy expenditure, activity levels and dietary habits. **Participant characteristics at baseline:** young adults • Age: 22.6 (3.9)y • Female: 53% • Race and/or ethnicity: NR • Socioeconomic position: 65% were university students • Anthropometry: NR • Physical activity: levels of activity: 22% low, 44% moderate, 34% high • Smoking: NR • TEI: NR • Habitual diet at baseline: eat breakfast 5x/wk **Excluded from study or analysis:** illness or medical condition that would affect participation in the study	**Intervention:** Breakfast vs No Breakfast (NB) Breakfast: ad libitum high-carbohydrate breakfast cereals with milk, and/or toast with butter and/or jam if requested ingested between 8-9:15am; participants were provided with breakfast ad libitum in addition to water, tea, or coffee NB: no breakfast was provided but water, tea, or coffee was offered Duration: 1wk (consecutive, no washout) Compliance: NR **Outcomes and assessment methods:** • During 1wk intervention • Energy intake was estimated from 3 consecutive days of food diaries. Participants were asked to record everything they ate and drank from the moment they woke to when they went to bed. Energy intake per day, and from noon until the end of the day, was averaged within participant and condition.	**Energy intake (kcal)**, Mean (SEM) **Males** NB: 1796 (88) Breakfast: 1987 (107) p=0.127 **Females** NB: 1800 (128) Breakfast: 1859 (98) p=0.567	**Limitations:** • Methods for randomization and concealment NR • Potential bias from period and carryover effects • Unclear if outcome assessors were aware of intervention assignment • No power calculation • No preregistered data analysis plan • Water/Beverages were not accounted for in exposure assessment **Funding:** Roehampton University

LeCheminant, 2017[19]
RCT-Parallel, U.S.
Baseline N=54, Analytic N=49 (Attrition: 9%)

Study objective: To determine the effects of eating breakfast on energy intake, physical activity, body weight, and body fat in women who are nonhabitual breakfast eaters over a 4wk period

Participant characteristics at baseline:
women who are non-habitual breakfast eaters

- Age: ~23y
- Female: 100%
- Race and/or ethnicity: NR
- Socioeconomic position: NR
- Anthropometry: BMI ~22 (3.9) kg/m^2
- Physical activity: NS between groups
- Smoking: 100% nonsmoker
- TEI: 1843 (495) kcal
- Habitual diet at baseline: All ate breakfast ≤2d/wk (inclusion criteria)

Excluded from study or analysis: age <18 or >55y, habitual breakfast eaters (eat breakfast >2d/wk), irregular sleepers (<6h of sleep a night and inconsistent wakeup time) such as night shift workers, not weight stable for 3mo prior to the study, tobacco or alcohol use, current dieting, eating disorders, digestive disorders, medications that alter metabolism, presence of a metabolic disease that affects energy balance (e.g., diabetes mellitus, cancers, heart disease, etc.), excessive exercise training (vigorous-intensity activity >4 days/week and 30 min per session), participation in college athletics or any elite sport, inability to exercise at a moderate-intensity level (3.0-6.0 METs)

Intervention: Breakfast vs No Breakfast (NB)

Breakfast: participants were required to eat within 1.5hr of waking and had to finish eating breakfast meal (15% total energy intake) by 8:30am. There were no eating or snack restrictions after the breakfast meal.
NB: participants did not consume a snack or meal (with the exception of noncaloric beverages) until after 11:30am. Participants were shown examples of typical breakfasts using pictures but were not instructed to eat particular foods.

Both groups were asked to wake up by 8am.

Duration: 4wk
Compliance: 90% for breakfast group and 98% for NB group

Outcomes and assessment methods:

- At baseline, during 4wk intervention
- Energy intake was calculated from ten 24hr dietary recalls (2 weekdays and 1 weekend day at baseline, and 5 weekdays and 2 weekend days during intervention). Energy intake was averaged over baseline and intervention periods. Food consumption during the day was divided into 4 periods: breakfast (4:30-11:3am), lunch (11:30am-4:30pm), dinner (4:30-10:30pm), night eating (10:30pm-4:30am). Food consumption during these times was summed and averaged over 7d.

Energy intake (kcal), Mean (SD)
Breakfast (4:30-11:30am)
Within group: baseline, during 4wk intervention
NB: 66.8 (123.9), 3.02 (14.5)
Breakfast: 98.6 (128.2), 424.3 (135.0), p≤0.05
Between group: p≤0.05 during 4wk interaction
p-interaction<0.01

Lunch (11:30am-4:30pm)
Within group: baseline, during 4wk intervention
NB: 664.6 (276.0), 701.1 (289.0), p=NS
Breakfast: 831.6 (273.3), 774.5 (280.2), p=NS
Between group: p=NS at baseline and during 4wk interaction
p-interaction=0.11

Dinner (4:30-10:30pm)
Within group: baseline, during 4wk intervention
NB: 695.7 (329.2), 836.7 (304.9), p=NS
Breakfast: 840.5 (396.0), 746.0 (254.5), p=NS
Between group: p=NS at baseline and during 4wk interaction
p-interaction=0.39

Night eating (10:30pm-4:30am)
Within group: baseline, during 4wk intervention
NB: 104.7 (146.9), 79.8 (115.7), p=NS
Breakfast:112.3 (191.0), 88.0 (113.6), p=NS
Between group: p=NS at baseline and during 4wk interaction
p-interaction=0.76

Total
Within group: baseline, during 4wk intervention
NB: 1696 (407), 1685 (459), p=NS
Breakfast: 1689 (505), 1952 (464), p<0.01
Between group: p=NS at baseline
NB<Breakfast during 4wk intervention:

Limitations:

- Methods for randomization and concealment NR
- No preregistered data analysis plan
- Water/Beverages were not accounted for in exposure assessment

Funding:
Brigham Young University

Study and Population Characteristics	Intervention, Comparator, and Outcome	Results	Study Limitations
		p=0.05 p-interaction=0.01	

Study and Population Characteristics	Intervention, Comparator, and Outcome	Results	Study Limitations
Leidy, 2013[21] **RCT-Crossover, U.S.** Baseline N=22, Analytic N=20 (Attrition: 9%) **Study objective:** To examine whether a high-protein breakfast leads to daily improvements in appetite control, satiety, food motivation/reward, and evening snacking compared with normal protein ready-to-eat cereal breakfast meals in breakfast skipping teenage girls with overweight or obesity **Participant characteristics at baseline:** Breakfast-skipping young adult women with overweight and obesity • Age: 19 (1)y • Female: 100% • Race and/or ethnicity: NR • Socioeconomic position: NR • Anthropometry: BMI 28.6 (0.7) kg/m2 • Physical activity: NR • Smoking: NR • TEI: NR • Habitual diet at baseline: Skips breakfast: Mean (SEM), 6 (1) d/wk **Excluded from study or analysis:** age <15 or >20y; BMI <25 or >35 kg/m2; metabolic or neurologic diseases or other health complications; taking medications that would influence food intake regulation, appetite, or metabolism; clinically diagnosed with an eating disorder; currently or previously (within the past 6 mo) on a weight-loss or other special diet; pregnant; frequent breakfast eating habits (i.e., >2 breakfast occasions/wk as assessed from a 7-d screening breakfast questionnaire); left-handed (for consistency with the fMRI neural responses).	**Intervention:** High protein breakfast vs. Normal protein breakfast vs. No Breakfast (NB) Participants were either served a high protein breakfast (HP; egg and beef-rich; 35g protein), normal protein breakfast (NP; ready-to-eat-cereal-based; 13g protein), or continued breakfast skipping (No breakfast). The NB group continued their habitual practice of skipping breakfast for 6d. The NP and HP groups were provided with specific breakfast meals and asked to consume these at home (before school) between 7-9:30am for 6d. All participants were permitted to eat ad libitum throughout the remainder of each day. On day 7, all participants reported to the lab between 6-8am. The NP and HP groups consumed their breakfast meals (including 240 mL water) and the NB group drank 240 mL water only; all participants consumed the meal and/or water within 30 minutes. NP and HP breakfast were matched for energy (~350 kcal), fat content, energy density, dietary fiber, sugar content, dairy and plant protein qualities, and palatability Duration: 7 consecutive days (≥1wk washout) Compliance: 100% on testing days and 99% during the 6 acclimation days based on daily check-off logs indicating consumption **Outcomes and assessment methods:** • On day 7 • Participants were given dinner at 5pm to eat ad libitum. After dinner, participants were given a cooler containing various snacks to consume ad libitum, at home, throughout the evening; the cooler contained a total of 4000 kcal. All food items were initially recorded and weighed. The participants were instructed to return all uneaten foods as well as all wrappers and containers from the snacks that were consumed. Any partially eaten, returned items were weighed accordingly. Total energy intake during dinner and from evening snacks was determined from the recorded weights.	**Energy intake (kcal)**, Mean (SEM) **At dinner** NB: 845 (60) NP-breakfast: 820 (71) HP-breakfast: 787 (50) p=NS **From evening snacking** NB: 656 (108) NP-breakfast: 621 (110) HP-breakfast: 486 (84) NB vs NP-breakfast: p=NS NB vs HP-breakfast: p<0.05 **Total including breakfast** NB: 2002 (111) NP-breakfast: 2292 (115) HP-breakfast: 2123 (71) NB vs NP-breakfast: p<0.003 NB vs HP-breakfast: p=NS	**Limitations:** • Methods for randomization and concealment NR **Funding:** The Beef Check-off; Egg Nutrition Center/American Egg Board

Study and Population Characteristics	Intervention, Comparator, and Outcome	Results	Study Limitations
Leidy, 2015[20] **RCT-Parallel, U.S.** Baseline N=67, Analytic N=54 (Attrition: 19%) **Study objective:** To evaluate whether longer-term consumption of normal-protein vs. high-protein breakfast meals improves appetite control, food intake, and body composition in "breakfast skipping" young people with overweight/obesity **Participant characteristics at baseline:** Breakfast-skipping young adults with overweight and obesity • Age: 19 (1)y • Female: 59% • Race and/or ethnicity: Caucasian: 61%; African American: 35%; Other: 4% • Socioeconomic position: NR • Anthropometry: BMI ~29 kg/m2 • Physical activity: Examined as potential confounder - NS association with study outcomes • Smoking: NR • TEI: NR • Habitual diet at baseline: Skips breakfast: ~6 days/wk **Excluded from study or analysis:** age <13 and >20y, BMI <25 and ≥40 kg/m2; those with metabolic diseases/conditions, currently/previously on a weight loss diet; those that do not consistently skip breakfast every weekday	**Intervention:** High protein breakfast vs. Normal protein breakfast vs. No Breakfast (NB) Participants were either served a high protein breakfast (HP; egg and pork-rich; 35g protein; n=24), normal protein breakfast (NP; ready-to-eat-cereal-based; 13g protein; n=21), or continued breakfast skipping (No breakfast; n=9). The NP and HP groups were provided with specific breakfast meals on a weekly basis with meal preparation instructions and asked to consume these between 6-9:45am. NP and HP breakfast were matched for energy (~1464 kJ) and fat content. The NB group continued their habitual practice of skipping breakfast (nothing to eat or drink besides water) before 10am. Duration: 12wk Compliance: Mean 98±1% (NS difference between groups) based on daily check-off logs indicating consumption at the designated times and returned containers of uneaten food **Outcomes and assessment methods:** • At baseline, 12wk follow-up • Average daily energy intake calculated from three 24hr dietary recalls (2 weekdays and 1 weekend day)	**<u>Energy intake (kcal), change from baseline to 12wk</u>**, Mean (SEM) NB: +372 (178) NP-breakfast: +118 (51) HP-breakfast: -412 (228) NB vs HP-breakfast: p=0.03 NB vs NP-breakfast: p=NS	**Limitations:** • Unclear if outcome assessors were aware of intervention assignment • No power calculation • No preregistered data analysis plan **Funding:** Pork Checkoff

Study and Population Characteristics	Intervention, Comparator, and Outcome	Results	Study Limitations
Levitsky, 2013[22] **RCT-Crossover, U.S.** Baseline N=24 (study 1); 18 (study 2), Analytic N=24 (study 1); 13 (study 2) (Attrition: 0% (study 1); 28% (study 2)) **Study objective:** The first study examined the effect of skipping breakfast on the amount consumed at lunch. The second study examined the effect of eating a larger breakfast on the amount consumed at lunch and during the rest of the day. **Participant characteristics at baseline:** young adults • Age: Study 1, 22.1 (2.7)y; Study 2, 24.0 (2.8)y • Female: 80% • Race and/or ethnicity: NR • Socioeconomic position: All university students • Anthropometry: Study 1 BMI, 21 (5.2) kg/m^2; Study 2 BMI, 24.1 (2.2) kg/m^2 • Physical activity: NR • Smoking: NR • TEI: NR • Habitual diet at baseline: Regular breakfast eaters: 75% in study 1, 61% in study 2 **Excluded from study or analysis:** aversions or allergies to foods that would be served; medications (Study 1)	**Intervention:** **STUDY 1:** High-carbohydrate breakfast (HC) vs High-fiber breakfast (HF) vs No Breakfast (NB) HC: plain bagel, jelly, orange or apple juice (335 kcal) HF: cereal and 1% milk (338 kcal) NB: no breakfast, unclear if water was allowed **STUDY 2:** Breakfast vs No Breakfast (NB) Breakfast served ad libitum, buffet-style (cereal, milk, juice, bagel w CC, jelly, coffee). Duration: 1d (1wk washout) Compliance: NR **Outcomes and assessment methods:** • Same day as intervention • Study 1: Participants were provided with an ad libitum lunch and the amount of food remaining on plate was used to calculate energy intake. • Study 2: Participants ate breakfast and lunch in the lab. Snacks and dinners were eat at home and participants were asked to return uneaten food in order to calculate energy intake.	**STUDY 1** **Energy intake (kcal)**, Mean (SE) **At lunch** NB vs HC, p=NS NB vs HF, p=NS **Breakfast + lunch** NB: 600 (50) HF: 930 (65) HC: 955 (42) NB < HF and HC, both p<0.001 **STUDY 2** **Energy intake (kcal)** **At lunch** NB > Breakfast (data NR, figure only), p=0.04 **Mid-afternoon snack, dinner, evening snack** NB vs Breakfast, p=NS for all eating occasions **Total (including breakfast)** NB consumed 450 fewer kcal compared to Breakfast group, p<0.01	**Limitations:** • Methods for randomization and concealment NR • No preregistered data analysis plan • Water/Beverages were not accounted for in exposure assessment **Funding:** NR

Study and Population Characteristics	Intervention, Comparator, and Outcome	Results	Study Limitations
Neumann, 2016[23] **RCT-Parallel, U.S.** Baseline N=40, Analytic N=24 (Attrition: 40%) **Study objective:** To determine if breakfast macronutrient composition improved TEF and appetite after a 1wk adaptation in young women who habitually skip breakfast. **Participant characteristics at baseline:** young women who habitually skip breakfast • Age: 24.1 (2)y • Female: 100% • Race and/or ethnicity: Caucasian: 58%; Black: 13%; Asian: 8%; Indian: 8%; Hispanic: 13% • Socioeconomic position: NR • Anthropometry: BMI ~27 kg/m^2 • Physical activity: Asked to maintain typical levels during intervention • Smoking: All nonsmokers • TEI: NR • Habitual diet at baseline: All skipped breakfast ≥5d/wk (inclusion criteria) **Excluded from study or analysis:** smoked, had dietary restrictions, were actively trying to lose weight/restricting eating, had lost weight in the last 6mo, were taking medication (excluding hormonal birth control), were athletes or participated in regular physical activity >3 times per week, had any pre-existing metabolic conditions (e.g., type 1 or 2 diabetes) that prevented them from consuming the test breakfasts	**Intervention:** Protein-based breakfast vs. Carbohydrate-based breakfast vs. No Breakfast (NB) Participants were either served a protein-based breakfast (PRO), carbohydrate-based breakfast (CHO), or continued breakfast skipping (No breakfast). PRO consisted of a breakfast sandwich, Greek yogurt, and 227 mL water. CHO consisted of English muffin, yogurt, cream cheese, and 227 mL water. The NB group continued their habitual practice of skipping breakfast and drank 227 mL water only. The groups were provided with their specific breakfast meals to consume at home for 6d within 2hr of waking and no later than 10am. CHO and PRO breakfast were matched for energy (~350 kcal), fat, and fiber. Duration: 1-8d Compliance: NR **Outcomes and assessment methods:** • 3d out of the 8d intervention (2 weekdays and 1 weekend), specific timing not described • Total energy intake was assessed using three 24hr diet records (2 weekdays and 1 weekend, including all meals, snacks, and beverages). Results were used to calculate average daily energy intake during the 8d intervention.	**Total energy intake (kcal)**, Mean (SEM) NB: 2009 (193) CHO: 1603 (127) PRO: 2137 (349) p=NS	**Limitations:** • Methods for randomization and concealment NR • Concerns with deviations from intended intervention • Unclear if outcome assessors were aware of intervention assignment • Timing of outcome assessment unclear and unclear whether occurred at the same time for all participants • Not sufficiently powered, and unclear what power calculations were based on • No preregistered data analysis plan **Funding:** Arkansas Biosciences Institute; USDA

Study and Population Characteristics	Intervention, Comparator, and Outcome	Results	Study Limitations
Reeves, 2014[24] **RCT-Crossover, UK** Baseline N=37, Analytic N=37 (Attrition: 0%) **Study objective:** To investigate the effect of breakfast and breakfast omission on food intake and the timing of subsequent food intakes. **Participant characteristics at baseline:** adults with normal and overweight • Age: 29.5 (7.9)y among normal weight and 36.2 (16.3)y among overweight • Female: 57% • Race and/or ethnicity: NR • Socioeconomic position: NR • Anthropometry: BMI 21.31 (1.79) kg/m^2 among normal weight and 29.63 (5.32) among overweight (49% normal weight and 51% overweight/obesity) • Physical activity: NR • Smoking: NR • TEI: NR • Habitual diet at baseline: 51% habitually ate breakfast >5 days/wk; 49% habitually ate breakfast ≤2 days/wk **Excluded from study or analysis:** dieting, diabetes, symptoms such as dizziness, fainting and blackouts, high blood pressure or cholesterol medication	**Intervention:** Breakfast vs No Breakfast (NB) Breakfast: participants were requested to eat breakfast within 1hr of waking NB: participants were asked to refrain from eating until midday (unclear if water was allowed) Participants were not instructed to eat particular foods. Duration: 1wk (≥1wk washout) Compliance: NR **Outcomes and assessment methods:** • During 1wk intervention • Energy intake was estimated from 7 days of food diaries. Participants were asked to record everything they ate and drank from the moment they woke to when they went to bed. Energy intake was also analyzed by four 3hr periods (12-3pm, 3-6pm, 6-9pm, 9pm-12am).	**Energy intake (kcal)**, Mean (SD) **12-3pm** NB > Breakfast, p=0.009 p-interaction (BMI)=0.26 **3-6pm** NB: 267 (160) Breakfast: 208 (138) p=0.043 p-interaction (BMI)>0.15 **6-9pm** NB vs Breakfast: p>0.20 Overweight: 637 (219) Normal weight: 450 (162) p-interaction (BMI)<0.0005 **9pm-12am** NB vs Breakfast: p>0.35 p-interaction (BMI)>0.35 **Total (12pm-12am)** NB: 1787 (516) Breakfast: 1948 (488) p=0.03 p-interaction (BMI)>0.50	**Limitations:** • Methods for randomization and concealment NR • Unclear if outcome assessors were aware of intervention assignment • No power calculation • No preregistered data analysis plan • Water/Beverages were not accounted for in exposure assessment **Funding:** Kellogg's Ltd

Study and Population Characteristics	Intervention, Comparator, and Outcome	Results	Study Limitations
Rosi, 2018[25] **RCT-Crossover, Italy** Baseline N=15, Analytic N=15 (Attrition: 0%) **Study objective:** To investigate the effect of nutritional and cognitive-perceived characteristics of breakfast on metabolic and behavioral variables related to food intake **Participant characteristics at baseline:** male habitual breakfast eaters • Age: 24 (2)y • Female: 0% • Race and/or ethnicity: NR • Socioeconomic position: NR • Anthropometry: BMI 23.4 (1.6) kg/m^2 • Physical activity: All moderately active (inclusion criteria) • Smoking: All nonsmokers • TEI: NR • Habitual diet at baseline: All eat breakfast daily (inclusion criteria) **Excluded from study or analysis:** aged <18 and >30y, BMI <20 and >25 kg/m^2, unstable body weight (>±5% change in 3mo before study), smokers, taking medication, moderately inactive lifestyle, habitual breakfast skippers, following a specific diet, known food allergy	**Intervention:** Breakfast (Bread) Vs. Breakfast (Muesli) vs. Breakfast (Rice) vs No Breakfast (NB) Breakfast-Bread (B-Bread): white bread with chocolate hazelnut spread Breakfast-Muesli (B-Muesli): muesli with dark chocolate chips and nuts Breakfast-Rice (B-Rice): chocolate-flavored puffed rice NB: 125mL decaffeinated tea (0 kcal) Breakfast meals were iso-energetic and similar for protein content. Duration: 1wk (≥1wk washout) Compliance: NR **Outcomes and assessment methods:** • Same day as intervention and over 1wk • Participants were provided with an ad libitum lunch, which was double weighed before and after to measure energy intake during lunch. Participants completed a 7d weighed food diary to calculate daily energy intake over the week (as total intake and intake the rest of the day after breakfast).	<u>**Energy intake (kcal), Mean (SEM)**</u> **During lunch** NB: 2043 (156) B-Bread: 1762 (149) B-Muesli: 1705 (85) B-Rice: 1879 (113) p=NS **After breakfast** NB: 2712 (199) B-Bread: 2473 (130) B-Muesli: 2379 (156) B-Rice: 2376 (157) NB vs B-Bread: p=NS NB > B-Muesli: p=0.023 NB > B-Rice: p=0.029 **Total including breakfast** NB: 2712 (199) B-Bread: 2806 (130) B-Muesli: 2707 (156) B-Rice: 2706 (157) p=NS	**Limitations:** • Water/Beverages were not accounted for in exposure assessment **Funding:** “Soremartec Italia Srl” (Alba, Cuneo, Italy)

Study and Population Characteristics	Intervention, Comparator, and Outcome	Results	Study Limitations
Slater, 2022[26] **RCT-Crossover, UK** Baseline N=14, Analytic N=14 (Attrition: 0%) **Study objective:** To examine the effects of a very-low-energy, viscous placebo breakfast on subjective appetite, peripheral appetite-regulatory hormone concentrations, and subsequent energy intake at an ad libitum lunch, compared to a typical whole-food breakfast and a water-only control. **Participant characteristics at baseline:** male habitual breakfast eaters • Age: 24 (2)y • Female: 0% • Race and/or ethnicity: NR • Socioeconomic position: NR • Anthropometry: BMI 23.5 (2.3) kg/m^2 • Physical activity: NR • Smoking: All nonsmokers • TEI: NR • Habitual diet at baseline: All "regularly consumed breakfast" (inclusion criteria) **Excluded from study or analysis:** smokers; habitual breakfast skippers; exhibited restrained, disinhibited, or hungry eating tendencies	**Intervention:** Breakfast vs Placebo Breakfast (PB) vs No Breakfast (NB) Breakfast: typical whole-food breakfast (cereal, milk, bread, jam, apple juice); 20% of EER, 573±30 kcal PB: viscous breakfast meal (low-calorie flavored squash, xantham gum, and water); equating to 5 mL/kg body mass, 16±1 kcal NB: water-only control All groups consumed the same volume of water (618±54 mL) Duration: 1d (4d washout) Compliance: adherence with standardization measures were confirmed verbally before each experimental trial **Outcomes and assessment methods:** • Same day as intervention • Participants were provided with an ad libitum lunch and water intake for 20min. Food and water were weighed before and after to quantify intakes.	**Energy intake (kcal)**, Mean (SD) **During lunch** NB: 1093 (249) PB: 1062 (273) Breakfast: 981 (284) NB vs PB, p=1.000 NB > Breakfast, p<0.05 PB vs Breakfast, p=0.088 **Breakfast + lunch** NB: 1093 (249) PB: 1078 (274) Breakfast: 1554 (301) NB vs PB, p=1.000 NB < Breakfast, p<0.001 PB < Breakfast, p<0.001	**Limitations:** • No preregistered data analysis plan **Funding:** Nottingham Trent University

Study and Population Characteristics	Intervention, Comparator, and Outcome	Results	Study Limitations
Thomas, 2015[27] **RCT-Crossover, U.S.** Baseline N=24, Analytic N=17 (Attrition: 29%) **Study objective:** To investigate the metabolic and appetitive responses to skipping breakfast in overweight women who were habitual breakfast Eaters or Skippers. **Participant characteristics at baseline:** Women with overweight • Age: 29 (27-32)y • Female: 100% • Race and/or ethnicity: Caucasian: 72%; African American: 22%; Asian: 6%; Non-Hispanic: 88% • Socioeconomic position: NR • Anthropometry: BMI 30.2 (28.6-33.7) kg/m^2 • Physical activity: NR • Smoking: NR • TEI: NR • Habitual diet at baseline: 50% ate breakfast ≤2d/wk **Excluded from study or analysis:** aged <25 or >40y, BMI <27 or >35 kg/m^2, eating disorders, women without menses, night eating syndrome, active dieting or intensive exercise training	**Intervention:** Breakfast vs No Breakfast (NB) Breakfast: 250mL water + breakfast meal containing 25% of total daily energy intake (cereal, milk, eggs, orange juice) consumed within 20min NB: 250mL water Duration: 1d (1mo washout) Compliance: 1 participant did not follow protocol **Outcomes and assessment methods:** • Same day as intervention • All participants were provided with a standard lunch 4hr after breakfast; lunch contained 35% of daily energy intake and they had 20min to consume. Participants were provided with an ad libitum dinner (2600 kcal) 5hr after lunch and intake was determined by weigh-back methods. Participants were provided with a box of snack foods to take home and uneaten portions were returned the following day to calculate energy intake.	<u>**Energy intake (kcal)**</u>, Median (IQR) **At dinner** NB: 837 (594-972) Breakfast: 815 (550-1072) p=NS **During evening snack** NB: 716 (360-1197) Breakfast: 701 (177-1023) p=NS **Total including breakfast and lunch** NB: 2344 (1913-2777) Breakfast: 2516 (2363-3324) p=NS	**Limitations:** • No power calculation • No preregistered data analysis plan **Funding:** NIH; Nutrition Obesity Research Center

Study and Population Characteristics	Intervention, Comparator, and Outcome	Results	Study Limitations
Veasey, 2015[28] **RCT-Crossover, UK** Baseline N=25, Analytic N=22 (Attrition: 12%) **Study objective:** To compare the effects of two different sized breakfasts and no breakfast consumed prior to morning exercise on cognitive function, mood, appetite and energy intake for the remainder of the day **Participant characteristics at baseline:** habitually active females • Age: 20.9 (2.3)y • Female: 100% • Race and/or ethnicity: NR • Socioeconomic position: NR • Anthropometry: BMI 21.9 (1.9) kg/m^2 • Physical activity: All exercised for ≥30min 3x/wk during the previous 6mo (inclusion criteria) • Smoking: All nonsmokers • TEI: NR • Habitual diet at baseline: All habitually consumed breakfast **Excluded from study or analysis:** age <18 or >35y; smoker; taking medication or herbal and dietary supplements; history of head trauma, learning difficulties, attention deficit hyperactivity disorder, dyslexia, migraines or gastric problems; BMI <18 or >25 kg/m^2; blood pressure >140/90 mmHg; not habitually active and did not regularly exercise in the morning, unable to run for 30min continuously at a moderate speed, habitually skipped breakfast prior to a morning exercise session	**Intervention:** Breakfast (20g) vs. Breakfast (40g) vs No Breakfast (NB) 20g Breakfast (20g): 20g cereal + 83mL milk (118 kcal total), consumed within 10 minutes 40g Breakfast (40g): 40g cereal + 166 mL milk (236 kcal total), consumed within 10 minutes NB: no breakfast (unclear if water was allowed) Duration: 1d (≥2d washout) Compliance: NR **Outcomes and assessment methods:** • Same day as intervention • Participants were provided with an ad libitum pasta lunch in pre-weighed servings in order to calculate energy intake at lunch. Participants completed a food diary for the rest of the day, which was used to estimate food intake after lunch.	**Energy intake (kcal)**, Mean (SEM) **Ad-libitum lunch** NB: 763.2 (37.2) 20g: 786.2 (37.1) 40g: 778.7 (38.8) p=NS **Self-reported intake after lunch** NB: 1000.8 (76.9) 20g: 1055.9 (105.6) 40g: 1067.5 (114.5) p=NS **Total (breakfast, lunch, after lunch)** NB: 1780.14 (80.59) 20g: 1957.21 (114.64) 40g: 2088.57 (132.30) P=NS	**Limitations:** • Methods for randomization and concealment NR • Unclear if outcome assessors were aware of intervention assignment • Not sufficiently powered • No preregistered data analysis plan • Water/Beverages were not accounted for in exposure assessment **Funding:** Northumbria University

Study and Population Characteristics	Intervention, Comparator, and Outcome	Results	Study Limitations
Yoshimura, 2017[29] **RCT-Crossover, Japan** Baseline N=20, Analytic N=20 (Attrition: 0%) **Study objective:** To evaluate the acute effects of skipping breakfast on energy intake and physical activity under free-living conditions among healthy lean women who are habitual breakfast eaters **Participant characteristics at baseline:** healthy, lean women • Age: 21.8 (0.9)y • Female: 100% • Race and/or ethnicity: NR • Socioeconomic position: All were university students • Anthropometry: Mean BMI: 20.2 kg/m^2 • Physical activity: NR • Smoking: NR • TEI: NR • Habitual diet at baseline: All eat breakfast ≥5 times/wk (inclusion criteria) **Excluded from study or analysis:** aged >21 or >25y, BMI <17.3 or >24.2 kg/m^2, metabolic disorders, habitual breakfast skippers (≥2d/wk)	**Intervention:** Breakfast vs No Breakfast (NB) Breakfast: at 8am, participants ate rice, ham, eggs, and salad (30% of total daily energy), and 500 mL of water and were asked to consume the meal within 20 minutes NB: 500 mL of water Duration: 1d (2.3±0.7d washout) Compliance: NR **Outcomes and assessment methods:** • Same day as intervention • Energy intake was evaluated by adding values from food labels of purchased food (participants were instructed to eat all purchased food). Meals were photographed to confirm contents. The meal was divided into 4 categories by eating time (lunch, mid-afternoon snack, dinner, evening snack). The meal between lunch and dinner was defined as a mid-afternoon snack; the meal after dinner was defined as an evening snack.	**Energy intake (kcal)**, Mean (SD) **At lunch** NB: 780 (140) Breakfast: 649 (166) p=0.0057 **At mid-afternoon snack, dinner, or evening snack** NB vs Breakfast (data NR, figure only): p=NS for all eating occasions **Total excluding breakfast** NB: 1853 (410) Breakfast: 1573 (348) p=0.009 **Total including breakfast** NB: 1853 (410) Breakfast: 2215 (348) p=0.013	**Limitations:** • No power calculation **Funding:** Yazuya Co., Ltd.
PROSPECTIVE COHORT STUDY			

Zhang, 2017[30]
PCS, Secondary analysis of an RCT comparing AHA diet to high-fiber diet, U.S.
Analytic N=178

Study objective: To examine the association between breakfast skipping and body weight, nutrient intake, and metabolic parameters in participants with metabolic syndrome

Participant characteristics at baseline:
adults with MetS
- Age: 52.2y
- Female: 73%
- Race and/or ethnicity: White: 88%; Other: 12%
- Socioeconomic position: Education: 75% Bachelor's degree or less; 25% Graduate/professional; Household income: 27% ≤$50k, 50% ≥$50,001, 23% unclear; 79% employed full-time or part-time
- Anthropometry: 48% BMI 30-34.9 and 52% BMI 35-40 kg/m^2
- Physical activity: Mean duration of total physical activity: 235 min/wk in NB group vs 200 min/wk in Breakfast group, p=0.02
- Smoking: All nonsmokers
- TEI: Breakfast: 1984 kcal/d vs NB: 1816 kcal/d; p=0.05
- Habitual diet at baseline: 33% skipped breakfast, 33% ate breakfast daily

Excluded from study or analysis: age <21 and >70y; BMI <30 and >40 kg/m^2; smokers; no diagnosis of MetS; clinically diagnosed diabetes or fasting blood sugar levels ≥126 mg/dL, an acute coronary event within last 6mo, pregnant or lactating, PCOS, intention to move out of the area within 1yr study period, current participation in a weight loss program, an eating disorder, bariatric surgery, elevated depression or suicidal ideation, or subjects following a low-carbohydrate, high fat dietary regimen.

Exposure: Breakfast vs No Breakfast (NB)

Participants who reported eating breakfast at least once were considered breakfast eaters and those who did not consume any breakfast on the three dietary recall days were categorized as breakfast skippers. Breakfast included consumption of any food/beverage (excluding water) at the first eating episode no later than 10am.

Assessment methods and timing:
- Self-reported using three unannounced 24hr diet recalls
- At baseline

Outcomes and assessment methods:
- At baseline, 1yr follow-up

Total energy intake assessed by three 24hr dietary recalls

Change in total energy intake (kcal) over 1yr, Mean (95% CI)
NB: -133.9 (-365.1, 97.4)
Breakfast: -260.7 (-398.1, -123.3)
p=0.23

Model adjustments:
- Key confounders: sex, age, race and/or ethnicity, socioeconomic position, physical activity, smoking
- Other: group

Limitations:
- Did not account for key confounders: anthropometry
- Exposure assessment method not validated and exposure data only assessed at baseline leading to a concern that changes in exposure status occurred over 1yr f/u
- No information on non-completers
- No preregistered data analysis plan

Funding:
NHLBI; China Scholarship Council

[a] Abbreviations: B: breakfast; BMI: body mass index; BE: breakfast-exercise; BR: breakfast-rest; CHO: carbohydrate-based; CON: control; d: day; EI: energy intake; EX: exercise; HC: high carbohydrate; HF: high fat; HP: high protein; kcal: kilocalories; MJ: megajoule; MVPA: moderate to vigorous physical activity; NB: no breakfast; NBE: no breakfast-exercise; NBR: no breakfast-rest; NP: normal protein; NR: not reported; NS: not significant; PRO: protein-based; SE: standard error; SD: standard deviation; SN: snack; TEI: total energy intake; wk: week(s); y: year(s)

Table 11. Risk of bias for randomized controlled trials examining breakfast consumption in adults and energy intake[a]

Article	Randomization	Period and carryover effects	Deviations from intended interventions	Missing outcome data	Outcome measurement	Selection of reported result	Overall risk of bias
Astbury, 2011[6]	SOME CONCERNS	LOW	LOW	LOW	LOW	SOME CONCERNS	SOME CONCERNS
Betts, 2014[7]	LOW	NOT APPLICABLE	LOW	LOW	LOW	LOW	LOW
Chowdhury, 2015[10]	SOME CONCERNS	LOW	LOW	LOW	LOW	LOW	SOME CONCERNS
Chowdhury, 2016a[9]	LOW	NOT APPLICABLE	LOW	LOW	LOW	LOW	LOW
Chowdhury, 2016b[11]	SOME CONCERNS	LOW	LOW	LOW	LOW	LOW	SOME CONCERNS
Chowdhury, 2018[12]	LOW	NOT APPLICABLE	LOW	LOW	LOW	LOW	LOW
Chowdhury, 2019[8]	LOW	NOT APPLICABLE	LOW	LOW	LOW	LOW	LOW
Clayton, 2015[13]	SOME CONCERNS	LOW	LOW	LOW	LOW	SOME CONCERNS	SOME CONCERNS
Edinburgh, 2019[14]	LOW	LOW	LOW	LOW	LOW	LOW	LOW
Farshchi, 2005a[15]	SOME CONCERNS	LOW	LOW	LOW	SOME CONCERNS	SOME CONCERNS	SOME CONCERNS

Article	Randomization	Period and carryover effects	Deviations from intended interventions	Missing outcome data	Outcome measurement	Selection of reported result	Overall risk of bias
Gonzales, 2013[16]	SOME CONCERNS	LOW	LOW	LOW	LOW	SOME CONCERNS	SOME CONCERNS
Griffiths, 2020[17]	SOME CONCERNS	SOME CONCERNS	LOW	LOW	LOW	SOME CONCERNS	SOME CONCERNS
Gwin, 2018[31]	SOME CONCERNS	SOME CONCERNS	LOW	HIGH	LOW	LOW	HIGH
Halsey, 2012[18]	SOME CONCERNS	HIGH	LOW	LOW	SOME CONCERNS	SOME CONCERNS	HIGH
LeCheminant, 2017[19]	SOME CONCERNS	NOT APPLICABLE	LOW	LOW	LOW	SOME CONCERNS	SOME CONCERNS
Leidy, 2013[21]	SOME CONCERNS	LOW	LOW	LOW	LOW	LOW	SOME CONCERNS
Leidy 2015[20]	SOME CONCERNS	NOT APPLICABLE	LOW	SOME CONCERNS	LOW	SOME CONCERNS	SOME CONCERNS
Levitsky, 2013[22]	SOME CONCERNS	LOW	LOW	LOW	LOW	SOME CONCERNS	SOME CONCERNS
Neumann, 2016[23]	SOME CONCERNS	NOT APPLICABLE	SOME CONCERNS	LOW	SOME CONCERNS	SOME CONCERNS	SOME CONCERNS
Reeves, 2014[24]	SOME CONCERNS	SOME CONCERNS	LOW	LOW	SOME CONCERNS	SOME CONCERNS	SOME CONCERNS
Rosi, 2018[25]	LOW	LOW	LOW	LOW	LOW	LOW	LOW

Article	Randomization	Period and carryover effects	Deviations from intended interventions	Missing outcome data	Outcome measurement	Selection of reported result	Overall risk of bias
Slater, 2022[26]	LOW	LOW	LOW	LOW	LOW	SOME CONCERNS	SOME CONCERNS
Thomas, 2015[27]	LOW	LOW	LOW	LOW	LOW	SOME CONCERNS	SOME CONCERNS
Veasey, 2015[28]	SOME CONCERNS	SOME CONCERNS	LOW	LOW	SOME CONCERNS	SOME CONCERNS	SOME CONCERNS
Yoshimura, 2017[29]	LOW	LOW	LOW	LOW	LOW	LOW	LOW

Table 12. Risk of bias for observational study examining breakfast in adults and energy intake[b]

	Confounding	Exposure measurement	Selection of participants	Post-exposure interventions	Missing data	Outcome measurement	Selection of reported result	Overall risk of bias
Zhang, 2017[30]	SOME CONCERNS	SOME CONCERNS	LOW	LOW	HIGH	LOW	SOME CONCERNS	HIGH

[a] Possible ratings of low, some concerns, or high determined using the "Cochrane Risk-of-bias 2.0" (RoB 2.0) (August 2019 version)" (Sterne JAC, Savović J, Page MJ, et al. RoB 2: a revised tool for assessing risk of bias in randomised trials. *BMJ* 2019; **366**: l4898. doi:10.1136/bmj.l4898.)

[b] Possible ratings of low, some concerns, high, very high, no information, or not applicable were determined using the "Risk of Bias in Non-randomized Studies of Exposures (ROBINS-E)" tool (Higgins JPT, Morgan RL, Rooney AA, et al. A tool to assess risk of bias in non-randomized follow-up studies of exposure effects (ROBINS-E). *Environment International* 2024 (published online Mar 24); doi: 10.1016/j.envint.2024.108602.)

Table 13. Evidence examining the relationship between number of eating occasions in adults and energy intake [a]

Study and Population Characteristics	Intervention, Comparator, and Outcome(s)	Results	Study Limitations
RANDOMIZED CONTROLLED TRIALS			
Bachman, 2012[32] **RCT-Parallel, Lifestyle, Eating, and Activity Patterns (LEAP), U.S.** Baseline N=51, Analytic N=51 (Attrition: 0%) **Study objective:** To examine the effect of eating frequency on hunger, energy intake, and weight loss during a 6-month behavioral weight loss intervention **Participant characteristics at baseline:** adults with overweight/obesity participating in a 6mo behavioral weight loss intervention • Age: 51 (9.9)y • Female: 58% • Race and/or ethnicity: White: 94%; Black: 6%; Asian: 0%; American Indian: 0%; Other: 0%; non-Hispanic: 98% • Socioeconomic position: Education: 8% high school, 4% vocational school, 31% some college, 31% college graduate, 26% graduate school; 78% married; 12% divorced/separated • Anthropometry: BMI 35.5 kg/m^2 (100% with overweight or obesity) • Physical activity: ~800 kcal/wk expended • Smoking: NR • TEI: ~2200 kcal/d • Habitual diet at baseline: ~4 eating bouts/d (~2.8 meals, 1.2 snacks) **Excluded from study or analysis:** age <21 and >65y; BMI <27 and >45 kg/m^2, reported a heart condition; chest pain or loss of consciousness during activity, unable to walk 2 blocks without stopping, major psychological disease; diabetes; recent weight loss or in a weight loss program; moving outside the area; pregnant, lactating, <6mo postpartum, or planned to become pregnant; unwilling to complete study meetings, assessments, or food diaries for duration of study	**Intervention:** 6 vs 3 meals per day (hypocaloric) 6 Meal Group (n=26): Instructions to "graze" by eating at least 100 kcal every 2-3hr + standard behavioral intervention for obesity for 6mo (~6 eating bouts/d at 3 and 6mo, 3 meals and 3 snacks) 3 Meal Group (n=25): Instructions to eat 3 meals/d + standard behavioral intervention for obesity for 6mo (~3 eating bouts/d at 3 and 6mo, all 3 meals) Participants defined meals and snacks, which were only counted if at least 25kcal were consumed. All foods and beverages eaten within ½hr of the start of a meal/snack were counted as a single eating bout. Eating frequency equaled the number of meals, snacks, and total eating bouts (meals + snacks) reported in the food records. Duration: 6mo Compliance: Based on percent of self-monitoring diaries turned in and attendance for each participant. NS difference between conditions for self-monitoring, attendance, and retention at 3 or 6 month assessments. **Outcomes and assessment methods:** • At baseline, 3mo, and 6mo • Overall energy intake was assessed by 3 day (2 weekdays, 1 weekend) dietary records. Each food record was entered into NDSR and mean intake of overall energy intake over the 3 days was calculated.	**<u>Total daily energy intake (kcal)</u>**, Mean (SD) Within group: 0mo, 3mo, 6mo, p<0.001 3 Meals: 2142 (727), 1111 (249), 1217 (354), p<0.001 6 Meals: 2252 (667), 1280 (210), 1314 (352), p<0.001 Between groups: p=NS at 0, 3, 6mo	**Limitations:** • Water was not accounted for in exposure assessment **Funding:** American Heart Association

Study and Population Characteristics	Intervention, Comparator, and Outcome(s)	Results	Study Limitations
Forslund, 2008[33] **RCT-Parallel, Sweden** Baseline N=140, Analytic N=93 (Attrition: 34%) **Study objective:** To examine the effect of two different recommended eating frequencies on 1-year weight loss **Participant characteristics at baseline:** adults with obesity • Age: ~41 (11)y • Female: 71% • Race and/or ethnicity: NR • Socioeconomic position: NR • Anthropometry: All with BMI >30 kg/m^2 • Physical activity: NR • Smoking: NR • TEI: ~2700 kcal/d • Habitual diet at baseline: NR **Excluded from study or analysis:** aged <18 or >60y; BMI <30 kg/m^2; participants reporting previous obesity surgery, anti-obesity drug treatment the last year, drug or insulin-treated diabetes, hypothyroidism, severe psychiatric disorder, bulimia, drug or alcohol abuse	**Intervention:** 6 vs 3 meals per day (hypocaloric) 6 meals a day (6M, n=44): daily energy intake divided into breakfast (20%), lunch (25%), dinner (25%) and 3 snacks (10% each). 3 meals a day (3M, n=46): daily energy intake divided in breakfast (30%), lunch (35%) and dinner (35%). No snacks with the exception of limited fruit intake and calorie-free drinks. Duration: 1yr Compliance: Measured using repeated telephone intervals at 6 time periods during the 1yr intervention **Outcomes and assessment methods:** • At baseline, 1yr • Energy intake assessed using self-administered dietary questionnaire on habitual intake during the past 3mo	<u>**Total daily energy intake (kcal)**</u>, Mean (SD) **Total Sample** Within group: baseline, 1yr 3Meals: 2805 (1230), 2098 (609), p<0.001 6Meals: 2652 (910), 2150 (877), p<0.01 Between group: difference in change from baseline to 1yr 95% CI for difference between changes: (-746, 375), p=0.51 <u>**Change from baseline to 1yr (kcal)**</u> **Men** 3Meals: 991 6Meals: 484 **Women:** 3Meals: 618 6Meals: 544	**Limitations:** • Concerns with deviations from intended intervention • High rates of attrition, and unclear how missing data impacted results • Not sufficiently powered • No preregistered data analysis plan • Water/Beverages were not accounted for in exposure assessment **Funding:** Västra Götalandsregionen

Study and Population Characteristics	Intervention, Comparator, and Outcome(s)	Results	Study Limitations
Grangeiro, 2021[34] **RCT-Parallel, Brazil** Baseline N=47, Analytic N=40 (Attrition: 15%) **Study objective:** To examine the effect of different meal frequencies on weight loss, body composition, blood glucose, plasma lipids, active ghrelin, and energy expenditure outcomes among women with obesity who had enrolled in a weight loss intervention. **Participant characteristics at baseline:** women with obesity enrolled in a weight loss intervention • Age: Mean ~30y • Female: 100% • Race and/or ethnicity: NR • Socioeconomic position: NR • Anthropometry: BMI ~35 kg/m2 • Physical activity: Asked to maintain physical activity during intervention • Smoking: All nonsmokers • TEI: ~1900 kcal/d • Habitual diet at baseline: NR **Excluded from study or analysis:** BMI <30 and ≥50 kg/m^2, aged <20 or >45y, menopausal, smokers, with restricted diets, with recent changes in body weight (±3 kg in the previous three months), undergone bariatric surgery, athletes, users of medication or supplements for weight control, people diagnosed with acute or chronic disease, (e.g., decompensated hypothyroidism, diabetes, respiratory complications, cancer, inflammatory bowel disease, liver and severe kidney diseases, and heart disease), dyslipidemia, illiterate, those with severe food compulsion at baseline (based on Binge Eating Scale)	**Intervention:** 6 vs 3 meals a day (hypocaloric) The 6-meal group was a hypocaloric diet divided into breakfast (15% TEE), snack (5-10% TEE), lunch (25% TEE), snack (5-10% TEE), dinner (25% TEE) and evening snack (5-10% TEE). The 3-meal group was a hypocaloric diet divided into breakfast (20-25% TEE), lunch (35-40% TEE), and dinner (35-40% TEE). The diets had the same macronutrient distribution. Diets were reduced 500-1000 kcal/d to obtain body weight reduction of 2-4 kg/mo. Breakfast, lunch and dinner were defined to provide more than 15% of the TEE and the snacks provided less than 15% of the TEE. Duration: 12wk Compliance: Self-reported dietary adherence: NS difference between groups; percentage (~75%) remained similar throughout intervention period **Outcomes and assessment methods:** • At baseline, 12wk • Energy intake measured from self-reported food records that were conducted at three periodic visits during the 12wk intervention	**<u>Total daily energy intake (kcal)</u>**, Marginal mean (SD) Within group: baseline, 12wk 3-meal: 1973.91 (86.73), 1530.00 (104.88), p=0.0106 6-meal: 1892.13 (79.65), 1292.06 (111.34), p=0.001 Between groups: p=0.888 at baseline p=0.544 at 12wk **<u>Change in energy intake (kcal) from baseline to 12wk</u>**, Marginal mean (SD) 3-meal: -356.84 (157.58) 6-meal: -733.19 (171.07) p=0.216	**Limitations:** • Methods for concealment NR • Concerns with deviations from intended intervention • Differences in attrition • Water/Beverages were not accounted for in exposure assessment **Funding:** Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES)

Study and Population Characteristics	Intervention, Comparator, and Outcome(s)	Results	Study Limitations
Meessen, 2022[36] **RCT-Crossover, Norway** Baseline N=13, Analytic N=11 (Attrition: 15%) **Study objective:** To investigate the physiological effects of eucaloric time-restricted eating (22/2, one meal per day in the evening) for 11 days on metabolic health and physical performance in free-living healthy lean individuals compared to normal food intake (three meals per day) in a crossover design. **Participant characteristics at baseline:** lean adults • Age: 31.0 (1.7)y • Female: 55% • Race and/or ethnicity: NR • Socioeconomic position: NR • Anthropometry: BMI 24.0 (0.6) kg/m2; fat mass 24.0 (0.6)% • Physical activity: All with training experience in order to perform physical performance tests (inclusion criteria) • Smoking: All nonsmokers • TEI: NR • Habitual diet at baseline: NR **Excluded from study or analysis:** BMI <20 or >30 kg/m2; fat mass <12 or >30%; no training experience; history of cardiovascular disease, diabetes mellitus (type 1 or type 2), eating disorders, mental disorders, other diseases which may affect metabolism; cholecystectomy; smoking; already on an intermittent fasting pattern (self-reported)	**Intervention:** 3 vs 1 meals per day (eucaloric) 3 eating occasions: participants ate 3 meals a day (breakfast, lunch, dinner) 1 eating occasion: participants ate 1 meal a day between 5-7pm Participants consumed individually designed diets (based on gender, age, weight, height, and activity pattern) in order to maintain a stable weight. Participants were allowed to consume unlimited water, coffee or tea (without sugar/honey). Only artificial sweeteners were allowed. Duration: 11d (2wk washout) Compliance: NR **Outcomes and assessment methods:** • Day 5, 8, and 11 of the intervention • Participants completed food diaries, which was used to calculate energy intake.	**Energy intake (kcal)**, Mean (SEM) **Day 5** 1 meal: 2342 (233) 3 meals: 2391 (211) $p>0.05$ **Day 8** 1 meal: 2245 (305) 3 meals: 2421 (208) $p>0.05$ **Day 11** 1 meal: 2307 (289) 3 meals: 2404 (248) $p>0.05$	**Limitations:** • Methods for randomization and concealment NR • Unclear if outcome assessors were aware of intervention assignment • No preregistered data analysis plan • Water/Beverages were not accounted for in exposure assessment **Funding:** ZonMW; Dutch Diabetes Foundation

Study and Population Characteristics	Intervention, Comparator, and Outcome(s)	Results	Study Limitations
Papakonstantinou, 2018[37] **RCT-Crossover, Greece** Baseline N=53, Analytic N=47 (Attrition: 11%) **Study objective:** To evaluate the effects of long-term 6 vs 3 meal eucaloric eating patterns on indices of glycemic control and satiety in subjects with obesity and either IGT or T2D on a weight maintenance diet **Participant characteristics at baseline:** adults with impaired glucose tolerance or overt T2D • Age: 49.3 (1.8)y • Female: 53% • Race and/or ethnicity: NR • Socioeconomic position: NR • Anthropometry: BMI 32.4 (0.8) kg/m^2 (all with obesity) • Physical activity: PAL 1.40 (0.03) • Smoking: 19% smokers • TEI: NR • Habitual diet at baseline: Adherence to Mediterranean-like dietary pattern (range 0-55): 32.2 (0.6) **Excluded from study or analysis:** 2hr plasma glucose concentrations ≤140 mg/dL after a 75 g oral glucose tolerance test; BMI <30 or >45 kg/m^2; age <19 or >65y; previous lifestyle modification interventions (structured dietary plans and/or exercise weight loss programs); antidiabetic drug treatment; kidney, liver or cardiovascular disease; hematological abnormalities; hyper- or hypothyroidism; cancer; and mental disorders	**Intervention:** 6 vs 3 meals a day (eucaloric) Participants followed a weight maintenance diet consumed either as a 3- or 6-meal pattern. Meals were defined as eating occasions providing >150 kcal in the morning ('breakfast'), at midday ('lunch') and in the evening ('dinner'). Snacks were defined as eating episodes of <150 kcal consumed at times other than specific meal times. Duration: 12wk (washout NR) Compliance: determined from food records and structured interviews; all participants completed their food diaries **Outcomes and assessment methods:** • Biweekly during the 12wk intervention • Participants recorded their caloric intake on a daily basis, including the type and amount of any food and beverage consumed throughout the intervention periods. There was NS difference between 3- and 7-day food records, so data from 3-day food records (2 consecutive weekdays and 1 weekend day) were used for analysis.	**Total daily energy intake (kcal) during the 12wk intervention**, Mean (SEM) 3-meals: 1917 (56) 6-meals: 2081 (92) p=0.13	**Limitations:** • Bias arising from carryover effects • No power calculation • Water/Beverages were not accounted for in exposure assessment **Funding:** None reported

Study and Population Characteristics	Intervention, Comparator, and Outcome(s)	Results	Study Limitations
PROSPECTIVE COHORT STUDIES			
Huseinovic, 2021[35] **PCS, Secondary analysis of LEVA (Lifestyle for effective weight loss during lactation) RCT, Sweden** Analytic N=60 **Study objective:** To examine associations among change in eating frequency and change in energy intake and weight during a 12-week successful weight loss intervention in postpartum women with overweight or obesity **Participant characteristics at baseline:** Postpartum women with overweight and obesity undergoing a 12wk weight loss intervention • Age: 33.2 (4.1)y • Female: 100% • Race and/or ethnicity: NR • Socioeconomic position: 8% ≤high school; 20% ≤3y beyond high school; 72% >3y beyond high school; 95% married or cohabitating; 3% single; 2% couple with different residences • Anthropometry: BMI 30.1 (2.7) kg/m^2 • Physical activity: NR • Smoking: NR • TEI: NR • Habitual diet at baseline: Mean (SD) 5.9 (1.2) number of eating occasions per day (range 4-10) **Excluded from study or analysis:** Missing diet record at 12wk	**Exposure:** Eating frequency defined as the mean number of intake occasions per day. An intake occasion was defined as an energy intake of ≥50 kcal, including foods and/or beverages, separated in time from the preceding and following intake occasion by at least 30 min. Assessment methods and timing: • 4d diet record • At 10-14wk postpartum and 12wk later (post-intervention at 22-26wk postpartum) **Outcomes and assessment methods:** • At 10-14wk postpartum and 12wk later (post-intervention at 22-26wk postpartum) • Energy intake calculated from weighed 4d diet records; participants were provided with electronic scale and instructed to register all foods and beverages and weigh to the nearest 1g	**Change in total daily energy intake (kcal) by change in eating frequency over 12wk**, β (SE) 169 (69), p=0.017	**Model adjustments:** • Key confounders: sex, age, socioeconomic position, anthropometry, physical activity • Other: parity; human milk feeding; dietary treatment (intervention group); eating frequency (for weight analysis) **Limitations:** • Did not account for key confounders: race and/or ethnicity, smoking • Did not describe or account for missing data • No preregistered data analysis plan; • Water/Beverages were not accounted for in exposure assessment • Did not adjust for TEI **Funding:** Swedish Research Council; Swedish Council for Working Life and Social Research

[a] Abbreviations: BMI: body mass index; CON: control; d: day(s); EI: energy intake; EX: exercise; g: gram(s); kcal: kilocalories; MJ: megajoule; MVPA: moderate to vigorous physical activity; PCS: prospective cohort study; NB: no breakfast; NR: not reported; NS: not significant; RCT: randomized controlled trial; SD: standard deviation; SE: standard error; SEM: standard error of the mean; SN: snack; TEE: total energy expenditure; TEI: total energy intake; wk: week(s); y: year(s)

Table 14. Risk of bias for randomized controlled trials examining number of eating occasions in adults and energy intake[a]

Article	Randomization	Period and carryover effects	Deviations from intended interventions (effect of assignment)	Missing outcome data	Outcome measurement	Selection of the reported result	Overall risk of bias
Bachman, 2012[32]	LOW	NOT APPLICABLE	LOW	LOW	LOW	LOW	LOW
Forslund, 2008[33]	LOW	NOT APPLICABLE	HIGH	SOME CONCERNS	LOW	SOME CONCERNS	HIGH
Grangeiro, 2021[34]	SOME CONCERNS	NOT APPLICABLE	SOME CONCERNS	SOME CONCERNS	LOW	LOW	SOME CONCERNS
Meessen, 2022[36]	SOME CONCERNS	SOME CONCERNS	LOW	LOW	SOME CONCERNS	SOME CONCERNS	SOME CONCERNS
Papakonstantinou, 2018[37]	LOW	SOME CONCERNS	LOW	LOW	LOW	LOW	SOME CONCERNS

Table 15. Risk of bias for observational study examining number of eating occasions in adults and energy intake[b]

	Confounding	Exposure measurement	Selection of participants	Post-exposure interventions	Missing data	Outcome measurement	Selection of reported result	Overall risk of bias
Huseinovic, 2021[35]	HIGH	SOME CONCERNS	LOW	LOW	HIGH	LOW	SOME CONCERNS	HIGH

[a] Possible ratings of low, some concerns, or high determined using the "Cochrane Risk-of-bias 2.0" (RoB 2.0) (August 2019 version)" (Sterne JAC, Savović J, Page MJ, et al. RoB 2: a revised tool for assessing risk of bias in randomised trials. *BMJ* 2019; **366**: l4898. doi:10.1136/bmj.l4898.)

[b] Possible ratings of low, some concerns, high, very high, no information, or not applicable were determined using the "Risk of Bias in Non-randomized Studies of Exposures (ROBINS-E)" tool (Higgins JPT, Morgan RL, Rooney AA, et al. A tool to assess risk of bias in non-randomized follow-up studies of exposure effects (ROBINS-E). *Environment International* 2024 (published online Mar 24); doi: 10.1016/j.envint.2024.108602.)

Table 16. Evidence examining the relationship between snacking in adults and energy intake[a]

Study and Population Characteristics	Intervention, Comparator, and Outcome(s)	Results	Study Limitations
Bachman, 2012[32] **RCT-Parallel, Lifestyle, Eating, and Activity Patterns (LEAP), U.S.** Baseline N=51, Analytic N=51 (Attrition: 0%) **Study objective:** To examine the effect of eating frequency on hunger, energy intake, and weight loss during a 6-month behavioral weight loss intervention **Participant characteristics at baseline:** adults with overweight/obesity participating in a 6mo behavioral weight loss intervention • Age: 51 (9.9)y • Female: 58% • Race and/or ethnicity: White: 94%; Black: 6%; Asian: 0%; American Indian: 0%; Other: 0%; non-Hispanic: 98% • Socioeconomic position: Education: 8% high school, 4% vocational school, 31% some college, 31% college graduate, 26% graduate school; 78% married; 12% divorced/separated • Anthropometry: BMI 35.5 kg/m^2 (100% with overweight or obesity) • Physical activity: ~800 kcal/wk expended • Smoking: NR • TEI: ~2200 kcal/d • Habitual diet at baseline: ~4 eating bouts/d (~2.8 meals, 1.2 snacks) **Excluded from study or analysis:** age <21 and >65y; BMI <27 and >45 kg/m^2, reported a heart condition; chest pain or loss of consciousness during activity, unable to walk 2 blocks without stopping, major psychological disease; diabetes; recent weight loss or in a weight loss program; moving outside the area; pregnant, lactating, <6mo postpartum, or planned to become pregnant; unwilling to complete study meetings, assessments, or food diaries for duration of study	**Intervention:** Snacking vs No Snacking (hypocaloric) Snacking (n=25): Instructions to eat 3 meals/d + standard behavioral intervention for obesity for 6mo (~3 eating bouts/d at 3 and 6mo, all 3 meals) No Snacking (Grazing, n=26): Instructions to "graze" by eating at least 100 kcal every 2-3hr + standard behavioral intervention for obesity for 6mo (~6 eating bouts/d at 3 and 6mo, 3 meals and 3 snacks) Participants defined meals and snacks, which were only counted if at least 25kcal were consumed. All foods and beverages eaten within ½hr of the start of a meal/snack were counted as a single eating bout. Eating frequency equaled the number of meals, snacks, and total eating bouts (meals + snacks) reported in the food records. Duration: 6mo Compliance: Based on percent of self-monitoring diaries turned in and attendance for each participant. NS difference between conditions for self-monitoring, attendance, and retention at 3 or 6 month assessments. **Outcomes and assessment methods:** • At baseline, 3mo, and 6mo • Overall energy intake was assessed by 3 day (2 weekdays, 1 weekend) dietary records. Each food record was entered into NDSR and mean intake of overall energy intake over the 3 days was calculated.	**Total daily energy intake (kcal)**, Mean (SD) Within group: 0mo, 3mo, 6mo, p<0.001 No Snacking: 2142 (727), 1111 (249), 1217 (354), p<0.001 Snacking: 2252 (667), 1280 (210), 1314 (352), p<0.001 Between groups: p=NS at 0, 3, 6mo	**Limitations:** • Water was not accounted for in exposure assessment **Funding:** American Heart Association

Study and Population Characteristics	Intervention, Comparator, and Outcome(s)	Results	Study Limitations
Forslund, 2008[33] **RCT-Parallel, Sweden** Baseline N=140, Analytic N=93 (Attrition: 34%) **Study objective:** To examine the effect of two different recommended eating frequencies on 1-year weight loss **Participant characteristics at baseline:** adults with obesity • Age: ~41 (11)y • Female: 71% • Race and/or ethnicity: NR • Socioeconomic position: NR • Anthropometry: All with BMI >30 kg/m^2 • Physical activity: NR • Smoking: NR • TEI: ~2700 kcal/d • Habitual diet at baseline: NR **Excluded from study or analysis:** aged <18 or >60y; BMI <30 kg/m^2; participants reporting previous obesity surgery, anti-obesity drug treatment the last year, drug or insulin-treated diabetes, hypothyroidism, severe psychiatric disorder, bulimia, drug or alcohol abuse	**Intervention:** Snacking vs No Snacking (hypocaloric) Snacking: consumed snacks 3x/day (10% of daily energy intake each) in additional to 3 meals No Snacking: consumed no snacks (with the exception of limited fruit intake and calorie free drinks) Duration: 1yr Compliance: Measured using repeated telephone intervals at 6 time periods during the 1yr intervention **Outcomes and assessment methods:** • At baseline, 1yr • Energy intake assessed using self-administered dietary questionnaire on habitual intake during the past 3mo	<u>**Total daily energy intake (kcal)**</u>, Mean (SD) **Total Sample** Within group: baseline, 1yr No Snacking: 2805 (1230), 2098 (609), p<0.001 Snacking: 2652 (910), 2150 (877), p<0.01 Between group: difference in change from baseline to 1yr 95% CI for difference between changes: (-746, 375), p=0.51 <u>**Change from baseline to 1yr (kcal)**</u> **Men** No Snacking: 991 Snacking: 484 **Women:** No Snacking: 618 Snacking: 544	**Limitations:** • Concerns with deviations from intended intervention • High rates of attrition, and unclear how missing data impacted results • Not sufficiently powered • No preregistered data analysis plan • Water/Beverages were not accounted for in exposure assessment **Funding:** Västra Götalandsregionen

Study and Population Characteristics	Intervention, Comparator, and Outcome(s)	Results	Study Limitations
Grangeiro, 2021[29] **RCT-Parallel, Brazil** Baseline N=47, Analytic N=40 (Attrition: 15%) **Study objective:** To examine the effect of different meal frequencies on weight loss, body composition, blood glucose, plasma lipids, active ghrelin, and energy expenditure outcomes among women with obesity who had enrolled in a weight loss intervention. **Participant characteristics at baseline:** women with obesity enrolled in a weight loss intervention • Age: Mean ~30y • Female: 100% • Race and/or ethnicity: NR • Socioeconomic position: NR • Anthropometry: BMI ~35 kg/m2 • Physical activity: Asked to maintain physical activity during intervention • Smoking: All nonsmokers • TEI: ~1900 kcal/d • Habitual diet at baseline: NR **Excluded from study or analysis:** BMI <30 and ≥50 kg/m^2, aged <20 or >45y, menopausal, smokers, with restricted diets, with recent changes in body weight (±3 kg in the previous three months), undergone bariatric surgery, athletes, users of medication or supplements for weight control, people diagnosed with acute or chronic disease, (e.g., decompensated hypothyroidism, diabetes, respiratory complications, cancer, inflammatory bowel disease, liver and severe kidney diseases, and heart disease), dyslipidemia, illiterate, those with severe food compulsion at baseline (based on Binge Eating Scale)	**Intervention:** Snacking vs No Snacking (hypocaloric) Snacking: a hypocaloric diet divided into breakfast (15% TEE), snack (5-10% TEE), lunch (25% TEE), snack (5-10% TEE), dinner (25% TEE) and evening snack (5-10% TEE). No Snacking: a hypocaloric diet divided into breakfast (20-25% TEE), lunch (35-40% TEE), and dinner (35-40% TEE). The diets had the same macronutrient distribution. Diets were reduced 500-1000 kcal/d to obtain body weight reduction of 2-4 kg/mo. Breakfast, lunch and dinner were defined to provide more than 15% of the TEE and the snacks provided less than 15% of the TEE. Duration: 12wk Compliance: Self-reported dietary adherence: NS difference between groups; percentage (~75%) remained similar throughout intervention period **Outcomes and assessment methods:** • At baseline, 12wk • Energy intake measured from self-reported food records that were conducted at three periodic visits during the 12wk intervention	**<u>Total daily energy intake (kcal)</u>**, Marginal mean (SD) Within group: baseline, 12wk No Snacking: 1973.91 (86.73), 1530.00 (104.88), p=0.0106 Snacking: 1892.13 (79.65), 1292.06 (111.34), p=0.001 Between groups: p=0.888 at baseline p=0.544 at 12wk **<u>Change in energy intake (kcal) from baseline to 12wk</u>**, Marginal mean (SD) No Snacking: -356.84 (157.58) Snacking: -733.19 (171.07) p=0.216	**Limitations:** • Methods for concealment NR • Concerns with deviations from intended intervention • Differences in attrition • Water/Beverages were not accounted for in exposure assessment **Funding:** Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES)

Study and Population Characteristics	Intervention, Comparator, and Outcome(s)	Results	Study Limitations
Johnstone, 2000[38] **RCT-Crossover, UK** Baseline N=8, Analytic N=8 (Attrition: 0%) **Study objective:** To examine the effects of ingesting mandatory snacks v. no snacks and the composition of isoenergetically-dense snacks high in protein, fat or carbohydrate, on food intake and energy intake in eight men with ad libitum access to a diet of fixed composition **Participant characteristics at baseline:** men with normal weight • Age: 27.3 (6.4)y • Female: 0% • Race and/or ethnicity: NR • Socioeconomic position: NR • Anthropometry: Weight 76.5 (10.2)kg • Physical activity: NR • Smoking: All nonsmokers • TEI: NR • Habitual diet at baseline: NR **Excluded from study or analysis:** unstable weight history, medication, smokers	**Intervention:** Snack (3 isoenergetic conditions) vs. No snack (NSn) High-protein snack (HP), high-carbohydrate snack (HC), and high-fat snack (HF) were provided at fixed time intervals (11:30am, 3:30pm, 7:30pm) and each provided 30% of participants estimated daily energy requirements. Duration: 7d (≥1wk washout), each 7d intervention was preceded by 2d of a fixed, maintenance diet Compliance: NR **Outcomes and assessment methods:** • 9d • Participants were provided with ad libitum access to a medium-fat diet for meals (breakfast, lunch, supper), snacks, and drinks. Food was weighed before and after consumption to calculate energy intake. Energy intake was also broken down into meals (breakfast, lunch, and supper).	**Ad libitum energy intake throughout the day (kcal)**, Mean NSn: 3322 HP: 2796 HC: 2796 HF: 2916 p=0.007 **Ad libitum energy intake (kcal) at breakfast, lunch, supper, or snacks:** p=NS between groups **Total energy intake including snacks (kcal)**, Mean NSn: 3322 HP: 3418 HC: 3370 HF: 3537 p=0.63	**Limitations:** • Methods for randomization and concealment NR • No power calculation • No preregistered data analysis plan • Water/Beverages were not accounted for in exposure assessment **Funding:** Scottish Office; Slimming World

Study and Population Characteristics	Intervention, Comparator, and Outcome(s)	Results	Study Limitations
VanderWal, 2006[39] **RCT-Parallel, U.S.** Baseline N=80, Analytic N=41 (Attrition: 0%) **Study objective:** To examine whether providing a structured post-dinner snack would enhance weight loss among night snackers with obesity participating in a novel partial meal replacement program and to examine the efficacy of that program **Participant characteristics at baseline:** adult night snackers with obesity • Age: ~46y • Female: 72% • Race and/or ethnicity: NR • Socioeconomic position: NR • Anthropometry: BMI ~38 kg/m^2 (all with obesity) • Physical activity: NR • Smoking: NR • TEI: ~2350 kcal/d • Habitual diet at baseline: NR **Excluded from study or analysis:** aged <18 or >65y, BMI <30 kg/m^2, unstable 6mo weight history, did not endorse night snacking as contributing to their weight problem	**Intervention:** Post dinner snack (PDS) vs No snack (NSn) PDS (n=18): participants ate a standardized bowl of ready-to-eat cereal and low-fat milk 90min after supper meal NSn (n=23): participants were given no further instructions after supper Both groups consumed a standardized breakfast, mid-morning snack, and lunch in addition to an individually planned supper. Duration: 8wk Compliance: defined as consumption of post-dinner snack and meal replacement products by the PDS group; NS difference between groups when comparing compliance **Outcomes and assessment methods:** • At baseline, 8wk • Participants were provided with food supplies to follow the diets. Participants returned unused food products at follow-up visits that were conducted every 2wk, and this was used to calculate energy intake.	**Change in energy intake (kcal) from baseline to 8wk**, Mean (SD) NSn: -3074.02 (5471.19) PDS: -982.91 (4411.26) p=NS	**Limitations:** • Methods for randomization and concealment NR • Concerns with deviations from intended intervention • Differences in attrition • Unclear if outcome assessors were aware of intervention assignment • No power calculation • No preregistered data analysis plan • Water/Beverages were not accounted for in exposure assessment **Funding:** Kellogg Company

[a] Abbreviations: BMI: body mass index; CON: control; d: day(s); EI: energy intake; EX: exercise; kcal: kilocalorie(s); m: meter(s); min: minute(s); MJ: megajoule; MVPA: moderate to vigorous physical activity; NB: no breakfast; NR: not reported; NS: not significant; NSn: no snack; PDS: post dinner snack; RCT: randomized controlled trial; SE: standard error; SD: standard deviation; SN: snack; TEI: total energy intake; wk: week(s); y: year(s)

Table 17. Risk of bias for randomized controlled trials examining snacking in adults and energy intake[a]

Article	Randomization	Period and carryover effects	Deviations from intended interventions (effect of assignment)	Missing outcome data	Outcome measurement	Selection of the reported result	Overall risk of bias
Bachman, 2012[32]	LOW	NOT APPLICABLE	LOW	LOW	LOW	LOW	LOW
Grangeiro, 2021[34]	SOME CONCERNS	NOT APPLICABLE	SOME CONCERNS	SOME CONCERNS	LOW	LOW	SOME CONCERNS
Forslund, 2008[33]	LOW	NOT APPLICABLE	HIGH	SOME CONCERNS	LOW	SOME CONCERNS	HIGH
Johnstone, 2000[38]	SOME CONCERNS	LOW	LOW	LOW	LOW	SOME CONCERNS	SOME CONCERNS
VanderWal, 2006[39]	SOME CONCERNS	NOT APPLICABLE	SOME CONCERNS	HIGH	LOW	SOME CONCERNS	HIGH

[a] Possible ratings of low, some concerns, or high determined using the "Cochrane Risk-of-bias 2.0" (RoB 2.0) (August 2019 version)" (Sterne JAC, Savović J, Page MJ, et al. RoB 2: a revised tool for assessing risk of bias in randomised trials. *BMJ* 2019; **366**: l4898. doi:10.1136/bmj.l4898.)

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Appendices

Appendix 1: Abbreviations

Table A 1. List of abbreviations

Abbreviation	Full name
BMI	Body Mass Index
HHS	United States Department of Health and Human Services
Kcal	Kilocalories
NESR	Nutrition Evidence Systematic Review
RCT	Randomized Controlled Trial
TEI	Total Energy Intake
USDA	United States Department of Agriculture

Appendix 2: Literature search strategy

Database: PubMed

Provider: U.S. National Library of Medicine
Date(s) Searched: May 15, 2023
Dates Covered: January 1, 2000 – May 15, 2023

Table A 2. Search for PubMed

Search #	Concept	String
#1	Frequency of meals and snacking	((“Feeding Behavior”[Mesh:noexp] OR “Meals”[Mesh] OR meal*[tiab] OR lunch[tiab] OR dinner[tiab] OR eating[tiab]) AND (frequenc*[tiab] OR time*[tiab] OR timing*[tiab] OR skip*[tiab] OR episode*[tiab] OR occasion*[tiab])) OR “Breakfast”[MeSH] OR breakfast[tiab] OR “morning meal”[tiab] OR “Snacks”[MeSH] OR snack*[tiab] OR “daily meal*”[tiab]
#2	Growth, body composition, and risk of obesity	"Adipose Tissue"[Mesh] OR "Body Composition"[Mesh] OR "Body Weights and Measures"[MeSH:NoExp] OR "Body Fat Distribution"[Mesh] OR "Body Mass Index"[Mesh] OR "Body Size"[Mesh] OR "Skinfold Thickness"[Mesh] OR "Waist-Hip Ratio"[Mesh] OR "Overnutrition"[Mesh] OR "Growth"[Mesh:NoExp] OR anthropometr*[tiab] OR body fat[tiab] OR fat mass[tiab] OR fat free mass[tiab] OR lean mass[tiab] OR obese[tiab] OR obesity[tiab] OR underweight[tiab] OR overweight[tiab] OR weight status[tiab] OR head circumference[tiab] OR arm circumference[tiab] OR calf circumference[tiab] OR neck circumference[tiab] OR thigh circumference[tiab] OR waist circumference[tiab] OR waist to hip ratio[tiab] OR waist hip ratio[tiab] OR body mass index[tiab] OR BMI[tiab] OR adipos*[tiab] OR body weight[tiab] OR body height[tiab] OR body size[tiab] OR body composition[tiab] OR overnutrition[tiab] OR wasting[tiab] OR healthy weight[tiab] OR skin fold[tiab] OR skin folds[tiab] OR skinfold[tiab] OR skinfolds[tiab] OR "Weight Reduction Programs"[Mesh] OR "Body-Weight Trajectory"[Mesh] OR "Weight Gain"[MeSH] OR "Weight Loss"[MeSH:NoExp] OR “Diet, Reducing"[Mesh] OR weight gain*[tiab] OR diet reduc*[tiab] OR weight cycling[tiab] OR weight decreas*[tiab] OR weight watch*[tiab] OR weight control*[tiab] OR weight retention[tiab] OR weight management[tiab] OR "maintain weight"[tiab:~4] OR "maintains weight"[tiab:~4] OR "maintaining weight"[tiab:~4] OR "maintained weight"[tiab:~4] OR "weight maintenance"[tiab:~4] OR "reduce weight"[tiab:~4] OR "reduces weight"[tiab:~4] OR "reducing weight"[tiab:~4] OR "reduced weight"[tiab:~4] OR "weight reduction"[tiab:~4] OR "lose weight"[tiab:~4] OR "loses weight"[tiab:~4] OR "losing weight"[tiab:~4] OR "lost weight"[tiab:~4] OR "weight loss"[tiab:~4] OR "change weight"[tiab:~4] OR "changes weight"[tiab:~4] OR "changing weight"[tiab:~4] OR "changed weight"[tiab:~4] OR “Growth Charts”[Mesh] OR growth chart*[tiab]OR stunting[tiab] OR stunted[tiab] OR weight for height[tiab] OR stature for age[tiab] OR weight for age[tiab] OR height for age[tiab] OR length for age[tiab] OR weight for length[tiab] OR failure to thrive[tiab]

#3	Diet quality	"Guideline Adherence"[Mesh] OR HEI[tiab] OR "healthy eating index"[tiab] OR "dietary guideline*"[tiab] OR "nutrition guideline*"[tiab] OR "nutritional guideline*"[tiab] OR "dietary recommendation*"[tiab] OR "dietary consumption"[tiab] OR "diet score*"[tiab] OR "diet index*"[tiab] OR “diet indices”[tiab] OR "dietary index*"[tiab] OR “dietary indices”[tiab] OR "food score*"[tiab] OR "dietary pattern*"[tiab] OR "diet pattern*"[tiab] OR "eating pattern*"[tiab] OR "food pattern*"[tiab] OR "diet quality"[tiab] OR "dietary quality"[tiab] OR “Healthy diet”[tiab] OR kidmed[tiab] OR MedDietScore[tiab]
#4	Energy intake	"Energy Intake"[MeSH] OR "energy intake"[tiab] OR "calorie intake"[tiab] OR "caloric intake"[tiab] OR "total energy"[tiab] OR "total calorie*"[tiab] OR "total caloric*"[tiab] OR "energy consum*"[tiab] OR "calorie consum*"[tiab] OR "caloric consum*"[tiab]
#5		#1 AND (#2 OR #3 OR #4)
#6	Limits	#5 NOT ("Animals"[Mesh] NOT ("Animals"[Mesh] AND "Humans"[Mesh])) NOT (editorial[ptyp] OR comment[ptyp] OR commentary[tiab] OR news[ptyp] OR letter[ptyp] OR review[ptyp] OR systematic review[ptyp] OR systematic review[ti] OR meta-analysis[ptyp] OR meta-analysis[ti] OR meta-analyses[ti] OR protocol[ti] OR retracted publication[ptyp] OR retraction of publication[ptyp] OR retraction of publication[tiab] OR retraction notice[ti] OR “retracted publication”[ti] OR "Congress"[Publication Type] OR "Consensus Development Conference"[Publication Type] OR “conference abstract*”[tiab] OR “conference proceeding*”[tiab] OR “conference paper*”[tiab] OR "practice guideline"[ptyp] OR "practice guideline"[ti]) Filters applied: English, from 2000/1/1 - 3000/12/12.

Database: Embase

Provider: Elsevier
Date(s) Searched: May 15, 2023
Dates Covered: January 1, 2000 – May 15, 2023

Table A 3. Search for Embase

Search #	Concept	String
#1	Frequency of meals and snacking	('feeding behavior'/de OR 'meal'/exp OR meal*:ab,ti OR lunch:ab,ti OR dinner:ab,ti OR eating:ab,ti) AND (frequenc*:ab,ti OR time*:ab,ti OR timing*:ab,ti OR skip*:ab,ti OR episode*:ab,ti OR occasion*:ab,ti) OR 'meal skipping'/exp OR breakfast:ab,ti OR 'morning meal':ab,ti OR snack*:ab,ti OR 'daily meal*':ab,ti

#2	Growth, body composition, and risk of obesity	‘adipose tissue’/exp OR ‘body composition’/exp OR ‘anthropometry’/de OR ‘body mass’/exp OR ‘anthropometric parameters’/exp OR ‘skinfold thickness’/exp OR ‘overnutrition’/exp OR ‘growth’/de OR ‘anthropometr*’:ab,ti OR ‘body fat’:ab,ti OR ‘fat mass’:ab,ti OR ‘fat free mass’:ab,ti OR ‘lean mass’:ab,ti OR ‘obese’:ab,ti OR ‘obesity’:ab,ti OR ‘underweight’:ab,ti OR ‘overweight’:ab,ti OR ‘weight status’:ab,ti OR ‘head circumference’:ab,ti OR ‘arm circumference’:ab,ti OR ‘calf circumference’:ab,ti OR ‘neck circumference’:ab,ti OR ‘thigh circumference’:ab,ti OR ‘waist circumference’:ab,ti OR ‘waist to hip ratio’:ab,ti OR ‘waist hip ratio’:ab,ti OR ‘body mass index’:ab,ti OR ‘BMI’:ab,ti OR ‘adipos*’:ab,ti OR ‘body weight’:ab,ti OR ‘body height’:ab,ti OR ‘body size’:ab,ti OR ‘body composition’:ab,ti OR ‘overnutrition’:ab,ti OR ‘wasting’:ab,ti OR ‘healthy weight’:ab,ti OR ‘skin fold*’:ab,ti OR ‘skinfold*’:ab,ti OR ‘body weight management’/exp OR ‘body weight change’/exp OR ‘weight gain*’:ab,ti OR ‘diet reduc*’:ab,ti OR ‘weight cycling’:ab,ti OR ‘weight watch*’:ab,ti OR ‘weight control*’:ab,ti OR ‘weight retention’:ab,ti OR ‘weight management’:ab,ti OR (weight NEAR/4 (decreas* OR gain* OR maint* OR reduc* OR loss* OR chang*)):ab,ti OR ‘weight chart’/exp OR ‘growth chart*’:ab,ti OR stunting:ab,ti OR stunted:ab,ti OR ‘weight for height’:ab,ti OR ‘stature for age’:ab,ti OR ‘weight for age’:ab,ti OR ‘height for age’:ab,ti OR ‘length for age’:ab,ti OR ‘weight for length’:ab,ti OR ‘ failure to thrive’:ab,ti
#3	Diet duality	**'**healthy eating index'/exp OR HEI:ab,ti OR ‘healthy eating index’:ab,ti OR ‘dietary guideline*’:ab,ti OR ‘nutrition guideline*’:ab,ti OR ‘nutritional guideline*’:ab,ti OR ‘dietary recommendation*’:ab,ti OR ‘dietary consumption’:ab,ti OR ‘diet score*’:ab,ti OR ‘diet index*’:ab,ti OR ‘diet indices’:ab,ti OR ‘dietary index*’:ab,ti OR ‘dietary indices’:ab,ti OR ‘food score*’:ab,ti OR ‘dietary pattern*’:ab,ti OR ‘diet pattern*’:ab,ti OR ‘eating pattern*’:ab,ti OR ‘food pattern*’:ab,ti OR ‘diet quality’:ab,ti OR ‘dietary quality’:ab,ti OR ‘Healthy diet’:ab,ti
#4	Energy intake	‘caloric intake’/exp OR ‘energy intake’:ab,ti OR ‘calorie intake’:ab,ti OR ‘caloric intake’:ab,ti OR ‘total energy’:ab,ti OR ‘total calorie*’:ab,ti OR ‘total caloric*’:ab,ti OR ‘energy consum*’:ab,ti OR ‘calorie consum*’:ab,ti OR ‘caloric consum*’:ab,ti
#5		#1 AND (#2 OR #3 OR #4)
#6	Limits	#5 AND ([article]/lim OR [article in press]/lim) NOT ([animals]/lim NOT ([animals]/lim AND [humans]/lim)) AND [english]/lim NOT ([conference abstract]/lim OR [conference paper]/lim OR [conference review]/lim OR [editorial]/lim OR [erratum]/lim OR [letter]/lim OR [note]/lim OR 'retraction of publication':ab,ti OR 'retraction notice':ti OR 'retracted publication':ab,ti OR [review]/lim OR [systematic review]/lim OR [meta analysis]/lim OR 'practice guideline':ti OR 'protocol':ti) AND [2000-2023]/py

Database: Cochrane Central Register of Controlled Trials (CENTRAL)

Provider: John Wiley & Sons
Date(s) Searched: May 15, 2023
Dates Covered: January 1, 2000 – May 15, 2023

Table A 4. Search for Cochrane CENTRAL

Search #	Concept	String
#1	Frequency of meals and snacking	(([mh ^"Feeding Behavior"] OR [mh "Meals"] OR (meal* OR lunch OR dinner OR eating):ti,ab,kw) AND (frequenc* OR time* OR timing* OR skip* OR episode* OR occasion*):ti,ab,kw) OR [mh "Breakfast"] OR [mh "Snacks"] OR (breakfast OR “morning meal” OR snack* OR “daily meal*”):ti,ab,kw
#2	Growth, body composition, and risk of obesity	([mh "Adipose Tissue"] OR [mh "Body Composition"] OR [mh ^"Body Weights and Measures"] OR [mh "Body Fat Distribution"] OR [mh "Body Mass Index"] OR [mh "Body Size"] OR [mh "Skinfold Thickness"] OR [mh "Waist-Hip Ratio"] OR [mh Overnutrition] OR [mh ^Growth] OR anthropometr* OR “body fat” OR “fat mass” OR “fat free mass” OR “lean mass” OR obese OR obesity OR underweight OR overweight OR “weight status” OR “head circumference” OR “arm circumference” OR “calf circumference” OR “neck circumference” OR “thigh circumference” OR “waist circumference” OR “waist to hip ratio” OR “waist hip ratio” OR “body mass index” OR BMI OR adipos* OR “body weight” OR “body height” OR “body size” OR “body composition” OR overnutrition OR wasting OR “healthy weight” OR “skin fold” OR “skin folds” OR skinfold OR skinfolds):ti,ab,kw OR ([mh "Weight Reduction Programs"] OR [mh "Body-Weight Trajectory"] OR [mh "Weight Gain"] OR [mh ^“Weight Loss”] OR [mh "Diet, Reducing"] OR “diet reduc*” OR “weight cycling” OR “weight watch*” OR “weight control*” OR “weight retention” OR “weight management”):ti,ab,kw OR ((weight NEAR/4 (decreas* OR gain* OR maint* OR reduc* OR loss* OR chang*)) OR [mh “Growth Charts”] OR “growth chart*” OR stunting OR stunted OR “weight for height” OR “stature for age” OR “weight for age” OR “height for age” OR “length for age” OR “weight for length” OR “ failure to thrive”):ti,ab,kw
#3	Diet quality	[mh "Guideline Adherence"] OR (HEI OR "healthy eating index" OR "dietary guideline" OR "dietary guidelines" OR "nutrition guideline" OR "nutrition guidelines" OR "nutritional guideline" OR "nutritional guidelines" OR "dietary recommendation" OR "dietary recommendations" OR "dietary consumption" OR "diet score" OR "diet scores" OR "diet index" OR "diet indexes" OR “diet indices” OR "dietary index" OR "dietary indexes" OR “dietary indices” OR "food score" OR "food scores" OR "dietary pattern" OR "dietary patterns" OR "diet pattern" OR "diet patterns" OR "eating pattern" OR "eating patterns" OR "food pattern" OR "food patterns" OR "diet quality" OR "dietary quality" OR “healthy diet”):ti,ab,kw

#4	Energy intake	[mh "Energy Intake"] OR ("energy intake" OR "calorie intake" OR "caloric intake" OR "total energy" OR "total calorie*" OR "total caloric*" OR "energy consum*" OR (calorie NEXT consum*) OR (caloric NEXT consum*)):ti,ab,kw
#5	Limits	#1 AND (#2 OR #3 OR #4) with Publication Year from 2000 to 2023, in Trials (Word variations have been searched)

Database: CINAHL

Provider: EBSCO
Date(s) Searched: May 15, 2023
Dates Covered: January 1, 2000 – May 15, 2023

Table A 5. Search for CINAHL

Search #	Concept	String
#1	Frequency of meals and snacking	TI (((MH "Eating Behavior") OR meal* OR lunch OR dinner OR eating) AND (frequenc* OR time* OR timing* OR skip* OR episode* OR occasion*)) OR AB (((MH "Eating Behavior") OR meal* OR lunch OR dinner OR eating) AND (frequenc* OR time* OR timing* OR skip* OR episode* OR occasion*)) OR (MH "Breakfast") OR (MH "Snacks") OR TI (breakfast OR “morning meal”OR snack* OR “daily meal*”) OR AB (breakfast OR “morning meal”OR snack* OR “daily meal*”)

#2	Growth, body composition, and risk of obesity	(MH “Adipose Tissue+”) OR (MH "Body Composition+") OR (MH "Body Weights and Measures") OR (MH "Arm Circumference") OR (MH "Body Height") OR (MH "Body Mass Index") OR (MH "Body Size") OR (MH "Body Weight+") OR (MH "Crown-Rump Length") OR (MH "Waist Circumference") OR (MH "Waist-Hip Ratio") OR (MH "Skinfold Thickness") OR (MH "Obesity+") OR (MH "Overnutrition") OR (MH "Growth") OR (TI anthropometr* OR “body fat” OR “fat mass” OR “fat free mass” OR “lean mass” OR obese OR obesity OR underweight OR overweight OR “weight status” OR “head circumference” OR “arm circumference” OR “calf circumference” OR “neck circumference” OR “thigh circumference” OR “waist circumference” OR “waist to hip ratio” OR “waist hip ratio” OR “body mass index” OR BMI OR adipos* OR “body weight” OR “body height” OR “body size” OR “body composition” OR overnutrition OR wasting OR “healthy weight” OR “skin fold” OR “skin folds” OR skinfold OR skinfolds) OR (AB anthropometr* OR “body fat” OR “fat mass” OR “fat free mass” OR “lean mass” OR obese OR obesity OR underweight OR overweight OR “weight status” OR “head circumference” OR “arm circumference” OR “calf circumference” OR “neck circumference” OR “thigh circumference” OR “waist circumference” OR “waist to hip ratio” OR “waist hip ratio” OR “body mass index” OR BMI OR adipos* OR “body weight” OR “body height” OR “body size” OR “body composition” OR overnutrition OR wasting OR “healthy weight” OR “skin fold” OR “skin folds” OR skinfold OR skinfolds) OR (MH “Weight Reduction Programs”) OR (MH "Body Weight Changes") OR (MH "Weight Gain+") OR (MH "Weight Loss") OR (MH "Diet, Reducing") OR (TI “diet reduc*” OR “weight cycling” OR “weight watch*” OR “weight control*” OR “weight retention” OR “weight management”) OR (AB “diet reduc*” OR “weight cycling” OR “weight watch*” OR “weight control*” OR “weight retention” OR “weight management”) OR (TI (weight N4 (decreas* OR gain* OR maint* OR reduc* OR loss* OR chang*))) OR (AB (weight N4 (decreas* OR gain* OR maint* OR reduc* OR loss* OR chang*))) OR (TI “growth chart*” OR stunting OR stunted OR “weight for height” OR “stature for age” OR “weight for age” OR “height for age” OR “length for age” OR “weight for length” OR “failure to thrive”) OR (AB “growth chart*” OR stunting OR stunted OR “weight for height” OR “stature for age” OR “weight for age” OR “height for age” OR “length for age” OR “weight for length” OR “failure to thrive”)

#3	Diet quality	(MH "Guideline Adherence") OR TI (HEI OR "healthy eating index" OR "dietary guideline*" OR "nutrition guideline*" OR "nutritional guideline*" OR "dietary recommendation*" OR "dietary consumption" OR "diet score*" OR "diet index*" OR “diet indices” OR "dietary index*" OR “dietary indices” OR "food score*" OR "dietary pattern*" OR "diet pattern*" OR "eating pattern*" OR "food pattern*" OR "diet quality" OR "dietary quality" OR “Healthy diet” OR kidmed OR MedDietScore) OR AB (HEI OR "healthy eating index" OR "dietary guideline*" OR "nutrition guideline*" OR "nutritional guideline*" OR "dietary recommendation*" OR "dietary consumption" OR "diet score*" OR "diet index*" OR “diet indices” OR "dietary index*" OR “dietary indices” OR "food score*" OR "dietary pattern*" OR "diet pattern*" OR "eating pattern*" OR "food pattern*" OR "diet quality" OR "dietary quality" OR “Healthy diet” OR kidmed OR MedDietScore)
#4	Energy intake	(MH "Energy Intake") OR TI ("energy intake" OR "calorie intake" OR "caloric intake" OR "total energy" OR "total calorie*" OR "total caloric*" OR "energy consum*" OR "calorie consum*" OR "caloric consum*") OR AB ("energy intake" OR "calorie intake" OR "caloric intake" OR "total energy" OR "total calorie*" OR "total caloric*" OR "energy consum*" OR "calorie consum*" OR "caloric consum*")
#5		S1 AND (S2 OR S3 OR S4)
#6	Limits	S5 NOT ((MH "Animals+") OR (MH "Animal Studies")) NOT ((MH "Literature Review") OR (MH "Meta Analysis") OR (MH "Systematic Review") OR (MH "News") OR (MH "Retracted Publication") OR (MH "Retraction of Publication)) Limiters - Publication Year: 2000-2023 Expanders - Apply equivalent subjects Narrow by Language: - English

Appendix 3: Excluded articles

The following table lists the articles excluded after full-text screening for this systematic review question. At least one reason for exclusion is provided for each article, though this may not reflect all possible reasons. Information about articles excluded after title and abstract screening is available upon request.

Table A 6. Articles excluded after full-text screening

	Citation	Rationale
1	. Skipping meals might increase the risk of metabolic syndrome. Nature Clinical Practice Endocrinology and Metabolism. 2008. 4:532-533. doi:10.1038/ncpendmet0934 .	Study design; Publication status
2	. Virchow and the Weight-loss Breakfast. Orthopedics. 2009. 32:397. doi:10.3928/01477447-20090511-03 .	Study design
3	Abdullatif, M, Alabady, K, Altheeb, et al. Prevalence of Overweight, Obesity, and Dietary Behaviors among Adolescents in Dubai Schools: A Complex Design Survey 2019. Dubai Medical Journal. 2022. 5:1-9. doi:10.1159/000519863 .	Study design
4	Abildso, CG, Schmid, O, Byrd, et al. Predictors of weight loss maintenance following an insurance-sponsored weight management program. J Obes. 2014. 2014:736080. doi:10.1155/2014/736080 .	Study design
5	Agras, WS, Hammer, LD, McNicholas, et al. Risk factors for childhood overweight: a prospective study from birth to 9.5 years. J Pediatr. 2004. 145:20-5. doi:10.1016/j.jpeds.2004.03.023 .	Intervention/Exposure
6	Ahc, Media. Time-Restricted Eating, Weight Loss, and Metabolism. Internal Medicine Alert. 2021. 43:1-3.	Intervention/Exposure; Publication status
7	Ahmad, Norliza, Shariff, Zalilah Mohd, Mukhtar, et al. Family-based intervention using face-to-face sessions and social media to improve Malay primary school children's adiposity: a randomized controlled field trial of the Malaysian REDUCE programme. Nutr J. 2018. 17:N.PAG-N.PAG. doi:10.1186/s12937-018-0379-1 .	Intervention/Exposure
8	Ainscough, KM, Kennelly, MA, Lindsay, et al. An observational analysis of meal patterns in overweight and obese pregnancy: exploring meal pattern behaviours and the association with maternal and fetal health measures. Ir J Med Sci. 2020. 189:585-594. doi:10.1007/s11845-019-02099-0 .	Outcome
9	Aizawa, M, Murakami, K, Takahashi, et al. Association between frequency of breakfast intake before and during pregnancy and infant birth weight: the Tohoku Medical Megabank Project Birth and Three-Generation Cohort Study. BMC Pregnancy Childbirth. 2023. 23:268. doi:10.1186/s12884-023-05603-8 .	Outcome
10	Aksungar, FB, Topkaya, AE, Akyildiz, et al. Interleukin-6, C-reactive protein and biochemical parameters during prolonged intermittent fasting. Ann Nutr Metab. 2007. 51:88-95. doi:10.1159/000100954 .	Intervention/Exposure
11	Aksungar, Fehime, Sarikaya, M, Coskun, et al. Comparison of intermittent fasting versus caloric restriction in obese subjects: A two year follow-up. Journal of Nutrition, Health & Aging. 2017. 21:681-685. doi:10.1007/s12603-016-0786-y .	Intervention/Exposure
12	Al-Ardhi, GH, Ibraheem, NJ, Al-Maamory, et al. Comparison of some physiological parameters determined by timing consumption of breakfast meal among adult women. Indian Journal of Forensic Medicine and Toxicology. 2021. 15:2394-2396. doi:10.37506/ijfmt.v15i3.15670 .	Study design; Intervention/Exposure
13	Albertson, AM, Affenito, SG, Bauserman, et al. The relationship of ready-to-eat cereal consumption to nutrient intake, blood lipids, and body mass index of children as they age through adolescence. J Am Diet Assoc. 2009. 109:1557-65. doi:10.1016/j.jada.2009.06.363 .	Intervention/Exposure
14	Aldhoon-Hainerová I, Hainer V, Zamrazilová H. Impact of dietary intake, lifestyle and biochemical factors on metabolic health in obese adolescents. *Nutr Metab Cardiovasc Dis*. 2017;27(8):703-710. doi:10.1016/j.numecd.2017.05.002	Study design
15	Alencar, MK, Beam, JR, McCormick, et al. Increased meal frequency attenuates fat-free mass losses and some markers of health status with a portion-controlled weight loss diet. Nutr Res. 2015. 35:375â€□383. doi:10.1016/j.nutres.2015.03.003 .	Outcome; Duration
16	Alexy, U, Wicher, M, Kersting, et al. Breakfast trends in children and adolescents: frequency and quality. Public Health Nutr. 2010. 13:1795-802. doi:10.1017/s1368980010000091 .	Intervention/Exposure; Outcome
17	Alhussain, MH, Macdonald, IA, Taylor, et al. Irregular meal-pattern effects on energy expenditure, metabolism, and appetite regulation: a randomized controlled trial in healthy normal-weight women. Am J Clin Nutr. 2016. 104:21-32. doi:10.3945/ajcn.115.125401 .	Outcome; Duration
18	Alinezhad-Namaghi, Maryam, Eslami, Saeid, Nematy, et al. Intermittent Fasting During Ramadan and Its Effects in Individuals With Metabolic Syndrome. Nutr Today. 2019. 54:159-164. doi:10.1097/NT.0000000000000351 .	Intervention/Exposure

	Citation	Rationale
19	Allirot X, Saulais L, Seyssel K, et al. An isocaloric increase of eating episodes in the morning contributes to decrease energy intake at lunch in lean men. *Physiol Behav*. 2013;110-111:169-178. doi:10.1016/j.physbeh.2013.01.009	Intervention/Exposure
20	Allirot, X, Seyssel, K, Saulais, et al. Effects of a breakfast spread out over time on the food intake at lunch and the hormonal responses in obese men. Physiol Behav. 2014. 127:37-44. doi:10.1016/j.physbeh.2014.01.004 .	Intervention/Exposure
21	Allison, KC, Hopkins, CM, Ruggieri, et al. Prolonged, Controlled Daytime versus Delayed Eating Impacts Weight and Metabolism. Curr Biol. 2021. 31:650-657.e3. doi:10.1016/j.cub.2020.10.092 .	Intervention/Exposure; Comparator
22	Almeneessier, A, Bahammam, A, Sharif, et al. The influence of intermittent fasting on the circadian pattern of melatonin while controlling for caloric intake, energy expenditure, light exposure, and sleep schedules: A preliminary report. Ann Thorac Med. 2017. 12:183-190. doi:10.4103/atm.ATM_15_17 .	Intervention/Exposure
23	Almeneessier, AS, BaHammam, AA, Alzoghaibi, et al. The effects of diurnal intermittent fasting on proinflammatory cytokine levels while controlling for sleep/wake pattern, meal composition and energy expenditure. PLoS One. 2019. 14:e0226034. doi:10.1371/journal.pone.0226034 .	Intervention/Exposure
24	Almoosawi, S, Prynne, CJ, Hardy, et al. Time-of-day and nutrient composition of eating occasions: prospective association with the metabolic syndrome in the 1946 British birth cohort. Int J Obes (Lond). 2013. 37:725-31. doi:10.1038/ijo.2012.103 .	Intervention/Exposure
25	Almoosawi, S, Prynne, CJ, Hardy, et al. 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. doi:10.1097/HJH.0b013e32835ecc06 .	Intervention/Exposure; Outcome
26	Alqaoud, N, Al-Jawaldeh, A, Al-Anazi, et al. Trend and Causes of Overweight and Obesity among Pre-School Children in Kuwait. Children (Basel). 2021. 8:. doi:10.3390/children8060524 .	Study design
27	Al-Rawi, N, Madkour, M, Jahrami, et al. Effect of diurnal intermittent fasting during Ramadan on ghrelin, leptin, melatonin, and cortisol levels among overweight and obese subjects: A prospective observational study. PLoS One. 2020. 15:e0237922. doi:10.1371/journal.pone.0237922 .	Intervention/Exposure
28	Alsharairi, NA, Somerset, SM. Skipping breakfast in early childhood and its associations with maternal and child BMI: a study of 2-5-year-old Australian children. Eur J Clin Nutr. 2016. 70:450-5. doi:10.1038/ejcn.2015.184 .	Intervention/Exposure; Outcome
29	Alviso-Orellana, C, Estrada-Tejada, D, Carrillo-Larco, et al. Sweetened beverages, snacks and overweight: findings from the Young Lives cohort study in Peru. Public Health Nutr. 2018. 21:1627-1633. doi:10.1017/s1368980018000320 .	Intervention/Exposure
30	Alwattar, AY, Thyfault, JP, Leidy, et al. The effect of breakfast type and frequency of consumption on glycemic response in overweight/obese late adolescent girls. Eur J Clin Nutr. 2015. 69:885-90. doi:10.1038/ejcn.2015.12 .	Outcome
31	Amosa, T, Rush, E, Plank, et al. Frequency of eating occasions reported by young New Zealand Polynesian and European women. Pac Health Dialog. 2001. 8:59-65.	Study design
32	Andersson I, Lennernäs M, Rössner S. Meal pattern and risk factor evaluation in one-year completers of a weight reduction program for obese men - the 'Gustaf' study. *J Intern Med*. 2000;247(1):30-38. doi:10.1046/j.1365-2796.2000.00569.x	Intervention/Exposure
33	Andrade, Lucia, Zazpe, Itziar, Santiago, et al. Ten-Year Changes in Healthy Eating Attitudes in the SUN Cohort. J Am Coll Nutr. 2017. 36:319-329. doi:10.1080/07315724.2016.1278566 .	Intervention/Exposure; Outcome
34	Andrews, Lisa. Daily Breakfast Brings Weight Loss. Communicating Food for Health. 2017. Pg. 7-8.	Study design
35	Antoni, R, Johnston, KL, Collins, et al. Intermittent v. continuous energy restriction: differential effects on postprandial glucose and lipid metabolism following matched weight loss in overweight/obese participants. Br J Nutr. 2018. 119:507-516. doi:10.1017/s0007114517003890 .	Intervention/Exposure
36	Antoni, R, Robertson, TM, Robertson, et al. A pilot feasibility study exploring the effects of a moderate time-restricted feeding intervention on energy intake, adiposity and metabolic physiology in free-living human subjects. J Nutr Sci. 2018. 7:. doi:10.1017/jns.2018.13 .	Intervention/Exposure
37	Arabshahi, S, Lahmann, PH, Hughes, et al. Dietary behaviours, weight loss attempts and change in waist circumference: 15-year longitudinal study in Australian adults. Asia Pac J Clin Nutr. 2017. 26:657-664. doi:10.6133/apjcn.062016.04 .	Intervention/Exposure
38	Arciero, PJ, Ormsbee, MJ, Gentile, et al. Increased protein intake and meal frequency reduces abdominal fat during energy balance and energy deficit. Obesity (Silver Spring). 2013. 21:1357-66. doi:10.1002/oby.20296 .	Outcome; Duration
39	Ardolino, Alyssa. Snacking Series: Do Snacks Lead to Weight Gain?. Food Insight. 2018. 3-3.	Study design

	Citation	Rationale
40	Arenaza L, Muñoz-Hernández V, Medrano M, et al. Association of Breakfast Quality and Energy Density with Cardiometabolic Risk Factors in Overweight/Obese Children: Role of Physical Activity. *Nutrients*. 2018;10(8):1066. Published 2018 Aug 10. doi:10.3390/nu10081066	Study design; Intervention/Exposure
41	Asghari, G, Yuzbashian, E, Mirmiran, et al. Prediction of metabolic syndrome by a high intake of energy-dense nutrient-poor snacks in Iranian children and adolescents. Pediatr Res. 2016. 79:697-704. doi:10.1038/pr.2015.270 .	Intervention/Exposure
42	Ashwell, M, Hunty, A. How does breakfast help manage bodyweight?. Nutrition Bulletin. 2012. 37:395-397. doi:10.1111/j.1467-3010.2012.01994.x .	Study design
43	Ask, AS, Hernes, S, Aarek, et al. Changes in dietary pattern in 15 year old adolescents following a 4 month dietary intervention with school breakfast--a pilot study. Nutr J. 2006. 5:33. doi:10.1186/1475-2891-5-33 .	Intervention/Exposure
44	Azadbakht, L, Haghighatdoost, F, Feizi, et al. Breakfast eating pattern and its association with dietary quality indices and anthropometric measurements in young women in Isfahan. Nutrition. 2013. 29:420-5. doi:10.1016/j.nut.2012.07.008 .	Study design
45	Özcan BA, Yeşilkaya B, Yaldiz N, Pehlivan M. Factors affecting diet quality in adolescents: the effect of sociodemographic characteristics and meal consumption. *Progress in Nutrition*. 2020;22(4):e2020094-e2020094. doi:https://doi.org/10.23751/pn.v22i4.10927	Study design
46	Bachman, JL, Phelan, S, Wing, et al. Eating frequency is higher in weight loss maintainers and normal-weight individuals than in overweight individuals. J Am Diet Assoc. 2011. 111:1730-4. doi:10.1016/j.jada.2011.08.006 .	Study design
47	Bailey, BW, Sullivan, DK, Kirk, et al. Dietary predictors of visceral adiposity in overweight young adults. Br J Nutr. 2010. 103:1702-5. doi:10.1017/s0007114509993771 .	Study design; Intervention/Exposure
48	Balieiro, LCT, Gontijo, CA, Marot, et al. Is chronotype associated with dietary intake and weight gain during pregnancy? A prospective and longitudinal study. Nutrition. 2022. 94:. doi:10.1016/j.nut.2021.111530 .	Intervention/Exposure
49	Ball, K, Brown, W, Crawford, et al. Who does not gain weight? Prevalence and predictors of weight maintenance in young women. Int J Obes Relat Metab Disord. 2002. 26:1570-8. doi:10.1038/sj.ijo.0802150 .	Intervention/Exposure
50	Bandín C, Scheer FA, Luque AJ, et al. Meal timing affects glucose tolerance, substrate oxidation and circadian-related variables: A randomized, crossover trial. *Int J Obes (Lond)*. 2015;39(5):828-833. doi:10.1038/ijo.2014.182	Intervention/Exposure; Comparator
51	Bantle, AE, Lau, KJ, Wang, et al. Time-restricted eating did not alter insulin sensitivity or Î²-cell function in adults with obesity: A randomized pilot study. Obesity (Silver Spring). 2023. 31 Suppl 1:108-115. doi:10.1002/oby.23620 .	Intervention/Exposure
52	Barba, G, Troiano, E, Russo, et al. Total fat, fat distribution and blood pressure according to eating frequency in children living in southern Italy: the ARCA project. Int J Obes (Lond). 2006. 30:1166-9. doi:10.1038/sj.ijo.0803257 .	Study design
53	Baron, KG, Reid, KJ, Kern, et al. Role of sleep timing in caloric intake and BMI. Obesity (Silver Spring). 2011. 19:1374-81. doi:10.1038/oby.2011.100 .	Intervention/Exposure
54	Barone Gibbs B, Kinzel LS, Pettee Gabriel K, Chang YF, Kuller LH. Short- and long-term eating habit modification predicts weight change in overweight, postmenopausal women: results from the WOMAN study. *J Acad Nutr Diet*. 2012;112(9):1347-1355.e2. doi:10.1016/j.jand.2012.06.012	Intervention/Exposure
55	Basdeki, ED, Argyris, AA, Efthymiou, et al. Systematic Breakfast Consumption of Medium-Quantity and High-Quality Food Choices Is Associated with Better Vascular Health in Individuals with Cardiovascular Disease Risk Factors. Nutrients. 2023. 15:. doi:10.3390/nu15041025 .	Study design
56	Basterra-Gortari FJ, Bes-Rastrollo M, Pardo-Fernández M, Forga L, Martinez JA, Martínez-González MA. Changes in weight and physical activity over two years in Spanish alumni. *Med Sci Sports Exerc*. 2009;41(3):516-522. doi:10.1249/MSS.0b013e318188607c	Intervention/Exposure
57	Batista-Jorge, GC, Barcala-Jorge, AS, Oliveira Dias, et al. Nutritional Status Associated to Skipping Breakfast in Brazilian Health Service Patients. Ann Nutr Metab. 2016. 69:31-40. doi:10.1159/000447363 .	Study design
58	Bawaked, RA, Gomez, SF, Homs, et al. Association of eating behaviors, lifestyle, and maternal education with adherence to the Mediterranean diet in Spanish children. Appetite. 2018. 130:279-285. doi:10.1016/j.appet.2018.08.024 .	Outcome
59	Beaudry, KM, Ludwa, IA, Thomas, et al. First-year university is associated with greater body weight, body composition and adverse dietary changes in males than females. PLoS One. 2019. 14:e0218554. doi:10.1371/journal.pone.0218554 .	Intervention/Exposure; Outcome
60	Beaulieu, K, Casanova, N, Oustric, et al. Matched Weight Loss Through Intermittent or Continuous Energy Restriction Does Not Lead To Compensatory Increases in Appetite and Eating Behavior in a Randomized Controlled Trial in Women with Overweight and Obesity. J Nutr. 2020. 150:623-633. doi:10.1093/jn/nxz296 .	Intervention/Exposure

	Citation	Rationale
61	Beaulieu, K, Oustric, P, Alkahtani, et al. Impact of Meal Timing and Chronotype on Food Reward and Appetite Control in Young Adults. Nutrients. 2020. 12:. doi:10.3390/nu12051506 .	Intervention/Exposure; Outcome
62	Beşoluk Ş. Association of dietary patterns with circadian preference, sleep and personality in high school students. *Biological Rhythm Research*. Published online January 17, 2018:1-13. doi:10.1080/09291016.2018.1427601	Study design; Outcome
63	Befort, CA, Stewart, EE, Smith, et al. Weight maintenance, behaviors and barriers among previous participants of a university-based weight control program. Int J Obes (Lond). 2008. 32:519-26. doi:10.1038/sj.ijo.0803769 .	Study design; Intervention/Exposure
64	Belderson, P, Harvey, I, Kimbell, et al. Does breakfast-club attendance affect schoolchildren's nutrient intake? A study of dietary intake at three schools. Br J Nutr. 2003. 90:1003-6. doi:10.1079/bjn20031011 .	Study design; Intervention/Exposure
65	Bellisle, F. Impact of the daily meal pattern on energy balance. Scandinavian Journal of Nutrition. 2004. 48:114-118. doi:10.1080/11026480410000454 .	Study design
66	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. 90:382-5. doi:10.1016/j.physbeh.2006.09.029 .	Outcome
67	Berendsen, M, Boss, M, Smits, et al. Chrono-Nutrition and Diet Quality in Adolescents with Delayed Sleep-Wake Phase Disorder. Nutrients. 2020. 12:. doi:10.3390/nu12020539 .	Intervention/Exposure
68	Berentzen, NE, Smit, HA, van Rossem, et al. Screen time, adiposity and cardiometabolic markers: mediation by physical activity, not snacking, among 11-year-old children. Int J Obes (Lond). 2014. 38:1317-23. doi:10.1038/ijo.2014.110 .	Intervention/Exposure
69	Berge, JericaM, Wall, Melanie, Hsueh, et al. The protective role of family meals for youth obesity: 10-year longitudinal associations. J Pediatr. 2015. 166:296-301. doi:10.1016/j.jpeds.2014.08.030 .	Intervention/Exposure
70	Berge, JM, MacLehose, RF, Loth, et al. Family meals. Associations with weight and eating behaviors among mothers and fathers. Appetite. 2012. 58:1128-35. doi:10.1016/j.appet.2012.03.008 .	Intervention/Exposure
71	Bernabe-Ortiz, A, Mendoza-Quispe, D, Jimenez, et al. Quantifying the childhood and adolescent overnutrition attributable to specific risk factors: The Young Lives Study in Peru. Pediatr Obes. 2023. 18:e13002. doi:10.1111/ijpo.13002 .	Intervention/Exposure
72	Bes-Rastrollo M, Basterra-Gortari FJ, Sánchez-Villegas A, Marti A, Martínez JA, Martínez-González MA. A prospective study of eating away-from-home meals and weight gain in a Mediterranean population: the SUN (Seguimiento Universidad de Navarra) cohort. *Public Health Nutr*. 2010;13(9):1356-1363. doi:10.1017/S1368980009992783	Intervention/Exposure
73	Bes-Rastrollo M, Sánchez-Villegas A, Gómez-Gracia E, Martínez JA, Pajares RM, Martínez-González MA. Predictors of weight gain in a Mediterranean cohort: the Seguimiento Universidad de Navarra Study 1. *Am J Clin Nutr*. 2006;83(2):362-395. doi:10.1093/ajcn/83.2.362	Study design; Intervention/Exposure
74	Beyerlein, A, Fahrmeir, L, Mansmann, et al. Alternative regression models to assess increase in childhood BMI. BMC Med Res Methodol. 2008. 8:59. doi:10.1186/1471-2288-8-59 .	Study design
75	Bhutani, S, vanDellen, MR, Cooper, et al. Longitudinal Weight Gain and Related Risk Behaviors during the COVID-19 Pandemic in Adults in the US. Nutrients. 2021. 13:. doi:10.3390/nu13020671 .	Study design; Outcome
76	Bhutani, S, Wells, N, Finlayson, et al. Change in eating pattern as a contributor to energy intake and weight gain during the winter holiday period in obese adults. Int J Obes (Lond). 2020. 44:1586-1595. doi:10.1038/s41366-020-0562-2 .	Intervention/Exposure
77	Bin Naharudin, MN, Yusof, A, Shaw, et al. Breakfast Omission Reduces Subsequent Resistance Exercise Performance. J Strength Cond Res. 2019. 33:1766-1772. doi:10.1519/jsc.0000000000003054 .	Outcome
78	Bjerre, N, Holm, L, Veje, et al. What happens after a weight loss intervention? A qualitative study of drivers and challenges of maintaining time-restricted eating among people with overweight at high risk of type 2 diabetes. Appetite. 2022. 174:106034. doi:10.1016/j.appet.2022.106034 .	Study design; Intervention/Exposure; Outcome
79	Black, MM, Papas, MA, Bentley, et al. Overweight adolescent African-American mothers gain weight in spite of intentions to lose weight. J Am Diet Assoc. 2006. 106:80-7. doi:10.1016/j.jada.2005.09.049 .	Intervention/Exposure
80	Bo, Liu, Hutchison, AmyT, Thompson, et al. Effects of Intermittent Fasting or Calorie Restriction on Markers of Lipid Metabolism in Human Skeletal Muscle. J Clin Endocrinol Metab. 2021. 106:e1389-e1399. doi:10.1210/clinem/dgaa707 .	Intervention/Exposure
81	Bo, S, De Carli, L, Venco, et al. Impact of snacking pattern on overweight and obesity risk in a cohort of 11- to 13-year-old adolescents. J Pediatr Gastroenterol Nutr. 2014. 59:465-71. doi:10.1097/mpg.0000000000000453 .	Study design

	Citation	Rationale
82	Bo, S, Fadda, M, Castiglione, et al. Is the timing of caloric intake associated with variation in diet-induced thermogenesis and in the metabolic pattern? A randomized cross-over study. Int J Obes (Lond). 2015. 39:1689â€1695. doi:10.1038/ijo.2015.138 .	Intervention/Exposure; Comparator
83	Bolze, C, Gray-Donald, K, Dugas, et al. Predictors of Weight Loss in Young Adults. Child Obes. 2015. 11:541-8. doi:10.1089/chi.2014.0160 .	Intervention/Exposure
84	Borg, P, Fogelholm, M, Kukkonen-Harjula, et al. Food selection and eating behaviour during weight maintenance intervention and 2-y follow-up in obese men. Int J Obes Relat Metab Disord. 2004. 28:1548-54. doi:10.1038/sj.ijo.0802790 .	Intervention/Exposure
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153	Dicken, SJ, Mitchell, JJ, Newberry Le Vay, et al. Impact of the COVID-19 Pandemic on Diet Behaviour Among UK Adults: A Longitudinal Analysis of the HEBECO Study. Front Nutr. 2021. 8:788043. doi:10.3389/fnut.2021.788043 .	Intervention/Exposure; Outcome
154	Domaszewski, P, Konieczny, M, Dybek, et al. Comparison of the effects of six-week time-restricted eating on weight loss, body composition, and visceral fat in overweight older men and women. Exp Gerontol. 2023. 174:112116. doi:10.1016/j.exger.2023.112116 .	Intervention/Exposure
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157	Dougkas, A, Minihane, AM, Givens, et al. Differential effects of dairy snacks on appetite, but not overall energy intake. Br J Nutr. 2012. 108:2274-85. doi:10.1017/s0007114512000323 .	Intervention/Exposure
158	Douglas, SM, Byers, AW, Leidy, et al. Habitual Breakfast Patterns Do Not Influence Appetite and Satiety Responses in Normal vs. High-Protein Breakfasts in Overweight Adolescent Girls. Nutrients. 2019. 11:. doi:10.3390/nu11061223 .	Intervention/Exposure
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170	Elinder, LS, Heinemans, N, Zeebari, et al. Longitudinal changes in health behaviours and body weight among Swedish school children--associations with age, gender and parental education--the SCIP school cohort. BMC Public Health. 2014. 14:640. doi:10.1186/1471-2458-14-640 .	Outcome
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214	Gabel, Kelsey, Varady, KristaA. Feasibility of Time-Restricted Eating. Obesity (19307381). 2020. 28:860-860. doi:10.1002/oby.22785 .	Study design; Intervention/Exposure
215	Gable, S, Chang, Y, Krull, et al. Television watching and frequency of family meals are predictive of overweight onset and persistence in a national sample of school-aged children. J Am Diet Assoc. 2007. 107:53-61. doi:10.1016/j.jada.2006.10.010 .	Intervention/Exposure
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217	Gage, R, Girling-Butcher, M, Joe, et al. The Frequency and Context of Snacking among Children: An Objective Analysis Using Wearable Cameras. Nutrients. 2020. 13:. doi:10.3390/nu13010103 .	Study design; Outcome
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246	Greene, LF, Malpede, CZ, Henson, et al. Weight maintenance 2 years after participation in a weight loss program promoting low-energy density foods. Obesity (Silver Spring). 2006. 14:1795-801. doi:10.1038/oby.2006.207 .	Intervention/Exposure
247	Greenhill, Claire. How effective is time-restricted eating for weight loss?. Nature Reviews Endocrinology. 2020. 16:677-677. doi:10.1038/s41574-020-00434-5 .	Study design; Intervention/Exposure
248	Gregori, D, Maffeis, C, Jahns, et al. Snacking and obesity: urgency of a definition to explore such a relationship. J Am Diet Assoc. 2007. 107:562-563. doi:10.1016/j.jada.2007.02.025 .	Study design; Publication status
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253	Gupta, CC, Centofanti, S, Dorrian, et al. Subjective Hunger, Gastric Upset, and Sleepiness in Response to Altered Meal Timing during Simulated Shiftwork. Nutrients. 2019. 11:. doi:10.3390/nu11061352 .	Intervention/Exposure; Outcome
254	Gur, EB, Turan, GA, Ince, et al. Effect of Ramadan fasting on metabolic markers, dietary intake and abdominal fat distribution in pregnancy. Hippokratia. 2015. 19:298-303.	Intervention/Exposure
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257	Haganes KL, Silva CP, Eyjólfsdóttir SK, et al. Time-restricted eating and exercise training improve HbA1c and body composition in women with overweight/obesity: A randomized controlled trial. *Cell Metab*. 2022;34(10):1457-1471.e4. doi:10.1016/j.cmet.2022.09.003	Intervention/Exposure
258	Hajna, S, Leblanc, PJ, Faught, et al. Associations between family eating behaviours and body composition measures in peri-adolescents: results from a community-based study of school-aged children. Can J Public Health. 2014. 105:e15-21. doi:10.17269/cjph.105.4150 .	Intervention/Exposure
259	Halkjaer J, Tjønneland A, Overvad K, Sørensen TI. Dietary predictors of 5-year changes in waist circumference. *J Am Diet Assoc*. 2009;109(8):1356-1366. doi:10.1016/j.jada.2009.05.015	Intervention/Exposure
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261	Harding, S, Teyhan, A, Maynard, et al. Ethnic differences in overweight and obesity in early adolescence in the MRC DASH study: the role of adolescent and parental lifestyle. Int J Epidemiol. 2008. 37:162-72. doi:10.1093/ije/dym252 .	Study design
262	Hart, CN, Jelalian, E, Raynor, et al. Early patterns of food intake in an adolescent weight loss trial as predictors of BMI change. Eat Behav. 2010. 11:217-22. doi:10.1016/j.eatbeh.2010.05.001 .	Intervention/Exposure
263	Hartman, TJ, Masters, M, Flanders, et al. Self-Reported Eating-Occasion Frequency and Timing are Reproducible and Relatively Valid in the American Cancer Society Cancer Prevention Study-3 Diet Assessment Substudy. J Nutr. 2023. 152:2827-2836. doi:10.1093/jn/nxac206 .	Study design; Outcome
264	Hassan, BK, Cunha, DB, da Veiga, et al. Changes in breakfast frequency and composition during adolescence: The Adolescent Nutritional Assessment Longitudinal Study, a cohort from Brazil. PLoS One. 2018. 13:e0200587. doi:10.1371/journal.pone.0200587 .	Outcome
265	Hatanaka, M, Hatamoto, Y, Tajiri, et al. An Earlier First Meal Timing Associate with Weight Loss Effectiveness in A 12-Week Weight Loss Support Program. Nutrients. 2022. 14:. doi:10.3390/nu14020249 .	Intervention/Exposure
266	Hatanaka, M, Hatamoto, Y, Tajiri, et al. An Earlier First Meal Timing Associates with Weight Loss Effectiveness in A 12-Week Weight Loss Support Program. Nutrients. 2022. 14:. doi:10.3390/nu14020249 .	Intervention/Exposure; Duplicate
267	He, M, Wang, J, Liang, et al. Time-restricted eating with or without low-carbohydrate diet reduces visceral fat and improves metabolic syndrome: a randomized trial. Cell reports. Medicine. 2022. 3:100777. doi:10.1016/j.xcrm.2022.100777 .	Intervention/Exposure
268	Hebestreit A, Börnhorst C, Barba G, et al. Associations between energy intake, daily food intake and energy density of foods and BMI z-score in 2-9-year-old European children [published correction appears in Eur J Nutr. 2014 Aug;53(5);1297-8]. Eur J Nutr. 2014;53(2):673-681. doi:10.1007/s00394-013-0575-x	Study design; Intervention/Exposure
269	Heden, TD, Liu, Y, Sims, et al. Meal frequency differentially alters postprandial triacylglycerol and insulin concentrations in obese women. Obesity (Silver Spring). 2013. 21:123-9. doi:10.1002/oby.20247 .	Outcome
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273	Hermenegildo-López Y, Donat-Vargas C, Sandoval-Insausti H, et al. A Higher Intake of Energy at Dinner Is Associated with Incident Metabolic Syndrome: A Prospective Cohort Study in Older Adults. *Nutrients*. 2021;13(9):3035. Published 2021 Aug 30. doi:10.3390/nu13093035	Intervention/Exposure
274	Hibi, M, Hari, S, Yamaguchi, et al. Effect of short-term increase in meal frequency on glucose metabolism in individuals with normal glucose tolerance or impaired fasting glucose: A randomized crossover clinical trial. Nutrients. 2019. 11:. doi:10.3390/nu11092126 .	Outcome
275	Hibi, M, Masumoto, A, Naito, et al. Nighttime snacking reduces whole body fat oxidation and increases LDL cholesterol in healthy young women. Am J Physiol Regul Integr Comp Physiol. 2013. 304:R94-r101. doi:10.1152/ajpregu.00115.2012 .	Intervention/Exposure; Comparator
276	Hoddy, KK, Kroeger, CM, Trepanowski, et al. Meal timing during alternate day fasting: Impact on body weight and cardiovascular disease risk in obese adults. Obesity (Silver Spring). 2014. 22:2524-31. doi:10.1002/oby.20909 .	Intervention/Exposure; Duration
277	Hoertel, HA, Will, MJ, Leidy, et al. A randomized crossover, pilot study examining the effects of a normal protein vs. high protein breakfast on food cravings and reward signals in overweight/obese "breakfast skipping", late-adolescent girls. Nutr J. 2014. 13:80. doi:10.1186/1475-2891-13-80 .	Outcome
278	Hohman, EE, Balantekin, KN, Birch, et al. Dieting is associated with reduced bone mineral accrual in a longitudinal cohort of girls. BMC Public Health. 2018. 18:1285. doi:10.1186/s12889-018-6206-y .	Intervention/Exposure; Outcome
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280	Holmstrup, ME, Owens, CM, Fairchild, et al. Effect of meal frequency on glucose and insulin excursions over the course of a day. e-SPEN. 2010. 5:e277-e280. doi:10.1016/j.eclnm.2010.10.001 .	Outcome
281	Hopkins, LC, Sattler, M, Steeves, et al. Breakfast Consumption Frequency and Its Relationships to Overall Diet Quality, Using Healthy Eating Index 2010, and Body Mass Index among Adolescents in a Low-Income Urban Setting. Ecol Food Nutr. 2017. 56:297-311. doi:10.1080/03670244.2017.1327855 .	Study design
282	Huang, SX, Fu, YX, Wang, et al. Effects of breakfast with different calorigenic amounts on blood glucose, insulin and glucagon levels. J Zhejiang Univ Sci. 2003. 4:753-5. doi:10.1631/jzus.2003.0753 .	Outcome; Country
283	Hunsberger M, Mehlig K, Börnhorst C, et al. Dietary Carbohydrate and Nocturnal Sleep Duration in Relation to Children's BMI: Findings from the IDEFICS Study in Eight European Countries. *Nutrients*. 2015;7(12):10223-10236. Published 2015 Dec 8. doi:10.3390/nu7125529	Study design
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401	Martínez-Lozano N, Tvarijonaviciute A, Ríos R, Barón I, Scheer FAJL, Garaulet M. Late Eating Is Associated with Obesity, Inflammatory Markers and Circadian-Related Disturbances in School-Aged Children. *Nutrients*. 2020;12(9):2881. Published 2020 Sep 21. doi:10.3390/nu12092881	Intervention/Exposure; Comparator
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432	Mok A, Haldar S, Lee JC, Leow MK, Henry CJ. Postprandial changes in cardiometabolic disease risk in young Chinese men following isocaloric high or low protein diets, stratified by either high or low meal frequency - a randomized controlled crossover trial. *Nutr J*. 2016;15:27. Published 2016 Mar 15. doi:10.1186/s12937-016-0141-5	Outcome
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439	Moro, T, Tinsley, G, Pacelli, et al. Twelve Months of Time-restricted Eating and Resistance Training Improves Inflammatory Markers and Cardiometabolic Risk Factors. Med Sci Sports Exerc. 2021. 53:2577-2585. doi:10.1249/mss.0000000000002738 .	Intervention/Exposure
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444	Mouchacca, J, Abbott, GR, Ball, et al. Associations between psychological stress, eating, physical activity, sedentary behaviours and body weight among women: a longitudinal study. BMC Public Health. 2013. 13:828. doi:10.1186/1471-2458-13-828 .	Intervention/Exposure
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446	Muñoz JSG, Cañavate R, Hernández CM, Cara-Salmerón V, Morante JJH. The association among chronotype, timing of food intake and food preferences depends on body mass status. Eur J Clin Nutr. 2017;71(6):736-742. doi:10.1038/ejcn.2016.182	Intervention/Exposure
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463	Neve, MJ, Morgan, PJ, Collins, et al. Behavioural factors related with successful weight loss 15 months post-enrolment in a commercial web-based weight-loss programme. Public Health Nutr. 2012. 15:1299-309. doi:10.1017/s1368980011003090 .	Study design
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471	Oellingrath, IM, Svendsen, MV, Brantsaeter, et al. Tracking of eating patterns and overweight - a follow-up study of Norwegian schoolchildren from middle childhood to early adolescence. Nutr J. 2011. 10:106. doi:10.1186/1475-2891-10-106 .	Intervention/Exposure
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483	Péneau, S, Thibault, H, Meless, et al. Anthropometric and behavioral patterns associated with weight maintenance after an obesity treatment in adolescents. J Pediatr. 2008. 152:678-84. doi:10.1016/j.jpeds.2007.09.053 .	Study design; Intervention/Exposure
484	Pachucki, MA. Food pattern analysis over time: unhealthful eating trajectories predict obesity. Int J Obes (Lond). 2012. 36:686-94. doi:10.1038/ijo.2011.133 .	Intervention/Exposure
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486	Papageorgiou M, Biver E, Mareschal J, et al. The effects of time-restricted eating and weight loss on bone metabolism and health: a 6-month randomized controlled trial. *Obesity (Silver Spring)*. 2023;31 Suppl 1(Suppl 1):85-95. doi:10.1002/oby.23577	Intervention/Exposure
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562	Shatenstein, B, Nadon, S, Ferland, et al. Determinants of diet quality among Quebecers aged 55-74. J Nutr Health Aging. 2004. 8:83-91.	Study design; Outcome
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567	Siega-Riz, AM, Herrmann, TS, Savitz, et al. Frequency of eating during pregnancy and its effect on preterm delivery. Am J Epidemiol. 2001. 153:647-52. doi:10.1093/aje/153.7.647 .	Study design; Outcome
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570	Simon, SL, Pan, Z, Marden, et al. Body mass index and variability in meal duration and association with rate of eating. Front Nutr. 2022. 9:941001. doi:10.3389/fnut.2022.941001 .	Study design; Intervention/Exposure
571	Singh, RB, Cornelissen, G, Mojto, et al. Effects of circadian restricted feeding on parameters of metabolic syndrome among healthy subjects. Chronobiol Int. 2020. 37:395â€402. doi:10.1080/07420528.2019.1701817 .	Intervention/Exposure; Comparator
572	Sitzman, K. Express speak. Eating breakfast helps sustain weight loss. AAOHN Journal. 2006. 54:136-136. doi:10.1177/216507990605400307 .	Study design
573	Skinner, JD, Ziegler, P, Pac, et al. Meal and snack patterns of infants and toddlers. J Am Diet Assoc. 2004. 104:s65-70. doi:10.1016/j.jada.2003.10.021 .	Study design
574	Skoczek-Rubińska A, Muzsik-Kazimierska A, Chmurzynska A, Walkowiak PJ, Bajerska J. Snacking may improve dietary fiber density and is associated with a lower body mass index in postmenopausal women. Nutrition. 2021;83:111063. doi:10.1016/j.nut.2020.111063	Study design
575	Slomski, A. Adding Time-Restricted Eating to Caloric Restriction for Weight Loss. Jama. 2022. 327:1950. doi:10.1001/jama.2022.8018 .	Study design
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578	Soini, S, Mustajoki, P, Eriksson, et al. Weight loss methods and changes in eating habits among successful weight losers. Ann Med. 2016. 48:76-82. doi:10.3109/07853890.2015.1136428 .	Study design; Outcome
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583	Stennett, M, Blokland, A, Watt, et al. Mid-adolescent ethnic variations in overweight prevalence in the UK Millennium Cohort Study. Eur J Public Health. 2021. 31:396-402. doi:10.1093/eurpub/ckab023 .	Study design; Intervention/Exposure
584	Stockman, NK, Schenkel, TC, Brown, et al. Comparison of energy and nutrient intakes among meals and snacks of adolescent males. Prev Med. 2005. 41:203-10. doi:10.1016/j.ypmed.2004.11.001 .	Study design
585	St-Onge, MP, Pizinger, T, Kovtun, et al. Sleep and meal timing influence food intake and its hormonal regulation in healthy adults with overweight/obesity. Eur J Clin Nutr. 2019. 72:76-82. doi:10.1038/s41430-018-0312-x .	Intervention/Exposure
586	Stote, KS, Baer, DJ, Spears, et al. A controlled trial of reduced meal frequency without caloric restriction in healthy, normal-weight, middle-aged adults. Am J Clin Nutr. 2007. 85:981â€988. doi:10.1093/ajcn/85.4.981 .	Intervention/Exposure; Duration

	Citation	Rationale
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