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Review article

Breakfast and behavior in morning tasks: Facts or fads?

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ABSTRACT

Background: Most of the studies investigating the effects of breakfast on cognitive performance have compared performance in subjects who have or have not consumed this meal. However, characteristics of breakfast itself may influence mental abilities. Moreover, as far as the positive effects of having breakfast is more evident, research may focus on the specific characteristics of an adequate breakfast.

Methods: To update an existing systematic review, published at the beginning of 2014, on the role of nutrient composition and/or energy intake at breakfast on the accomplishment of school-related tasks and cognition, we carried out a systematic review of the literature through PUBMED database.

Results: From the literature search, we identified 39 papers, of which 2 were eligible according to our inclusion criteria. Both the selected papers concerned randomized crossover studies on the acute effect of breakfast carried out in a school setting in the United Kingdom. Both studies compared 2 iso-energetic breakfasts with a similar macronutrient composition; however, the alternative breakfasts were meant to differ in terms of glycemic index or glycemic load. The effects of breakfast composition were investigated on memory, attention, and information processing in both studies. However, different tests and subdomains were considered.

Limitations: Studies on these issues are still inconsistent and quantitatively insufficient to draw firm conclusions.

Conclusions: While the hypothesis of a better mental performance with breakfast > 20% daily energy intake still needs confirmation, there does appear to be extra evidence that a lower postprandial glycemic response is beneficial to mental performance.

1. Introduction

More than two years have passed since the publication of our systematic review collecting evidence on the role of the amount of energy intake at breakfast and breakfast composition on various measures of cognitive/academic performance (Edefonti et al., 2014). Since then, there has been a growing interest on the several possible dimensions of the relation between breakfast and cognition. This is, in particular, witnessed by the publication of two very recent systematic reviews in the Supplement of the same number of Advances in Nutrition (Adolphus et al., 2016; Galioto and Spitznagel, 2016).

Both the reviews are still dedicated in part to consolidate the available results on the acute effects of breakfast compared with the 'no breakfast' option. In accordance with previous literature, their main conclusions are, indeed, that breakfast has generally a short-term positive, domain-specific effect on cognitive function – measured within a few hours post ingestion – in healthy children/adolescents (Adolphus et al., 2016) and adults (Galioto and Spitznagel, 2016). In detail, there is general agreement that memory domain benefits from having breakfast - as compared to fasting – whereas results on attention and executive functions are apparently different in children/adolescents and adults (Adolphus et al., 2016; Galioto and Spitznagel, 2016).

Moreover, both the reviews have recognized the attention dedicated in the literature to the relation between breakfast composition and cognitive/academic performance, as initially suggested by Dye et al. (Dye et al., 2000) for any eating occasion and, more recently, by our review on breakfast only (Edefonti et al., 2014). However, they did not deal with the (possibly independent) role of energy intake from breakfast in short-term mental processes. In addition, the two mentioned reviews (Adolphus et al., 2016; Galioto and Spitznagel, 2016) and ours (Edefonti et al., 2014) differ with respect to several inclusion/exclusion criteria, including the type of breakfast manipulation (acute/chronic, experimental or not), the inclusion of laboratory-developed

Abbreviations: BF, breakfast; CHO, carbohydrate; CH=, cholesterol; d=, day; EI=, energy intake; F=, females; GI, glycemic index; GL=, glycemic load; h, hour; min, minutes; M, males; N=, no; P, protein; RAG=, rapidly available glucose; s=, seconds; SAG, slowly available glucose; Y=, yes; y, year

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macronutrient manipulations, the type of comparison (breakfast *vs* fasting, energy at breakfast, breakfast composition), the duration of the overnight fasting period allowed, and the target subpopulation of the analysis. For this reason, the overlapping between the selected studies is minimal. Finally, the indicated databases were searched until July 2014 (Adolphus et al., 2016) and May 2015 (Galioto and Spitznagel, 2016).

The aim of the present paper is to provide an updated systematic review of the role of nutrient composition and/or energy intake at breakfast on objective cognitive/academic performance outcomes from any kind of studies in children, adolescents, and adults. Although it is still unclear whether breakfast is a determinant or a short-term indicator of cognitive performance, these issues may have important consequences in the definition of public health guidelines and in the assessment of the nutritional, educational and economic value of school breakfast programs (Ells et al., 2008).

2. Methods

2.1. Literature search

We updated our previously published systematic review (Edefonti et al., 2014) with a more recent systematic search through MEDLINE *via* PubMed (http://www.ncbi.nlm.nih.gov/pubmed/) to identify all the articles on the relationship between cognitive/academic/school performance and breakfast composition/energy intake published as full texts in English from January 1st, 2013, up to May 31st, 2016, based on the following original string *(breakfast OR "breakfast composition" OR "daily meal distribution") & ("energy intake" OR "energy contribution" OR "energy expenditure" OR quality OR energy OR skipping OR "glycemic index") & ("intellectual performance" OR "neuro-performance" OR "mental performance" OR "cognitive performance" OR "academic performance" OR "school performance" OR performance)*", following the guidelines from the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) group (Moher et al., 2009). Two authors (F.B. and V.E.) independently reviewed the papers and carried out the selection. The reference lists of the selected articles and of other systematic reviews focusing on similar topics were also examined to identify other relevant papers, if any. Discrepancies in article selection were resolved by involving a third author (M.F.).

2.2. Inclusion and exclusion criteria

Briefly, papers were included or excluded according to the following criteria.

2.2.1. Participants

Studies involving children, adolescents or adults of either sex were included. We did not include studies on subjects with acquired metabolic disorders (such as hyperlipidemia, or type-2 diabetes).

2.2.2. Breakfast definition

Breakfast was defined according to the descriptions provided in the papers. Although these varied, breakfast was generally considered as the first food/meal of the day, though some interventions did not provide explicit control for previous food consumption. Studies comparing different breakfast types were included. Studies comparing breakfast and "no breakfast" options were not included, unless when different breakfast options, with specified energy or composition, were compared. Studies were included no matter of the content of the meal. However, we excluded those studies where breakfast options differed by the presence/absence of coffee only. In addition, studies investigating the role of glucose-based or emulsion-based manipulations (including formula milk, foam like vanilla creams, gelatins resembling milkshakes in consistency, and spoonable creams) were not included. Studies considering intakes at other mealtimes were excluded, unless when the separate effect of different breakfast options during the morning was clearly reported.

2.2.3. Outcome measures

Studies that assessed any outcome of objectively measured of cognitive, academic (school grades and standardized achievement tests) and school (enrollment, attendance, achievement, in-class behavior and behavior at school, and school drop-out) performance were considered. Acute (=performance assessed within 12 h of breakfast consumption) and chronic effects of breakfast manipulations (typically, through school breakfast programs) were included. When reported, we included the name of the adopted cognitive test, as well as the corresponding psychological construct assessed. Otherwise, we simply reported the specific neurocognitive construct.

2.2.4. Exposure measures

2.2.4.1. Energy intake at breakfast. Studies providing quantitative estimates of total energy intake for different breakfast options, including either absolute intakes or percentages of daily energy intake provided by breakfast, were included. Studies based on standardized breakfast options with a fixed quantitative estimate of energy intake were excluded. Information on energy intake at breakfast was consistently expressed in kilocalories throughout the paper.

2.2.4.2. Breakfast composition. Studies providing quantitative estimates of the macronutrient composition of different breakfast options were considered. This included breakfast meals standardized for energy supply. When the authors stated in the papers that the considered breakfast options were iso-energetic or similar in energy intake, we reported this information in the tables. When the difference in energy content between treatments was higher than 10% and it was possible to distinguish the energy intake associated to each effect in the statistical models, we included the corresponding article in the analysis concerning energy intake at breakfast, too. We did not include studies assessing the relationship between cognition and the interaction between macronutrient composition of the breakfast and glucose tolerance, as there was no possibility to assess the separate effect of breakfast composition.

2.2.5. Association between exposure and outcome measures

Studies considering any kind of relationship between cognition/academic performance and energy intake at breakfast or breakfast composition were included. This included results obtained from different statistical approaches, including simpler tests and confidence intervals, correlation analysis, multiple regression models, and multivariate repeated measures ANOVA.

Finally, we decided not to exclude studies on the basis of their quality, because of their limited number and of the high variation in the adequacy of descriptions provided.

2.3. Data extraction

Information extracted included: 1. General characteristics of the studies (first author and year of publication, country, sponsorship, number/age of the participants, distribution by gender, inclusion/exclusion criteria, and study setting); 2. Design and characteristics of the intervention, and presence of any school program in support of it (type of design, randomization, counterbalancing and crossover details, when available, number of days of observation and schedule, information on the dinner the night before and on explicitly stated overnight fast, schedule of the breakfast); 3. Breakfast definition: list of the breakfast options and corresponding details on absolute/relative values