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Review

Feeding the brain: the importance of nutrients for brain functions and health

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Summary. 'We are what we eat', said the philosopher Feuerbach. In fact, the quality of the food we eat affects our mind as well: the brain, which represents 2% of our body weight, consumes about 20% of the calories we eat each day. Follow a few rules could therefore help to feed properly our brain, so it works to the best of its ability. It is important to know properties of foods especially regarding their aminoacidic composition because aminoacids are components of neurotransmitters, molecules needed for brain transmission and function. It is also possible to choose specific food to prevent or support different diseases that affects nervous system.

Key words: brain nutrition, neurotransmitters, acetylcholine, adrenaline, serotonin, endorphins

Introduction

The brain is composed of millions of cells called neurons. Thougths, memories, actions and other actions depends on the interactions between one cell and the others. The transmission between cells occur by chemicals called neurotransmitters (1). Neurotransmitters can be divided into two groups: inhibitory and excitatory. They are produced from exogenous substances; that is the reason because nutrition is essential for the correct function of the brain (2).

Neurotransmitters are composed of aminoacids that are found in food leading to a strong correlation between nutrition and mood (3).

Recent studies confirmed a relationship between food and mental disorders. A World Health Organization study of 14 countries reported a worldwide prevalence of mental disorders between 4.3 percent and 26.4 percent (4) and the prevalence of mental health disorders has increased in developed countries in correlation with the deterioration of the Western diet (5).

Previous research has shown nutritional deficiencies that correlate with some mental disorders (6,7). The most common nutritional deficiencies seen in mental disorder patients are of omega-3 fatty acids, B vitamins, minerals, and amino acids that are precursors to neurotransmitters. Compelling population studies link high fish consumption to a low incidence of mental disorders; this lower incidence rate has proven to be a direct result of omega-3 fatty acid intake (8-14). One to two grams of omega-3 fatty acids taken daily is the generally accepted dose for healthy individuals, but for patients with mental disorders, up to 9.6 g it has been shown to be safe and efficacious (15). Western diets are usually also lacking in fruits and vegetables, which further contributes to vitamin and mineral deficiencies (4).

Neurotransmitters in food

The principal neurotransmitters of the nervous system are acetylcholine (Ach), adrenaline and serotonin.

Acetylcholine

Ach is a parasympathetic neurotransmitter. It facilitates digestion and breathing. It is responsible of memory processes and of mental disorders.

Acetylcholine is not a component of foods; instead, it is built from choline. Choline is in lecithin and phosphatidyl choline, which is mostly contained in yolk, peanuts, wheat germ, meat, fish, cheese and vegetables such as cruciferous (16).

Eggs are a significant source of choline, mainly because their yolks contain lecithin. Raw egg yolks contain 682 mg of choline per 100 g of food, which is more than the total daily recommended amount. Cooked whole eggs have much less choline, depending on the method of preparation. Fried eggs have 272 mg, while hard-boiled eggs have 225 mg per 100 g of food (17).

Adrenaline

Adrenaline is synthesized from phenylalanine and is a sympathetic neurotransmitter. It contributes to gastrointestinal relax and dilation of the bronchi, increases heart rate, diverts blood flow to muscles, liver and brain and increases blood glucose. It is mostly contained in walnuts, almonds, meat and cheese.

Phenylalanine is an amino acid used to make proteins and brain chemicals including dopamine, adrenaline and thyroid hormones. Since our bodies cannot manufacture phenylalanine, we must obtain it from food. Phenylalanine is found in most foods that contain protein and also in the artificial sweetener aspartame. The recommended dosage is roughly 1000 mg for the average adult. Deficiencies are uncommon. A rare metabolic disorder called phenylketonuria, or PKU, occurs in people who cannot metabolize phenylalanine and can lead to irreversible mental retardation. People with PKU must eat a diet that avoids phenylalanine.

Most fish has high amounts of phenylalanine, in some cases nearly 1000 mg/100 g, which is an entire day's requirement. This includes cod, crab, lobsters, mussels, oysters, tuna, salmon and sardines. Meat, as a high-protein food, is also high in phenylalanine, in many cases containing more phenylalanine per serving than fish. Bacon, beef, turkey, liver, chicken and gelatin all contain over 1000 mg/100 g of phenylalanine.

Many milk products are high in phenylalanine. Cheese and milk, in particular, contain over 500 mg/100g. Cream and cream cheese, which are higher in fat and lower in protein, contain less amounts, but still in excess of 100 mg. An egg contains over 500 mg phenylalanine.

Most nuts are high in protein, which a significant amount is derived from phenylalanine. Five walnuts contains 540 mg, 10 almonds contains 980 mg, and 30 roasted peanuts contains 1400 mg. Peanut butter contains over 3500 mg/100 g. Beans, chickpeas and lentils contain the most phenylalanine, roughly 100 mg/100 g. Soy products, including soy protein isolate, soybean flour and tofu, are also good sources (18).

Serotonin

Serotonin is synthesized from tryptophan. Human body is not able to produce tryptophan so it has to be assumed with nutrients (19).

Serotonin is a inhibitory neurotransmitter, it acts on sleep patterns, sexual behavior, sensation of appetite and pain perception. It also stimulates intestinal peristalsis.

Many symptoms are associated to low serotonin levels such as pain, depression, personality disorders, insomnia, hunger, hypertension, premature ejaculation, poor memory, migraine.

Among the foods with the highest content of tryptophan there are cocoa (about 50 mg/100g), bananas (about 14 mg/100g), green vegetables (about 50mg/100g), almonds (394 mg/100g), whole grains (120 mg/100g), meat (about 400mg/100g), legumes (about 200 mg/100 g), yeast (more than 500 mg/100 g) and fish (about 300 mg/100 g) (20).

Endorphines

Endorphins are considered endogenous opiates. They are classified in pituitary endorphins (alpha, beta, gamma and delta) produced by the adenohypophysis and encephalic produced by the brain.

The highest concentrations of endorphins are found in the spinal cord, where there are the nerve fibers that transmit the sensations of pain to various parts of the body and in the brain in the areas involved in the perception of pain. Endorphin release is promoted by special conditions of physical and mental stress that put a strain to the body or to the mind (21).

Endorphins have analgesic action. Several studies have revealed low levels of endogenous morphine in people with headache. Everything that stimulates the production of endorphins can therefore represent a remedy for migraines and headaches.

Endorphins also have an antidepressant effect. Physical activity and smile stimulate the production and release of endorphins. They are also important for those who quit smoking as they replace the nicotine and during childbirth (22).

There are many sources of endorphins but their production can be increased; generally sweet and sugar stimulate their production, among them, the chocolate is at the first place but also the chili and spicy foods promote the release of endorphins (20, 23).

Food properties

Carbohydrates increase the absorption of tryptophan, which is converted in the brain to serotonin. That's why after consuming carbohydrates people feel more calm and relaxed for a few hours (24). Carbohydrates with low glycemic index (legumes, whole grains and fruits) have a relaxing effect due to the fact that do not cause large fluctuations in blood glucose levels and allow a reduced release of stress hormones. Contrary, the simple sugars, largely contained in industrial products, cause mood swings due to changes in blood glucose. The person becomes more irritable or less based on the blood glucose levels. Glucose also activates the dopaminergic system, effect similar to that one of drugs. This system, through the production of serotonin and norepinephrine, which gives a sense of calm and pleasure, pushes to persevere in taking certain substances (20, 23).

Rising food watch

Apples, grape juice, avocados and broccoli contain boron, responsible for hand-eye coordination and attention in the short term (25). The aroma of lemons can induce the feeling of alertness (20).

Rising food intelligence

Eggs, milk, liver, beef and turkey contain choline, essential for the construction of neurotransmitters (26, 27). Prunes contain high levels of antioxidants that neutralize free radicals responsible of the reducing memory and mental deterioration. Oats are able to increase the flow of blood to the brain with improvement of mental activities (28).

Food energizing

Tuna provides tyrosine, needed for the synthesis of dopamine and norepinephrine, which are important for the state of alert (20). Sunflower seeds contain magnesium. Magnesium is the fourth most abundant mineral and the second most abundant intracellular divalent cation and it has been recognized as a cofactor for more than 300 metabolic reactions in the body. Some of the processes in which magnesium is a cofactor include, but are not limited to, protein synthesis, cellular energy production and storage, reproduction, DNA and RNA synthesis, and stabilizing mitochondrial membranes. Magnesium also plays a critical role in nerve transmission, cardiac excitability, neuromuscular conduction, muscular contraction, vasomotor tone, blood pressure, and glucose and insulin metabolism. Because of magnesium many functions within the body, play a major role in disease prevention and overall health. Low levels of magnesium have been associated with a number of chronic diseases including migraine headaches, Alzheimer's disease, cerebrovascular accident (stroke), hypertension, cardiovascular disease, and type 2 diabetes mellitus. Good food sources of magnesium include unrefined (whole) grains, spinach, nuts, legumes, and white potatoes (tubers) (29).

Foods of happiness

The salmon elevates mood thanks to vitamin B12 and omega 3 that increase serotonin levels and reduce irritability (20). Tryptophan, which increases brain serotonin, is an effective antidepressant in mild to moderate depression. α-Lactalbumin, a minor constituent of milk, is one protein that contains relatively more tryptophane than most proteins. Acute ingestion

of α-Lactalbumin by humans can improve mood and cognition in some circumstances, presumably owing to increased serotonin (30).

Foods of sexuality

Walnuts, hazelnuts and peanuts contain L-arginine, which improves blood flow to the genitals. Chocolate controls the release of endorphins in the brain that increase the pleasure and contains phenylalanine which is a powerful stimulant (31).

Rising food sleep

Eating functional foods may promote sleep, including barley grass powder, whole grains, maca, panax, Lingzhi, asparagus powder, lettuce, cherry, kiwifruits, walnut, schisandra wine, and milk (32).

Sleep has an influence on eating behaviors, with insufficient sleep causing changes in the brain activity that may increase caloric consumption. The consumption of high-protein and carbohydrate intake may have a significant influence on sleep (33).

Food choices based on vegetable and fruit consumption are significantly associated with sleep duration (>8 h/night). Traditionally, lettuce has been recommended for its hypnotic property, with the main component found in n-butanol fraction of this plant (34).

Cherry ingestion may contribute to establish a high-quality sleep and be used as a potential nutraceutical tool to prevent sleep disorders with the advancing of age (35). The walnut may contribute to improve sleep based on the highest content in the antioxidants melatonin, serotonin and total polyphenols (36). Kiwifruit consumption may improve sleep onset, duration and efficiency in adults with self-reported sleep disturbances (37).

Conclusions

A healthy diet and regular physical activity can protect the brain from diseases, avoiding the risks incurred during aging (38).

The food on the encephalon works the same way as compounds pharmacologists.

Proper nutrition, sleep and exercise lead to activate a state of optimal mental health, resulting in an enhancement of brain function.

The immediate effects of the discovery of this connection include the ability to change diet in terms of improved cognitive skills, protection of brain diseases and slowed down the process of aging brain.

An important role is played by omega 3 fats contained in foods such as nuts, salmon and the kiwi, which help to prevent disorders of memory, depression and mental disorders such as schizophrenia, dyslexia and dementia.

The brain neurons communicate through synapses: omega-3s support synaptic plasticity, thus facilitating the process of memorization and learning.

In addition to the consumption of Omega 3, another important precaution to keep the brain in shape is absolutely avoid a high-calorie diet as Mediterranean diet shows (39).

Excessive consumption of calories reduces the flexibility of synapses, increasing the vulnerability of the cells, it is most exposed to damage of a free radical production (40).

On the contrary, it was shown that small portions of each food provide valuable nutrients and vary, furthermore guaranteeing complete protein and essential to the proper functioning of the brain (41).

Another sore point for the health of the brain is the consumption of junk food, high in saturated fats which are seriously detrimental to the welfare brain.

Experts warn that eating many packaged foods and unhealthy would like immediate consequence of being left with a brain junk, useless and malfunctioning, exposed to the danger diseases.

Obviously the diet alone is not enough to maintain a healthy brain, but it is important that it is accompanied by constant exercise and regular sleep.

Proper rest and the benefits of sport further strengthen the brain synapses, greatly improving the cognitive abilities of individuals.

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