

## Effects of Breakfast on Cognitive Function of Children

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### Abstract

In the present review article, importance of breakfast for the functioning of child's brain, his intelligence as reflected through various tests based on memory, mathematical or visual ability and verbal fluency has been discussed. Breakfast and no-breakfast conditions can affect the mental abilities of children. Many schools run programs to provide meal to kids. Type and quality of breakfast can influence the child's performance and intelligence. There could be varied reasons due to which a healthy child may skip his breakfast, however, the effects of including breakfast are more pronounced for the children who are nutritionally at-risk or malnourished. In such cases, provision of breakfast help bring improvement in performance.

**Keywords:** Breakfast; Cereal; Brain Function; Cognition; Children

### Introduction

The word 'cognition' means all the activities related to thinking, understanding, problem solving, assimilating, recalling and expressing while cognitive development is the learning process that is based on experiences and knowledge gained by a child from infancy to adulthood. It is a system through which person develops a certain set of habit and intelligence in addition to inborne responses and reflexes through learnings and practices, wherein he tries to explain every new experience based on existing terms and knowledge [1]. Recently, it was suggested that the second 1000 days are also very crucial for the growth and development of child's cognitive abilities along with the first 1000 days of his life [2]. In the changing scenarios of Covid-19, children's lifestyle is changing which is affecting their preferences and choices for food, frequency and timings of food intake. To attend online classes/offline school, skipping of breakfast is becoming common among children. The question comes in mind, is it going to affect their health and mental growth? Amid so many uncertainties and stress, parent want to follow an assured routine of food and diet plan that can support the well-being of their children. It is somehow true for adults that they fulfill the demand for various micronutrients

particularly because of the consumption of fortified breakfast cereals and fruit juices or milk beverages in comparison to breakfast skippers [3]. If children consume their breakfast regularly than it is more likely that would be able to meet the recommended daily allowances for different nutrients which can help prevent occurrence of many deficiency diseases. Interestingly, those adults who consumed breakfast cereal regularly and were also following healthier lifestyle were reported to have a healthier body weight [4]. Similarly, children who eat breakfast regularly have normal body mass index than those who do not [5].

### Importance of breakfast for child's brain

Our body gets energy by oxidation of food and brain can use only glucose as its energy source. In children (3 to 11 years), the brain consumes > 50% of body oxygen consumption [6] and utilizes oxygen 1.3 to 1.8 times higher than adults. Therefore, after overnight fasting in the morning hours, kids burn glycogen stores to meet the energy demand. Positron emission tomography of 30 children (aged 0-18 years), showed first an increase in cerebral glucose utilization among children up to the age of 10 years fol-

lowed by a gradual fall from the age of 10 years which got stabilized at ages of 16 to 18 years [7,8]. They recommended that the children need proper nutrition to meet the academic challenges along with maintaining the demand for body growth and higher metabolism.

### Effects of breakfast vs. no-breakfast on cognition

The effects of intake of breakfast have been reported on the cognitive activity of children particularly in terms of memorizing the content and increased in concentration. Towards late morning hours, the performance differences become more apparent on the children with no-breakfast. Some studies have shown positive effects of breakfast on verbal memory as well as on spatial memory. The intake of breakfast has shown improvement in spatial memory tasks however there was no improvement in the verbal memory of children as indicated through story telling [9]. However, in another research done without considering difference in change in response over time or time of testing post-consumption, improvement was seen on the immediate verbal recall test among children with breakfast at school than those with breakfast at home or who omitted breakfast [10]. Also, better results on 'quality of episodic memory' factor for children (age 9 to 16 years) for kids who had their breakfast v. no breakfast [11]. Less accuracy was reported in them on the tougher problems of the matching familiar figures task which measures visual perception [12] and also in children with lower IQ [13] after omitting breakfast. Visual perception might have been affected by improvement in nutritional status due to inclusion of breakfast by the children who were malnourished. After breakfast, higher level of accuracy was observed in performing the more complex problems based on various tests like visual search test and Stroop test than without breakfast. Also, with breakfast, accuracy was better maintained for longer hours [14]. Furthermore, responses particularly on the more complex levels on the Sternberg paradigm and visual search test were faster and accurate following breakfast. Effects of breakfast was more clearly seen when testing was conducted later in the morning particularly for tests with higher level of difficulty. In another study, breakfast enhanced cognitive function in an adolescent population when compared to no-breakfast. The adolescents who had taken breakfast reported a higher level of energy, feeling of fullness, less tiredness, less hunger and higher blood glucose levels. Improvement was reported in mathematical abilities in adolescents who took breakfast and who also performed 30 minutes exercise [15]. A study has shown that the neural network activity associated with mathematical problem solving was better among children who have eaten breakfast, whereas greater mental effort was required for by children who did not have breakfast [16].

### Effect of types of breakfasts on brain function

There are studies which find effects on cognitive function when different breakfasts are compared though most of them lacked exact detailing about the energy and nutrient composition to make clear comparison. Some studies have reported the comparison among kids' performance based on different types of breakfasts for example, cereals, doughnuts or toast. When cereal breakfasts with similar energy contents with complex carbohydrate or oatmeal or ready-to-eat cereal breakfast was compared, the performance did not differ between the type of breakfasts [9,11]. Any type of breakfast was found to be advantageous in comparison to the no-breakfast and glucose-drink conditions only.

The low glycemic index (GI) cereal breakfast helped in maintaining cognitive functions of children over a longer period of the day than the high GI cereal breakfast [17]. GI may be calculated from international tables of values [18] and used similarly for kids as for adults because not many separate studies have been undertaken to determine the GI for different foods for kids. Glycemic load (GL) of breakfasts was considered in one study comprising 6- to 7-year-old children [19]. The 3 breakfasts provided in the study varied in GL from 2.5 to 17.86 however the energy content of the breakfasts also varied from 657 to 820 kJ along with inconsistent actual intake between participants and cognitive test was conducted between 140 min and 210 min after breakfast. Time of conducting the tests after intake of breakfast was considered important, as the varied period between ingestion and testing between different conditions and children affected the test results. Better results were reported in the tests conducted at 60 min, 130 min and 200 min post breakfast than no-breakfast with no differences between the types of breakfast [9,11,17]. In another study, cognitive test was conducted at + 180 min and positive effects of breakfast was found in children with lower IQ only [13].

To examine the effects of providing breakfast to children of varied nutritional background, different studies were conducted in South America, in Jamaica and in India [13,20-25]. These studies studied the impacts of breakfast in healthy vs. malnourished (stunted and/or wasted nutritionally at risk) children. The cognitive performance was better following breakfast in the at-risk or undernourished group, with less changes seen on the healthy children. Cognitive tasks susceptible to nutritional intervention in nutritionally vulnerable children appear to be verbal fluency and memory tasks, particularly short-term recognition, Sternberg memory test, as well as the matching familiar figures test. Tasks

requiring attention, executive function, and memory were reported to be facilitated more by breakfast consumption over fasting, with effects more apparent in undernourished children [26]. It appeared that nutritionally at-risk children perform low in memory-based tests in comparison to well-nourished kids from similar location. However, a few studies differ in their view about the role of nutritional status and breakfast on person's intelligence [27].

### **Effects of school breakfast programs**

There are various studies that explore the effect of providing breakfast to kids at school. They primarily focus on comparing performance between kids having breakfast at school and no-school breakfast (either breakfast at home or no breakfast). The subjects in these studies were between 3 and 8 years of age. The kids who had breakfast at school performed better in mathematics tests than no-school breakfast which was related to decreased absenteeism of kids from school, mainly linked with breakfast provisions at school. Increased attendance benefitted all the kids irrespective of their nutritional status of being undernourished or at-risk group or healthy kids in performing better in various scholastic tests conducted after provision of breakfast [28]. Of these, one study showed improved response speed [25] and another reported improved concentration [29]. A positive effect of a school breakfast program on different spatial cognitive tests was also reported [30]. Acute effects of breakfast provision were reported in full-grade and multiple-grade schools, particularly related to memory-based tests and mathematical/arithmetic tests [31]. It was reported that the multiple-grade schools included children of different ages within the same class and were associated with poverty than kids in full-grade schools and included kids who were nutritionally at-risk.

### **Effects of breakfast quality**

There are few studies that explore the effects of habitual breakfast intake on cognitive abilities of children. In Spain, 3 studies were conducted which were based on food recall method as noted in food diaries by the subjects to determine the quality of breakfast intake based on target food groups. These studies suggest a positive relation between breakfast quality and school performance of children. One study emphasized on the inclusion of a snack that can help overcome the drawbacks of a poor-quality or no breakfast [32]. The studies measure the school performance. The kind of cereal consumed in the breakfast affected brain structure and intellectual in healthy children [33]. There were significant differences for gray matter ratio and regional gray matter volumes in healthy

children thus affecting the perceptual organization index being higher for the rice group than the bread group. Recently, there is a report on enhanced cognitive function resulted with frequent intake of meat/egg or grain/rice in breakfast among children over 6 years long study [34].

### **Glucose intake and intellect**

The variability in glucose supply to brain is reported to affect some sensitive areas of brain and its function despite the natural biological mechanisms that protect brain activity from disruption [35]. The glucose availability facilitates mental performance, particularly during long-duration tasks. The hippocampus region of brain is associated with the learning and memorizing activity which is supposed to be supported by the supply of glucose known as glucose memory facilitation effect. The intake or omission of breakfast has relevance to school performance particularly in case of malnourished children. Micronutrient supplementation also improves the intellectual performance among children and adolescents with very poor nutritional status. A study has reviewed the influence of glucose ingestion on neurocognitive tasks among normally functioning individuals and individuals with compromised neurocognition [36]. It was suggested that glucose is probably enhancing the memory performance for emotion-based stimuli.

### **Effect of high fat and refined sugar (HFS) in diet and cognition**

There is emerging evidence that HFS diets have long-term adverse impacts on brain function and behavior [37]. It is suggested that HFS diet can impair memory in humans, and it can also contribute to the development of neurodegenerative conditions.

### **Conclusion and Future Areas of Research**

Regular intake of nutritious cereal-based breakfast helps children to perform in various tasks. Brain gets enough energy via glucose metabolism to support cognitive behavior in terms of memory, concentration and mathematical problem solving of the growing children. In this context, research should be undertaken to explore the role of having dinner vs. no-dinner by children on their performance in various tasks the next morning. Time of dinner and its nutritional quality will probably affect the sleep pattern, mind relaxation as well as recuperation overnight and blood glucose level during morning hours which in turn might affect the cognitive abilities of children.

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