

Review Article

THE COGNITIVE EFFECTS OF BREAKFAST ON ACADEMIC PERFORMANCE IN HIGH SCHOOL STUDENTS: A REVIEW

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ABSTRACT

Introduction: The justification for this work was the fact that breakfast is recognized as the most important meal of the day, both for being an indispensable ally for the availability of nutrients and for contributing to the synthesis of neurotransmitters, which in turn are essential for the proper functioning of the central nervous system. This way, breakfast is believed to be favorable in terms of cognitive, impacting directly the academic performance in school-age children and adolescents. Therefore, this literature review intends to discuss and to a better understanding of the relationship between breakfast and school performance in adolescents. **Objective:** The objective of the study was to establish the cognitive effects of breakfast intake on academic performance in adolescents. **Methodology:** This article presents a narrative review of the literature based on the analysis of scientific articles published from 2010 to 2022 on PubMed, on breakfast and its association with cognitive performance on students. Two criterias were applied, titles that did not mention the thematic association between breakfast and cognitive performance and articles not written in English. After the application of the exclusion, 21 articles remained. **Discussion:** Indeed, children have a higher metabolic action of cerebral glucose than adults. The longer nocturnal fasting interval due to the greater need for sleep during childhood and adolescence favors the depletion of glycogen stores at night. Therefore, breakfast is essential for a continuous supply of energy to maintain this high metabolic rate, which has a very important role in the scholarly period, as the energy demand of several brain functions is greater. Thus, the first meal of the day can or cannot have domain-specific effects on areas of cognition, such as memory, attention, executive function, language and creativity. **Conclusion:** This study discussed the relation between the cognitive effects of breakfast and academic performance. Overall, it was evidenced that the habit of ingesting the first meal of the day has contributions to cognitive performance, it is worth highlighting the attention and the executive function. The sum of studies on such processes provides an explanation, although not yet completely clarified, of how breakfast affects the domain of language, learning, and memory.

Keywords: breakfast, cognitive, adolescents, and academic performance.

INTRODUCTION

Breakfast is recognized as the most important meal of the day and is often chosen as an indispensable ally for maintaining a healthy diet, as it provides a greater diversity of nutrients, including vitamins A, E, C, B6, and B12, iron, calcium, phosphorus, magnesium, potassium and dietary fiber, which would rarely be compensated for in other meals (1-5) Thus, when compared, those who skip this meal are less likely to meet the daily recommendation for a food group, such as vegetables and fruits (6). In addition, the habit of consuming breakfast favors the maintenance of an adequate body mass index (BMI) (7), since this practice leads to lower total fat and cholesterol (1). It is also observed that children have a higher metabolic action of cerebral glucose than adults (8). The longer nocturnal fasting interval due to the greater need for sleep during childhood and adolescence favors the depletion of glycogen stores at night. Therefore, breakfast is essential for a continuous supply of energy to maintain this high metabolic rate (9,10), in addition to providing nutrients necessary for the synthesis of monoamine neurotransmitters, which in turn are essential for the proper functioning of the central nervous system (9,11,12,13).

Indeed, breakfast is believed to be favorable in terms of behavior, cognitive and academic performance in school-age children and adolescents (11,14). Several studies reveal a positive result of breakfast compared to no breakfast, a fact that can be seen by an improvement in behavior while performing tasks in class (11,9). Furthermore, the benefits were most notably seen in children considered malnourished (9). However, the effects change along with the cognitive domain, the most explicit being those referring to memory and the occurrence of fewer errors during attention tasks, especially at the end of the morning, as performance decreases become more visible among fasting children and adolescents (11,15). However, breakfast is especially the most disregarded meal by young people (9), being more explicit in female students, adolescents, older children, and children from lower socioeconomic backgrounds (11,16,17,18), among the reasons for omitting this meal, including lack of time, not feeling hungry in the morning and concerns about weight (19). Skipping breakfast compromises attention and episodic memory for the specific morning it was eaten, indicating that the benefits are short-term (20,21). Since such immediate effects can contribute to academic performance, the habitual and regular consumption of this meal becomes extremely important (20). Given this cited and supported information, it can be said that breakfast is the most important meal of the day, not only for its comprehensive supply of nutrients but also for its contribution to the cognitive and academic performance of young people in school. The regular habit

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of eating breakfast as opposed to irregular consumption and fasting has shown beneficial results, such as increased attention, concentration, memory, and improved behavior in class, given that its effects are potentially manifested soon after eating. Therefore, this literature review objective is to discuss and contribute to a better understanding of the relationship between breakfast and academic performance in children and adolescents.

METHODS

A narrative literature review was performed based on the analysis of scientific articles published from 2010 to 2022 on PubMed (**figure 1**). In the database, 261 articles were found by the combination "effects" AND "cognition" AND "breakfast". 173 articles were selected after the first set of criteria - exclusion of titles not included in the research period 2010-2022, also articles not written in English. The second set of criteria was applied, which was based on the exclusion of titles that did not have "cognitive effects associated with breakfast" or "breakfast associated with academic performance", from which 145 articles were excluded. In total, 21 articles remained.

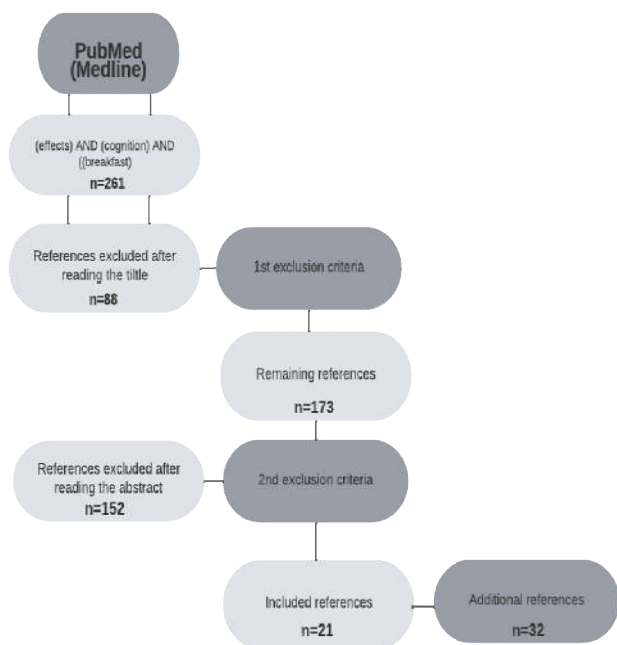


Figure 1. Articles addressing breakfast effect, behavior, academic performance, children and adolescents.

LEARNING AND MEMORY

The first meal of the day can have domain-specific effects on areas of cognition such as memory (22). Memory consolidation is a primary function that is related to the medial temporal regions of the brain, including the hippocampal formation, which is recognized to be vulnerable to hypoglycemia (23). The effect of glucose deprivation is noticeable by the drop in its basal concentrations in the blood, as in the interval of ten to twelve hours during dinner and breakfast. Therefore, it is possible that better memory performance after the first meal of the day reflects the resolution of reduced fasting glucose levels that are affecting hippocampal function (24, 25). Indeed, four studies examined immediate recall, which is based on the analysis of learning and the encoding of new information as task requirements. Of these studies, two did not obtain positive information on the effects of breakfast on immediate memory for learning tasks (26, 27). In contrast, the other two who tested healthy subjects demonstrated benefits of breakfast on immediate memory (28, 29). In one of these studies (29), the dose-response profile was tested in thirty subjects -

young and healthy adults - for the memory tasks, based on the administration of 25g of glucose after a few hours of fasting. The results in terms of advances in memory performance, significant facilitation in spatial work, immediate and delayed free recall, and learning were significant and confirmed the thesis that 25g of glucose is the ideal dose to present a significant improvement in memory tasks and learning for younger people (23). Thus, there were no clear and precise benefits of breakfast in the memory domains. The volatility of the tasks employed and the number of studies showing benefits and equivalence precludes a conclusion about the effects of breakfast on immediate memory.

ATTENTION

Attention is a behavioral and cognitive process of selectively concentrating on a discrete informational aspect, whether subjective or objective, ignoring other noticeable information (23). This way, attention performs a critical process on the dynamic stabilization of perceptual and cognitive learning, which have a very important role in the scholarly period, as the energy demand of several brain functions, including maintaining attention during class, is greater (30,31). A study performed a systematic review, expressing the acute cognitive effects of breaking the fast when consuming breakfast (23). It was analyzed several attention aspects, such as the attention capacity, the accuracy of attention in tests based on the sequence of repeated digits, the vigilance and focus, needed to maintain the attention during the time and, with this, detect target stimuli to ignore distractions, processing speed, ability to process information, and, finally, the execution of relevant operations during the determined time. Of the total of 6 studies that analyzed attention capacity, none showed a disadvantage, but only 2 (32.33) implied benefits. Of about 7 works that evaluated vigilance and focus, only 3 demonstrated advantages (34-36). Of the processing speed, of 10 studies, 3 were advantageous (37-39) and 1 was disadvantageous (40). Furthermore, another article performed an international study with a sample of 234 individuals, females and males, with 11-13 years, which compared children who consumed breakfast (ready cereals and milk) with those who did not. The results of this study showed benefits of the morning meal in sustained visual attention, evidenced by a greater number of correct answers, measured by the "RVIP task". In this context, the findings indicated that habitual consumption of the first meal of the day favors the ability to sustain attention over time, select relevant information and ignore unimportant ones (41).

EXECUTIVE FUNCTION

The executive functions are thinking abilities that contribute to reasoning, planning, problem-solving, and life management (23). The areas of the brain that underlie such skills are interconnected and influenced by activity in many different brain fields. Besides, higher-order executive functions are correlated with the frontal systems of the brain and the prefrontal cortex in particular (23). It is known that there are three main executive functions: inhibitory control, reasoning/planning, and working memory (42). The working memory is an important central executive function of children's education because is connected to a wide range of developmental changes, arithmetic and reading skills, emotion regulation, and academic accomplishment. Thus, the development of working memory early in life plays a critical role in long-term school and social competence (23). Several studies with children and adults showed that the abilities of executive functions- especially the working memory- could be improved. The idea that we can increase our ability to perform executive functions in ways that matter in our daily lives is far less established but seems to be a realistic possibility.

Three studies observed the effect of the macronutrients the macronutrient composition on working memory tasks, with different comparisons and disparate results. One of them demonstrated an advantage after the consumption of protein foods and a disadvantage after ingestion of carbohydrates (38). In the second study, it was verified that individuals who consumed foods rich in carbohydrates, to the detriment of those who ate foods with balanced compositions of carbohydrates and proteins, obtained greater precision, but with lower speed, in executive tasks (33). However, in the third study, it was evaluated that the performance was more beneficial on a high-fat diet than on a carbohydrate-protein diet (43). In addition, an examination of executive functions using manipulation of the glycemic index (GI) was performed and concluded that working memory performance was advantageous after a low GI breakfast (44). The domain of executive function has rarely been examined and studies focus on the assessment of working memory, however, different findings in the context of methodologies preclude conclusions (23).

LANGUAGE

Language is, fundamentally, a system of connections sound-meaning (45), which is performed by a language faculty that generates internal representations and maps them on the sensorimotor interface and the conceptual-intentional interface. Only from the language, do we learn what is typical and important to the comprehension and many situations. Therefore, language and cognition are separate mind mechanisms and closely related, as they evolve together in ontological development and learning (46). Given this viewpoint, 4

studies examined the language abilities comparing those who consumed breakfast and those who didn't, and the results were extensively ambiguous (23). Especially, 3 of them evaluated the verbal fluency, which corresponds to the word's oral production that fitted a specific category (semantic fluency), for example, animals, or that started with a specific letter (phonemic fluency), and 2 of them didn't establish a difference between the glucose drinks consumed, in the morning, the phonemic fluency (46) or the semantic fluency (47), however, the third study found an improvement tendency after the ingestion. The fourth study demonstrated that there weren't any effects in a semantic processing task by ingesting a cereal bar with the first meal (49). Accordingly, based on the reviewed articles it wasn't possible to ensure any meaningful alterations in language activity performance after breakfast consumption.

CREATIVITY

Creativity is a complex which involves a dynamic interaction between different brain and sensory modalities, such as visual, auditory, gustatory, olfactory, and tactile. This way, the creative process depends on the capacity to combine existing mental representations in new manners and to use, in a flexible way, the connections between the arbitrary constituents of an experience, such as cognitive functions being supported by the hippocampus, which, among the regions of the brain susceptible to modulation by diet, is particularly sensitive, possibly due to its high metabolic demand (50).making this meal indispensable, as fiber intake rates would hardly be offset in subsequent meals (1,51, 52, 53).

ACUTE EFFECT OF BREAKFAST vs. NO BREAKFAST				
COGNITIVE DOMAIN	TOTAL STUDIES	ADVANTAGE OF BREAKFAST	NO EFFECT	ADVANTAGE OF NO BREAKFAST
memory	4	2	2	0
attention	25	9	15	1
executive fuction	4	4	0	0
language	4	0	4	0
creativity	1	1	0	0

Figure 2. Acute effect of breakfast and no breakfast.

Cognitive Domains	Description	Authors
Language	Oral production of words fitting a specified category (e.g., animals) or beginning with a specified letter	Rachel Galioto e Mary Beth Spitznagel
Memory	Ability to accurately recognize learned visual and verbal information	Rachel Galioto e Mary Beth Spitznagel
Executive Function (working memory)	Allows information maintained in temporary storage to be manipulated for complex cognitive operations	Rachel Galioto e Mary Beth Spitznagel
Attention	Sustaining attention over time to detect target stimuli, often with a demand to ignore distractors. And ability to process information and execute relevant operations within the allotted time	Rachel Galioto e Mary Beth Spitznagel

Figure 3. Cognitive domains and description.

CONCLUSION

The article discussed the relationship between the habit of consuming breakfast and its effects on cognitive development. In front of the existing literature, it was evidenced that the habit of ingesting the first meal of the day has contributions to cognitive performance, it is worth highlighting the attention and the executive function. Therefore, this association is responsible for a better academic performance of children and adolescents, in addition to contributing to health, opting for a healthy diet, due to the availability of nutrients in the morning meal, and aiding in maintaining a convenient body mass index. From this perspective, it is very important to have the knowledge of the positive impact of the regular habit of eating breakfast, especially in invidious who are around school age, given that this group has a rapid growth period, the complexity of the academic work and tendency of skipping the first meal daily. Given this panorama, it is necessary for a greater number of researches focusing on adolescents, analyzing the regular ingestion of breakfast and its cognitive effects associated.

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Conflict of interest

The authors declare that they have no conflicts of interest. All authors read and approved the final manuscript.

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