SYSTEMATIC REVIEW

Effects of ultra-processed food on cognition and learning of adolescents: a rapid systematic review [version 1; peer review: awaiting peer review]

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Abstract

Overweight and obesity in adolescents are associated with high consumption of ultra-processed foods (UPF). UPF are industrially manufactured foods that contain large amounts of calories, trans fats, sugars, sodium, and chemical additives. It is also associated with lower intake of vitamins, milk, fruits and vegetables. Through adolescence, good nutrition is essential during neurodevelopment for optimal brain health. However, the relationship between UPF and educational variables are not clear; therefore, there is a lack of knowledge regarding the effect of UPF on variables such as cognition and learning processes. So, our aim was to evaluate the effects of UPF on cognition and learning of adolescents through systematic review. Understanding these effects is important because it may provide information for public health and educational policies mainly targeted at schools to ensure a healthy food environment. The results from the study showed that no study had met our eligibility criteria; however, we considered it relevant to share the findings.

Keywords

ultra-processed food, diet; brain; cognition, memory, learning, adolescent

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Introduction

Overweight is a key risk factor for the development of chronic non-communicable diseases.^{1–3} The global prevalence of overweight in adolescents is approximately 20–25%, and is associated with high consumption of ultra-processed foods (UPF).^{4–10} Generally, UPF are industrially manufactured foods that contain large amounts of calories, trans fats, sugars, sodium, and chemical additives.^{5,6,11} It is also associated with lower intake of vitamins, milk, fruits and vegetables.¹² Factors that may increase its consumption in adolescents include the presence of a school cafeteria and a fast-food restaurant.

Recent studies show that the consumption of UPF may increase over 10% each year,¹³ and is associated with binge drinking,¹⁴ poor sleep quality and duration,^{15,16} increased screen time,^{17,18} higher risk of psychological symptoms,¹⁹ greater impulsivity,^{20,21} violent behaviors²² and depression.²³ Other studies found that low educational background was related to a higher fast-food intake,¹³ and contradictory results showed that a higher degree level was associated with take-out food consumption.⁹ In most studies, the outcome is the eating behavior of the population, and it is evaluated as a consequence of the educational level. The relationship between UPF and educational variables are inconclusive; therefore, there is a lack of knowledge regarding the effect of UPF on variables such as cognition and learning processes.

Two recent systematic reviews showed that breakfast consumption affects cognitive performance and academic achievement,^{24,25} such that participants who consumed breakfast faced more cognitively demanding tasks, and improved response time, response speed variability and attention, and visual scanning speed. Moreover, nutrient intake resulted in cognitive enhancement²⁶ by providing a better energy source,²⁶ due to compositional differences in protein and fiber content, glycemic scores, and rate of digestion. Other systematic reviews focused on glycemic index in cognitive functioning.^{27,28}

Furthermore, some studies on dietary pattern indicated an association between high-sugar diets, high-fat diets (HFD) and “Western diets”—characterized by high intake of take-away foods, red and processed meat, soft drinks, and fried and refined food^{29,30}—with brain function³¹ and cognitive impairment.^{29,32–34} The impact of eating behavior on learning process has been well defined; however, the impact of UPF has not been established.

To the best of our knowledge, no systematic review has focused on the relationship between UPF and cognition and learning in young people. This can contribute to public health policies for adolescents worldwide. Thus, this study aimed to evaluate the effects of UPF on cognition and learning of adolescents.

Methods

This systematic review was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) guidelines³⁵ for the identification, screening, eligibility, and inclusion. We performed a systematic review to analyze the influence of UPF on cognition and learning, including longitudinal studies and clinical trials related to adolescents (individuals aged 10–19 years³⁶), with no restrictions for language or year of publication. The exclusion criteria were review articles and studies with supplementation interventions, studies with incomplete data, and samples including athletes, hospitalized adolescents, people with disease, people with disability, amputees, or pregnant and lactating women.

We performed searches in three databases (SCOPUS, PubMed, and Embase) on 1st August 2020. The following combination of keywords were used:

PubMed: (((((adolescent [MeSH Terms]) OR students [MeSH Terms]) OR minors [MeSH Terms])) AND (((memory [MeSH Terms]) OR learning [MeSH Terms]) OR mental processes [MeSH Terms])) AND (((((((((((Ultra-processed [Title/Abstract]) OR “ultra processed”[Title/Abstract]) OR ultraprocessed [Title/Abstract]) OR food processing [MeSH Terms]) OR ready-to-eat [Title/Abstract]) OR “ready to eat”[Title/Abstract]) OR “ready-to-consume”[Title/Abstract]) OR fast food [MeSH Terms]) OR “fast-food”[Title/Abstract]) OR “fast food”[Title/Abstract]) OR fastfood [Title/Abstract]) OR “junk food”[Title/Abstract]) OR “Ready Prepared Food”[Title/Abstract]) OR “Convenience Food”[Title/Abstract]));

Scopus: (TITLE-ABS-KEY (adolescent) OR TITLE-ABS-KEY (students) OR TITLE-ABS-KEY (minors)) AND (TITLE-ABS-KEY (memory) OR TITLE-ABS-KEY (learning) OR TITLE-ABS-KEY (“mental processes”) OR TITLE-ABS-KEY (“Cognitive Function”) OR TITLE-ABS-KEY (“cognition”)) AND (TITLE-ABS-KEY (“Ultra-processed”) OR TITLE-ABS-KEY (“ultra processed”) OR TITLE-ABS-KEY (ultraprocessed) OR TITLE-ABS-KEY (“Food Processing”) OR TITLE-ABS-KEY (“ready-to-eat”) OR TITLE-ABS-KEY (“ready to eat”) OR TITLE-ABS-KEY (“ready-to-consume”) OR TITLE-ABS-KEY (“Fast Food”)) OR TITLE-ABS-KEY (“fast-food”) OR

TITLE-ABS-KEY (“fast food”) OR TITLE-ABS-KEY (fastfood) OR TITLE-ABS-KEY (“junk food”) OR TITLE-ABS-KEY (“Ready Prepared Food”) OR TITLE-ABS-KEY (“Convenience Food”));

Embase: (‘adolescent’/exp OR ‘student’/exp OR ‘minor’/exp) AND (‘memory’/exp OR ‘learning’/exp OR ‘mental function’/exp OR ‘cognition’/exp OR ‘cognitive function’:ab,ti) AND (‘ultra-processed food’/exp OR ‘ultra processed’:ab,ti OR ‘ultraprocessed’:ab,ti OR ‘food processing’/exp OR ‘ready to eat’:ab,ti OR ‘ready to consume’:ab,ti OR ‘fast food’/exp OR ‘fast-food’:ab,ti OR ‘fast food’:ab,ti OR fastfood:ab,ti OR ‘junk food’/exp OR ‘ready prepared food’:ab,ti OR ‘convenience food’/exp).

After the literature search, articles found from the three databases (SCOPUS, PubMed, and Embase) were collated, and duplicates were removed using Mendeley software. In the next step, MN and CRM independently screened titles and abstracts of all remaining articles taking into account the inclusion and exclusion criteria. Disagreements were checked by a third reviewer (PRSN). Lastly, the remaining articles were read in full and evaluated to determine their eligibility. These steps were executed using Rayyan software with blind mode. All researchers involved in this process had previous experience on more than five systematic reviews and also were underwent a training which included a practice on 50 abstract using the Rayyan software.³⁷ We made plans to perform a descriptive analysis with a meta-analysis too.

Results

A total of 1150 eligible studies (PubMed, 340; Scopus, 167; Embase, 643) were identified. After removing duplicates (n = 171), 979 articles remained. Subsequently, we analyzed, both the titles and abstracts in order to identify studies which addressed our inclusion criteria. After this step, 14 articles were selected to be fully read (Figure 1).

All 14 articles were excluded as they did not meet our eligibility criteria; 12 reported outcomes other than cognition and learning, one was an illegible article type, and one had a population that were not adolescents.

Figure 1. Flow diagram of the selection criteria for the study.

Discussion

The results from the study showed that no study had met our eligibility criteria; however, we considered it relevant to share the findings. In accordance with Yaffe *et al.*,³⁸ if no study meets the eligibility criteria, the review is called an “empty review” and may help to stimulate appropriate future investigations in this field.³⁸

Adolescence is characterized by significant changes in neuroendocrine, neurodevelopmental, and behavioral systems. An important area of the brain denominated hippocampus, related to optimal cognitive function, is altered during adolescence, with increasing neurogenesis activity. The increased number of neurons in the hippocampus related to emotional behavior, cognitive function, and neural plasticity³³ is regulated by the diet of the individual. It has been demonstrated that HFD, high-sugar diets and “Western diets”, which are rich in processed foods, may cause cognitive impairment during adolescence^{33,34,39} and may have an impact on future cognitive performance in adulthood.^{33,34}

The effects in other regions of the brain, especially the medial prefrontal cortex (mPFC), have also been investigated, though the cognitive impact of diet on hippocampus is the most studied. The mPFC is known to be the last region of the brain to become mature due to a protracted maturation. This extended period of neuronal plasticity is related to experience-dependent learning and may be affected by stressor exposure, such as inappropriate eating habits.^{34,39}

In this sense, diets rich in fat and “Western” dietary patterns have been associated with poor cognition performance and academic achievement of adolescents.^{29,32} The “Western” diet is characterized by high intake of take-away food, red and processed meat, soft drinks, fried and refined foods, and other ready-to-consume foods. Most of these foods or food groups are classified as UPF according to the processing level.^{5,6} This is worrisome in the adolescence period because of many changes, including dietary habits, which make them vulnerable to the consumption of poor diets in the future.^{8,40–42} UPF are a very attractive readily available source of highly palatable foods.^{5,34,43} Studies have also shown that adolescents may have a substantial UPF dietary share,^{4,44,45} especially when they have access to UPF in the school cafeteria or fast-food stores near schools.^{46–49}

Furthermore, we hypothesized that the elevated consumption of UPF may have an important impact on the cognitive function of adolescents affecting learning, memory, and other important capacities. The lack of research on this topic highlights the necessity of conducting longitudinal studies, such as cohorts and clinical trials. This information would be beneficial to the literature due to the increase of adolescents eating ready-to-go meals. Future research may support public health and educational policies to regulate media advertisements, adjust taxes on UPF and control school cafeterias. This information is also useful and should be considered by nutritionists and dietitians in their clinical practice.

Some cross-sectional studies confirmed a relationship between school performance and dietary habits. Kim *et al.*⁵⁰ evaluated 359,264 Korean participants aged 12 to 18 years and found that frequent intake of fresh fruits, vegetables, and milk were related to good school performance, while consuming several UPF such as soft drinks, instant noodles, and fast-food were related to poor school performance. Edwards *et al.*⁵¹ evaluated 800 students from the United States, aged 11 to 13 years, and found higher academic performance level in students with lower prevalence of sweetened beverage consumption, as well as higher consumption of milk and breakfast. Another study,⁵² although performed among children, showed that the consumption of less healthy food groups, such as sweet snacks, salty snacks, and sweetened beverages, was associated with poorer academic achievement. These initial results need to be confirmed by prospective studies to better comprehend the effects of UPF on school performance.

Understanding the effects of UPF on memory and cognition is important because it may provide information for public health and educational policies mainly targeted at schools to ensure a healthy food environment,³¹ thereby promoting good health and appropriate physical, psychological, and social development of adolescents.²⁹

Data availability

Underlying data

All data underlying the results are available as part of the article and no additional source data are required.

Reporting guidelines

Figshare: PRISMA checklist for ‘Effects of ultra-processed food on cognition and learning of adolescent students: a systematic review’, <https://doi.org/10.6084/m9.figshare.15145599.v1>.⁵³

Data are available under the terms of the [Creative Commons Zero “No rights reserved” data waiver](#) (CC0 1.0 Public domain dedication).

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