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The Academic Impact of Eating Well: Biological and Behavioural Evidence

Beatriz Vilela Pacheco[1], Luiza Cristina Godim Domingues Dias[2]

[1]Faculdade de Ciências da Nutrição e da Alimentação da Universidade do Porto, Rua do Campo Alegre, n° 823, 4150-180, Porto, Portugal.

[2]Instituto de Biociências da Universidade Estadual Júlio de Mesquita, Distrito de Rubião Júnior, 18618-970, Botucatu, São Paulo, Brasil.

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Corresponding Author:
Luiza Cristina Godim Domingues Dias

ABSTRACT

Background: Academic performance is strongly influenced by cognitive, emotional and behavioural factors, many of which are affected by nutrition. Although many studies have reported positive links between dietary behaviours and academic success, the biological and behavioural mechanisms behind these effects have not been sufficiently explored.

Objective: This narrative review aims to summarise the current evidence on the biological and behavioural mechanisms linking breakfast consumption, diet quality and diversity, and adherence to the Mediterranean diet to academic performance in people of all ages.

Methods: A comprehensive literature search was conducted in PubMed, Web of Science, Scopus and Google Scholar. Keywords related to dietary behaviours, cognitive function, and academic outcomes were used. Studies were included if they provided mechanistic insights into the links between nutrition and cognitive or behavioural processes relevant to academic success.

Results: Consuming breakfast regularly supports cognitive performance by regulating glucose metabolism, improving attention and memory, and promoting classroom engagement - particularly when meals include low-glycaemic index foods, protein, and fiber. A high-quality, diverse diet enhances neurodevelopment by improving nutrient intake, neurotransmitter function, and emotional regulation. The Mediterranean diet, which is rich in anti-inflammatory and neuroprotective compounds, supports synaptic plasticity and higher-order cognitive function, while also fostering behavioural stability and well-being. Together, these dietary behaviours influence the brain physiology and behavioural patterns that are essential for academic success.

Conclusion: Nutrition plays a central role in academic achievement by impacting brain function and behaviour. Public health strategies should promote regular breakfast consumption, diverse and balanced meals, and adherence to the Mediterranean diet as part of a broader lifestyle approach. Governments should provide free, nutritious meals for all students to enable them to thrive cognitively, emotionally and academically.

INTRODUCTION

Optimal academic performance relies on a complex interplay of cognitive, emotional and behavioural factors, many of which are influenced by nutrition. A growing body of evidence has shown that dietary behaviours such as regularly eating breakfast, maintaining balanced meal patterns and consuming a healthy diet are positively associated with improved academic outcomes in children, adolescents and university students (Adolphus et al., 2016; Bouchefra et al., 2023; T. L. Burrows et al., 2017; Reuter et al., 2021). Studies have linked healthy eating habits to improved memory, attention and learning capacity. In particular, specific

nutrients and dietary patterns have been linked to enhanced brain function, suggesting that what students eat may directly affect their academic performance (Fadó et al., 2022; Gómez-Pinilla, 2008).

Despite this growing interest, the mechanisms through which dietary behaviours influence academic performance remain incompletely understood. While many studies report statistical associations between diet and school outcomes, fewer investigate the underlying biological and behavioural pathways responsible for these effects. Much of the literature focuses either on short-term behavioural changes, such as increased classroom participation or reduced inattention, or on isolated biological factors, such as blood glucose levels (Adolphus et al., 2016; Knight & Perfect, 2019). However, the interaction between biological processes (e.g. neurotransmitter activity and glucose metabolism) and behavioural patterns (e.g. self-regulation, attendance and attention span) has received limited attention. Additionally, many studies are limited by narrow age ranges, isolated dietary variables or a lack of mechanistic explanation.

This review is based on the hypothesis that dietary behaviours influence academic performance via biological and behavioural mechanisms. Specifically, it is proposed that certain dietary habits support neurophysiological processes that are essential for cognition, while also shaping behaviours that facilitate learning, such as sustained attention, emotional regulation and engagement with school (Fadó et al., 2022; Gomez-Pinilla & Tyagi, 2013).

By synthesising the latest evidence on biological and behavioural pathways, this article aims to address a significant gap in the literature. Understanding the impact of diet on academic performance, rather than merely establishing its existence, has significant implications for education policy, school nutrition programmes and parental guidance. This integrated approach can inform more holistic interventions to support cognitive development and academic success in students of all ages.

1. METHODS

This narrative review aimed to explore the mechanisms underlying the associations between dietary behaviours and academic performance across all age groups. To this end, a comprehensive literature search was conducted to identify peer-reviewed articles examining the influence of breakfast consumption, meal patterns and overall dietary quality on brain function and cognitive processes relevant to learning and academic achievement.

The search was conducted using the electronic databases PubMed, Web of Science, Google Scholar and Scopus. Relevant articles were identified through combinations of keywords including: 'dietary behaviours', 'diet quality', 'dietary patterns', 'breakfast', 'glycaemic index', 'academic performance', 'academic success', 'school achievements', and 'attention'. Boolean operators were used to refine the results, capturing studies that specifically addressed the biological or neurophysiological and behavioural mechanisms linking nutrition to academic outcomes.

Articles were eligible for inclusion if they provided mechanistic insights into the relationship between diet and academic performance, particularly with regard to glucose metabolism, neurotransmitter synthesis, synaptic plasticity, neuroinflammation, and brain structure and function. Both human and animal studies were considered if they offered relevant biological evidence. Studies focusing on behavioural associations without explicitly addressing biological pathways were also included.

The search was carried out between July and August 2025. To ensure scientific rigour and relevance, only articles published in English between 2010 and 2025 were included; however, earlier foundational studies were considered if they provided key insights into the biological or behavioural mechanisms under review.

2. RESULTS AND DISCUSSION

2.1. Biological and behavioural mechanisms linking breakfast consumption to academic performance

Breakfast has long been recognised as an important meal for supporting children's cognitive function and readiness for school. The timing and nutritional content of breakfast have a significant impact on brain function and behavioural outcomes that directly affect academic performance (Adolphus et al., 2013). Eating breakfast early in the morning helps to restore glucose levels after overnight fasting, ensuring that the brain receives a steady supply of energy during the day's most cognitively demanding period - typically the morning school hours (Adolphus et al., 2016; Benton & Parker, 1998).

Glucose is the brain's primary energy source, particularly for areas such as the hippocampus and prefrontal cortex, which play a role in memory consolidation, attention regulation and executive functioning (Preston & Eichenbaum, 2013). Fasting in the morning is associated with reduced glucose availability, which can hinder neurotransmitter synthesis (such as dopamine, serotonin, and acetylcholine) potentially affecting mood and focus, slow down neuronal firing potentially impacting information processing speed, and reduce the efficiency of cognitive processes, including slower reaction times and impaired memory (Alvarsson & Stanley, 2018; Chechko et al., 2015; Pereverzev & Osain Welcome, 2013).

The composition of breakfast also plays a significant role in determining its impact on cognitive performance. Breakfasts containing complex carbohydrates, fiber, protein and moderate amounts of fat have been linked to sustained improvements in cognitive performance, compared to high glycemic index/load breakfasts (Cooper et al., 2012; Edefonti et al., 2014; Gaylor et al., 2022). Complex carbohydrates and fiber provide a steady release of glucose, offering sustained energy for the brain, which helps maintain attention and reduce mental fatigue throughout the morning (Mahoney et al., 2005). Moderate fat prevents energy crashes and contributes to cell membrane integrity and anti-inflammatory processes. Protein is essential for building and repairing tissues,

including neurotransmitters - dopamine and serotonin - that play a role in alertness, mood and motivation, factors that enhance learning engagement and memory retention (Gomez-Pinilla & Tyagi, 2013). High-sugar or high glycaemic index (GI) meals, promote a rapid release of glucose into the bloodstream, causing fatigue and decreased focus (Crosier, 2020).

Children who regularly eat breakfast are more likely to arrive at school on time, report higher levels of alertness, higher motivation and exhibit fewer behavioural problems in class (Adolphus et al., 2013; T. Burrows et al., 2017; Martin et al., 2024). In addition, is linked to greater engagement at school, reduced absenteeism and more consistent participation in classroom activities (Rampersaud et al., 2005). Breakfast can also help to stabilise cortisol levels (Zahedi et al., 2022), improving mood and self-regulation, and reducing stress-induced disruptions to learning.

Furthermore, school breakfast programmes that provide nutritionally balanced meals have been shown to improve nutrient intake and educational outcomes, particularly among socioeconomically disadvantaged groups (Hoyland et al., 2009; Kristjansson et al.). It is believed that these improvements arise from a combination of nutritional factors and the establishment of structured, predictable routines that foster a positive learning environment (Selman & Dilworth-Bart, 2023).

Overall, the evidence suggests that eating breakfast improves academic performance by supporting brain energy metabolism, neurotransmission and neuroplasticity and enhancing mood, concentration and behavioural readiness to learn. A well-composed breakfast appears to stimulate the key biological pathways involved in memory and attention, while also promoting motivation and engagement in the classroom.

To reap the full cognitive benefits, it is best to eat breakfast within two hours of waking, when the brain starts to require more cognitive demand and blood glucose replenishment (Hoyland et al., 2009; Wesnes et al., 2003). Delayed eating may result in suboptimal cognitive performance, particularly during morning academic tasks. In terms of food composition, beneficial breakfasts include those that combine: low-GI carbohydrates (e.g. oats, wholemeal bread, pulses); lean proteins (e.g. milk, eggs, yoghurt); healthy fats (e.g. avocado, nuts and seeds), fruits and vegetables. A regular consumption of a balanced, nutrient-dense breakfast shortly after waking should be considered a foundational strategy for improving academic performance in students of all ages.

2.2. Biological and behavioural mechanisms linking diet quality and diversity to academic performance

The evidence suggests a strong relationship between a person's overall dietary quality and diet diversity and their academic achievement (Bouchefra et al., 2023; Florence et al., 2008).

A high-quality diet, typically comprising diverse fruits, vegetables, whole grains, lean proteins, dairy products and healthy fats, ensures an optimal supply of macronutrients and micronutrients that fuel the biological processes underlying cognitive development, memory consolidation and learning capacity (Florence et al., 2008; Nyaradi et al., 2013).

Micronutrients such as B vitamins, iron, iodine, zinc and omega-3 fatty acids play a crucial role in the synthesis of neurotransmitters, myelination, synaptic plasticity and neuronal growth - all of which are essential for attention, executive functioning and memory (Bryan et al., 2004; Nyaradi et al., 2013; Tardy et al., 2020). For instance, vitamin B12 and folate play a vital role in the methylation processes necessary for DNA synthesis and neurotransmission (Troen, 2012). Meanwhile, iron is crucial for transporting oxygen to brain tissues and for dopamine metabolism, which influences mood and cognitive control (Soladogun & Zhang, 2024). Inadequate levels of any of these nutrients may result in fatigue, impaired concentration and reduced academic performance.

In terms of behavioural mechanisms, a higher-quality diet is associated with better emotional regulation, reduced irritability and fewer symptoms of anxiety and depression (Firth et al., 2020). All of these factors can influence motivation, behaviour in the classroom and long-term engagement with academic studies (Sinval et al., 2025).

A frequent consumption of ultra-processed foods may lead to blood glucose fluctuations, mood instability and impaired attention span. In contrast, a more balanced, fibre-rich diet promotes stable energy levels and behavioural self-regulation (Adolphus et al., 2016).

Furthermore, students who eat a healthier diet often report improved sleep patterns and reduced daytime sleepiness. Both of these factors enhance cognitive alertness and memory retrieval during school hours (Alibabaei et al., 2021; Mehta, 2022).

Dietary diversity, a key component of diet quality, is particularly important as it increases the likelihood of achieving adequate nutrient intake. A varied diet provides complementary nutrients that interact synergistically to optimise brain metabolism and structure. For example, antioxidants (such as vitamins C and E), anti-inflammatory compounds (such as polyphenols) and essential fatty acids (such as DHA) work together to reduce neuroinflammation and oxidative stress, both of which are known to impair cognitive processing and neuroplasticity (Gómez-Pinilla, 2008).

Furthermore, a diverse plant-based diet supports a healthy gut microbiome. This microbiome communicates with the brain via the gut–brain axis, influencing mood, cognition and behaviour (Lach et al., 2020).

In order to promote a high-quality, diverse diet that supports academic performance, dietary recommendations should be aligned with established tools such as the Healthy Eating Index (HEI), the Dietary Diversity Score (DDS) and the Healthy Plate Model. These frameworks emphasise the importance of balance, variety and nutrient density, all of which have been associated with improved cognitive function, emotional regulation and academic achievement (Spencer et al., 2017).

In order to achieve a high-quality, diverse diet that supports cognitive and academic performance, food recommendations should focus on nutrient-dense options from all the main food groups, in the correct portion sizes throughout the day. Aim for at least five portions per day of fruits and vegetables, for example one medium-sized piece of fruit, half a cup of chopped vegetables or one cup of leafy greens. Aim for a variety of colours to maximise micronutrient and antioxidant intake. Include three to four servings daily of whole grain bread, oats, brown rice, quinoa or whole grain pasta. Incorporate two to three servings per day from sources such as eggs, poultry, fish (especially oily fish such as salmon or sardines twice a week), legumes or tofu. Include two to three servings daily of dairy or calcium-rich alternatives, such as one cup of milk or a small pot of yoghurt. Prioritise unsaturated fats from nuts, seeds, olive oil and avocados. A small handful of nuts or one tablespoon of olive oil per meal seems to be the adequate portion size. Encourage adequate water intake, as even mild dehydration can impair concentration and short-term memory. It is also critical to limit added sugars, excessive sodium and ultra-processed foods, as these can negatively affect mood regulation, attention and long-term brain health (Mottis et al., 2025).

In summary, promoting dietary patterns that achieve high scores on the HEI and DDS, guided by the Healthy Plate Model, can provide the essential nutrients and behavioural stability required for academic success. A balanced and diverse diet supports brain metabolism, cognitive performance and emotional resilience, and healthy lifestyle habits such as sleep hygiene and sustained engagement in academic activities, making it a vital focus for school nutrition policies and home practices alike.

2.3. Biological and behavioural mechanisms linking the Mediterranean Diet to academic performance

The Mediterranean Diet (MedDiet) has been consistently associated with enhanced cognitive function (Fu et al., 2022), improved memory (Fu et al., 2022), and gut health, which influences brain function (Maggi et al., 2023). Consequently, it has been linked to better academic performance (López-Gil et al., 2024).

This dietary pattern is rich in essential nutrients, antioxidants, and anti-inflammatory compounds that work synergistically to support both the biological integrity of the brain and the behavioural regulation necessary for learning and academic engagement. This includes working memory, long-term memory, verbal fluency and attention (Fu et al., 2022).

From a biological perspective, one of the most significant effects of the Mediterranean diet is its promotion of synaptic plasticity, which is the brain's capacity to strengthen or weaken synaptic connections in response to learning and experience. This process is essential for forming and consolidating memory, and is underpinned by core processes such as long-term potentiation (LTP) (Key & Szabo-Reed, 2023).

The MedDiet is rich in omega-3 fatty acids, polyphenols, flavonoids and B vitamins, all of which have been shown to promote synaptic growth and enhance neuronal communication (Picone et al., 2024). It also supports neurogenesis in the hippocampus; new neurons can integrate into existing neural circuits and potentially contribute to improved cognitive function (Poulose et al., 2017; Yau et al., 2015). Furthermore, the Mediterranean diet has been shown to reduce neuroinflammation and oxidative stress. If left unchecked, these factors can impair cognitive performance (Picone et al., 2024).

Polyphenols and flavonoids, which are found in fruits, vegetables, olive oil and nuts, can activate intracellular signalling pathways (e.g. MAPK and PI3K/Akt). These pathways enhance synaptic plasticity by increasing the expression of brain-derived neurotrophic factor (BDNF) (Fiore et al., 2025). Higher levels of BDNF have been linked to better memory retention and quicker learning, both of which are vital for academic success (Miranda et al., 2019).

Moreover, omega-3 fatty acids, particularly docosahexaenoic acid (DHA), which is found in oily fish, are essential components of neuronal membranes. They play a crucial role in facilitating signal transmission and plasticity. Adequate levels of DHA enhance the formation of synaptic vesicles and the density of dendritic spines, thereby optimising the brain's ability to adapt and store new information (Cao et al., 2009).

Furthermore, the MedDiet promotes glucose homeostasis, which is essential to prevent fatigue and inattentiveness in a classroom setting.

In terms of behaviour, sticking to the Mediterranean diet has been linked to better emotional regulation, improved sleep quality, lower incidence of depression and greater resilience to stress (Ventriglio et al., 2020). All of these factors contribute to better classroom behaviour, attention, task persistence, motivation and learning capacity (Boekaerts & Corno, 2005; Martínez-Lapiscina et al., 2013).

The MedDiet encourages regular eating patterns and nutrient-dense meals. This supports healthy routines and satiety, improving school attendance and time management while reducing distractions and enhancing self-regulation (DaSilva; Sánchez-Sánchez et al., 2020). These are all critical behaviours for effective learning.

Adherence to the Mediterranean diet has been associated with improved executive functioning such as planning, working memory and attention span (García-Pérez-de-Sevilla & Zapata-Lamana, 2025). It has also been associated with increased creativity (García-Pérez-de-Sevilla & Zapata-Lamana, 2025), as well as reduced hyperactivity and increased self-discipline (Aksoy & Doguer).

In summary, the Mediterranean diet supports academic performance by enhancing the biological foundations of learning and memory through its dual impact on neuroplasticity and synaptic function. It also promotes emotional regulation, behavioural consistency, and overall well-being. These effects contribute to improved attention, motivation and cognitive engagement, which

are all essential for academic success. Therefore, the updated Mediterranean Diet Pyramid encourages a lifestyle integrating daily physical activity, restful sleep, social interaction during meals and preserving traditional food practices (Serra-Majem et al., 2020), all of which play a meaningful role in cognitive health, psychosocial development and academic performance. Based on these principles, individuals and families are advised to prioritise plant-based foods (vegetables, fruits, whole grains, legumes, nuts, and olive oil) as the core of their diet, while reducing their consumption of red and processed meats and opting for seasonal, locally sourced foods. By embracing the holistic, sustainable lifestyle proposed by the New Mediterranean Diet Pyramid, students and families can foster brain health and learning potential while contributing to their long-term health.

3. CONCLUSION

Academic success is not solely determined by intellect and effort; nutrition and lifestyle also play a significant role. This narrative review highlights compelling biological and behavioural evidence linking specific dietary behaviours, such as regular breakfast consumption, a high-quality and diverse diet, and adherence to the Mediterranean diet, to improved academic performance across age groups.

Breakfast plays a critical role in restoring morning glucose levels, which are essential for brain function and support attention, memory and learning capacity. A balanced diet rich in diverse nutrients enhances neurotransmitter synthesis, synaptic plasticity and emotional regulation, providing a foundation for sustained cognitive engagement. As a holistic eating pattern and lifestyle, the Mediterranean Diet promotes neuroplasticity, anti-inflammatory effects, and psychosocial stability, all of which contribute to higher-order cognitive abilities that are crucial for academic achievement.

Taken together, these findings reinforce the powerful message that what and how we eat profoundly shapes how well we think, learn, and perform. Schools, families and health professionals must recognise the role of nutrition in education and integrate dietary strategies into broader efforts to support learning and development. To support optimal academic performance, the following evidence-based dietary and lifestyle recommendations are proposed: eat breakfast every day, ideally within two hours of waking; choose foods with a low glycaemic index to maintain steady energy levels and focus; follow a balanced and diverse diet throughout the day and adopt the principles of the Mediterranean Diet, which emphasizes plant-based foods as the dietary foundation, moderate consumption of animal products, locally sourced, seasonal foods, minimal consumption of ultra-processed foods, daily physical activity, adequate sleep, hydration and shared, mindful meals.

To truly harness the benefits of nutrition for educational outcomes, governments must play a proactive role. Providing all students, particularly those from vulnerable populations, with free, balanced and nutritious breakfast, lunch and dinner can be a transformative public health and education policy. This investment supports brain development and academic achievement, fostering greater school engagement, improved self-discipline and motivation to succeed. A well-fed generation is a generation that is prepared, focused and resilient - one that is capable of reaching its full intellectual and social potential.

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