Carbohydrates, Mood and Cognition

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The brain: The brain is the command center of the body, yet it lacks the ability of other organs to run on a range of fuels, and has only limited energy reserves. The brain is about two percent of body weight, and has been calculated to have about 86 billion neurons that consume 20% to 25% of basal metabolic rate, resulting in the consumption of 120 grams of glucose a day. The brain runs primarily on glucose, a source of energy that needs to be continually replenished as stores will be exhausted in five to ten minutes. A graphic illustration is offered by the occasions when patients with diabetes inject themselves with too much insulin and blood glucose falls to low values. Rapidly the brain, starved of glucose, is unable to function normally; vision may be blurred, speech slurred and cognitive functioning is generally disrupted. In the 1940s and 1950s insulin was used to starve the brain of glucose to induce a coma, in the belief it was a treatment for psychiatric disorders, in particular schizophrenia. As such, the level of glucose in the blood, largely a reflection of short and longer-term responses to carbohydrate consumption, plays an important role in neural functioning. Does carbohydrate consumption therefore influence how we think and feel? Do the effects of aging and dementia reflect changes in glucose metabolism and is carbohydrate supplementation beneficial?

Carbohydrate consumption: In fasted young and older adults, simply giving a drink containing glucose has been found to improve episodic memory.[1] Episodic memory is the recall of events associated with time, place and context, and contrasts with semantic memory that reflects factual information that lacks context. It is episodic memory that is particularly disrupted in dementia. Although various aspects of cognition have been studied, and on occasions a benefit from a sugary drink reported, the overwhelming impression is memory and mood improve most consistently.

Glucose tolerance: Glucose tolerance is an indication of how well, after the ingestion of carbohydrate, the body absorbs glucose from the blood. In those with good tolerance, after a meal blood glucose peaks after about half an hour, and returns to baseline values after about two hours. If levels initially rise to higher values, and stay at higher values for a longer period, this is described as impaired glucose tolerance or prediabetes. If the levels stay raised for even longer, then diabetes may be the reason. There are many reports that those with better glucose tolerance have a better memory. This phenomenon is found even in healthy young adults, where glucose tolerance is in the normal accepted range.[2] As we age, glucose tolerance tends to become impaired, and those with poorer glucose tolerance have a poorer memory.[3]

Glycemic load: If the pattern of changes in blood glucose level after a meal is associated with better memory, can foods enhance memory? Depending on the amount and type of the carbohydrate, foods differ in the extent to which they increase blood glucose levels. We often do not eat a single food, but rather several items that cumulatively produce the glycemic load (GL), the overall impact on blood glucose. There is increasing evidence that meals with a lower GL are beneficial, wherein blood glucose rises more slowly and

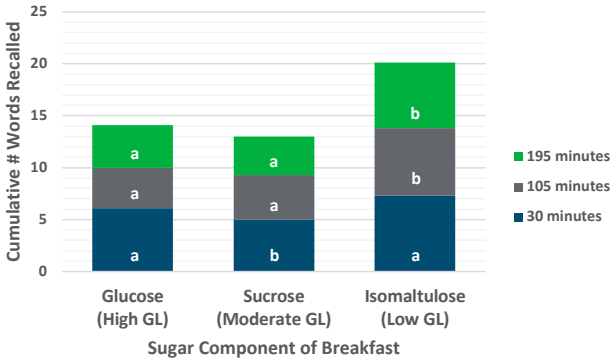

Fig 1. The influence of type of meal on memory.[3]
Groups with different letters show significant differences (P<0.03)
GL=glycemic load

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is released over a longer period. For example, a study of identical breakfasts, that varied only in the sugar chosen as a sweetener and hence differed in GL, reported that children at the end of the morning had better memories and mood after a low glycemic meal.[4] In older adults, without diabetes, it has been found that the memory and mood of those with good glucose tolerance were better after eating a meal with a low rather than high GL (Fig 1).[3] However, this effect was not observed in those with poorer glucose tolerance, albeit they did not have diabetes.

Children – a high risk group?: In children, basal metabolic rate, per unit of body mass, is higher than adults; in fact, from infancy to adulthood it declines to less than half its initial value. More specifically, a given amount of a child's brain tissue uses twice as much energy as a similar amount from an adult.[5] As such, we must consider whether children are particularly susceptible to the level of blood glucose and hence the consumption of carbohydrate. A study in the afternoon gave 9 to 10-year old children, on different days, a glucose-containing drink or a placebo.[6] On the days they received the glucose drink, they spent more time on task attending to their school work and had a better memory. Such a finding may be familiar to parents that find that the bad temper and poor attitude of their child can change for the better when the child has eaten at the end of the school day. Giving foods that slowly release glucose is likely a better choice over a sugary drink. Given the high metabolic requirements of children, a working hypothesis is that children need to regularly maintain blood glucose levels by consuming carbohydrate. The worry is that the advice to eat little and often, can become too much and too often, resulting in early obesity.

Blood glucose and dementia: Older adults are another high risk group, and may be more susceptible to the effect of blood glucose levels. Lower rates of brain glycolysis (glucose metabolism) are associated with the severity of the brain changes that are characteristic of Alzheimer's disease with its associated problems of memory.[7] As the hippocampus is the brain area responsible for memory, an interesting finding is that those, who some years before had higher levels of blood glucose, some years later had a greater reduction in the volume of this brain area.[8] Similarly, those who years before had higher levels of blood glucose, at post mortem had higher levels of brain glucose, that in turn were associated with the severity of dementia.[9] Although at present these relationships are only correlations, the question arises as to whether high levels of blood glucose, and hence carbohydrate consumption, predispose to dementia? In fact, persons with type 2 diabetes have a 60% greater chance of developing dementia, and some even call dementia "type 3 diabetes."[7]

What dietary advice should we give?: The association between high levels of blood glucose and the later development of dementia led to widespread media coverage with headlines such as "Sugar causes Alzheimer's disease." The more accurate but less sensational headline should have been "High blood glucose is associated with Alzheimer's disease." Similarly, throughout the lifespan, a low GL meal has been found to benefit mood and memory. Thus, the advice is to consume a low GL meal with a selection of low glycemic index (GI) foods to help maintain a healthy blood glucose level. The GI involves ranking foods on a scale from 0 to 100 according to the extent to which blood glucose increases after eating. A drink of pure glucose has a GI score of 100.

We need to shift our focus from sucrose as the major problem contributing to impaired glucose tolerance and high blood glucose levels. Sucrose is a disaccharide, that is only half glucose, with a moderate GI of 65. There are many more problematic foods with higher GI scores, eg, cornflakes, white bread, and baked potato. Adding fiber, protein and fat to a meal will help reduce the meal GL and slow the glycemic response.[10]

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