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Sugars and fatty acids associated with attention-deficit hyperactivity disorder: Myth or reality?

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In simple terminology, attention-deficit/hyperactivity disorder (ADHD) is a mental health condition that causes inattention, hyperactivity and impulsive behavior. Out of many etiological reasons, dietary changes and adoption of western style diet is recognized as one, aggravating symptoms of ADHD, although the possible linkage of ADHD to alternation in nutrients is still dubious. The current article attempts to review the literature related to the role of fatty acids and sugar in ADHD. It can be inferred that fatty acid supplementation helps in ADHD, possibly through modulating the activities of neurotransmitters. Glucose is an important fuel for brain, but some researches claim that high intake of sugar by children with ADHD may accentuate the symptoms of ADHD, whereas others argue no such augmentation. Hence, there is a strong need of conducting more controlled researches in this arena to come to a consensus regarding omission or addition of these macronutrients in the diet of ADHD subjects.

Keywords: ADHD, fatty acids, sugars

Attention Deficit Hyperactivity Disorder (ADHD) have been characterized by the symptoms of inattention (involves careless mistakes, difficulty in maintaining sustained attention, does not seem to listen when spoken directly, doesn't follow instructions, difficulty in organizing tasks, dislikes tasks involving sustained attention, forgetful of daily activities, etc. persisting for six months), hyperactivity (exhibited as talking excessively, fidgety, difficulty in playing or indulging in leisure activities quietly, often runs about or climbs excessively in situations in which it is inappropriate, etc. persisting for six months) and impulsivity (involves blurting out answers before the question is completed, difficulty in waiting for turn and interrupts and intrudes others)(DSM-IVTR, 2000), which, along with its worldwide - pooled prevalence of 5.29% (Polancyzk et al., 2007) makes the situation grave.

Public perceptions of ADHD are replete with myths, misconceptions and misinformation about the nature, course and the treatment of the disorder (Ellison, 2003). It was reported in an Indian study that most parents of children with ADHD in a community clinic were reluctant to accept a biomedical explanation for their child's problems, preferring to attribute them to learning and memory difficulties (Blas & Kurup, 2010). Due to the inability to understand and accept the etiological grounds of the disorder, many myths generate regarding the activities associated with the development of children, as being the causative factors of ADHD. One such factor which plays a pivotal role in the child's physical and cognitive development is nutrition, which, suffers from the burden of misconceptions due to lack of understanding of the processing of the nutrients in body and their role in the functioning of the physiological processes.

The nutrients, specifically, sugars and fatty acids have gained the utmost concern and eventually, misinformation regarding their role in ADHD. Hence, the present study attempts to create insight in the functioning of sugar and fatty acids in the physiological processes and analyze their role in ADHD.

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Nutrients and ADHD

The role of fatty acids and sugars in ADHD is quite debatable. To explore and unveil their mechanism in ADHD, an overview of related literature was done. The current review discusses specifically the impact of these two macronutrients on children with ADHD.

Fatty acids

Fatty acids play central role in normal growth and development of brain. An adverse fatty acid supply disrupts the process of neurogenesis, neurotransmitter metabolism, and alters learning and visual function. Controversies regarding the role of fatty acids in ADHD persist but there are many studies in support.

Joshi et al. (2006) have elucidated that highly unsaturated fatty acids (HUFAs) supplementation led to a reduction in ADHD related symptoms in children with specific learning difficulties. Raz et al. (2009) also found that short chain essential fatty acids (linoleic acid and α- linolenic acid (ALA)) helped in ameliorating symptoms in ADHD children.

The short chain essential fatty acids, viz., Linoleic acid and ALA can be further desaturated and elongated by a series of enzymes. The main essential fatty acids (EFAs) that can be found after desaturation and elongation include arachidonic acid (AA), an omega-6 fatty acid, and eicosapentanoic acid (EPA), an omega-3 acid. EPA is further metabolized into docosahexanoic acid (DHA), which can be converted back to EPA in vivo. AA, EPA, and DHA are usually referred to as long-chain PUFAs (Raz & Gabis, 2009).

These long-chain PUFA also play vital role in ADHD. Various researches have been conducted on the positive effect of PUFA in ADHD. An improvement in inattention, hyperactivity and oppositional behavior/conduct disorder scores has been observed in children consuming EPA and DHA (Sorgi et al., 2007; Germano et al., 2007; Johnson et al., 2009). Sinn and Bryan, (2007), Sinn et al. (2008), Yehuda et al. (2011) have shown improvements in a test of the ability to switch and control attention (Creature Counting), quality of life, ability to concentrate, sleep quality and hemoglobin levels in the PUFA supplemented groups, although the duration of supplementation were different.

A link between ADHD and ratio of omega-6 to omega-3 fatty acid imbalances, particularly, relative lack of omega-3 fatty acids has been suggested by Schuchardt et al. (2010). The efficacy of omega 3 fatty acids compared to omega- 6 fatty acids in alleviation of symptoms of inattention among children with ADHD have empirically proven by a randomized, double-blind, placebo-controlled study by Belanger et al. (2009).

A current research by Gustafsson et al. (2010) have shown improvement in two ADHD subgroups (oppositional and less hyperactive/impulsive children) after 15-week EPA treatment and concluded increasing EPA and decreasing omega-6 fatty acid concentrations in phospholipids were related to clinical improvement.

Several studies have concluded that ADHD subjects had lower levels of omega-3 fatty acids, higher omega-6 fatty acid and lower ratio of omega 3 to omega 6 fatty acids, higher saturated fatty acids compared to their control counterparts and on supplementation of EFA, the level rise to improve the symptoms of ADHD (Mitchell et al., 1987; Stevens et al., 1995; Chen et al., 2004; Antalis et al., 2006; Colter et al., 2008; Raz & Gabis, 2009).

Researchers have suggested omega-3 fatty acid supplementation, particularly with higher doses of EPA, was modestly effective in the treatment of ADHD. The relative efficacy of omega-3 fatty acid supplementation was modest and safe compared with currently available pharmacological interventions (Richardson & Puri, 2000; Bolch & Qawasmi, 2011).

On intriguing further certain studies, (Aman et al., 1987; Arnold et al., 1987; Voigt et al., 2001; Stevens et al., 2003; Hirayama et al., 2004; Sinn, 2007; Milte et al., 2009) showed that PUFA supplementation did ameliorate the symptoms of ADHD but the difference was not significant when compared to the controls. Recently in a review article (Transler et al., 2010) it was concluded that placebo-controlled studies with ADHD or hyperactive children showed no effects on behaviors or cognition when only omega-6 PUFA or only DHA or omega-6 and omega -3 short-chain PUFA were supplemented, rather a combination of long-chain omega-3 and omega-6 fatty acids (DHA, EPA and gamma-linolenic acid [GLA]) supplemented daily for 3 to 4 months could lead to a reduction in ADHD symptomatology. Raz and Gabis (2009) inferred that though children with ADHD presented lower levels of blood EFAs, and open-label EFA supplementation trials in ADHD raised EFA blood levels and improved symptoms of ADHD but randomized controlled trials have generally been unsuccessful in demonstrating any behavioral treatment effects.

Possible mechanism

Though there has been no conclusive result on impact of PUFA on ADHD symptoms but the studies which report in the favor may be due to following reasons: PUFA are highly concentrated in the brain and play a vital role in the process of cognition and behavior function. PUFA are required for synthesis of eicosanoids, important signaling hormones with numerous complex functions. PUFA are involved in the synthesis and activities of brain peptides which are involved in modulating the activities of neurotransmitters (Sinn et al., 2010). During ADHD inefficient conversion of EFA to long chain PUFA, and thus, long chain PUFA to eicosanoids and enhanced cellular metabolism of long chain PUFA through non enzymatic oxidation may occur (Burges et al., 2000).

Sugars

Impact of sugars in children with ADHD is debatable. Outcome of studies on sugar intake and hyperactivity in children is quite discrepant. Numerous scientific studies show that children do not react to sugar and that sugar does not play a role in ADHD. On the other side, contradictory studies are also present.

A premier study (Prinz et al., 1980) reported a correlation between retrospective reports of sugar intake and aggressive behavior in hyperactive children. Sugar intake was also correlated with movement in control children. Wender and Solanto (1991) found an increase in inattention as measured by a continuous task performance on sugar ingestion by children with ADHD although, they did not find a relationship between sugar and aggression. Similarly, Langseth and Dowd (1978) found that hyperactive children manifested abnormal glucose tolerance in response to a sucrose. Also it was suggested that sugar ingestion triggered certain metabolic abnormalities in ADHD children. Children with ADHD have a general impairment of hormone regulation with sugar metabolism, and sugar may accentuate this defect (Girardi et al., 1995).

But later, groups of researchers preponderate the earlier effect and found no difference on playroom observations, examiner ratings, impulsivity scores or cognitive test performance after sucrose consumption. These studies were done either on normal children or hyperactive children or children believed to be sensitive to sugar (Behar et al., 1984; Ferguson et al., 1986; Wolraich et al., 1994; Kanarek, 1994).

Few studies have been done specifically on diagnosed ADHD children. Milich and Pelham (1986) and Shaywitz et al. (1994) indicated that sucrose or aspartame had no effect on the cognitive and behavioral status of children with attention deficit disorder. In addition, aspartame does not appear to affect urinary excretion rates of monoamines and metabolites. Above studies represent yet another failure to find evidence for any pervasive or marked change in children's behavior after consuming sucrose. A recent study by Blunden et al. (2011) has suggested an interrelationship between higher intake of carbohydrate, particularly, sugar and sleep in children with ADHD. Sleep disorder may further aggravate the symptoms of inattention, and impulsivity.

Possible mechanism

The researches which talk in support of sugar as a cause for ADHD may be due to the reason that sucrose causes an increase in adrenaline levels in children resulting in difficulty concentrating, irritability and anxiety (Jones et al., 1995). Plasma norepinephrine levels were observed to be lower in children with attention deficit than in control children after a standard oral glucose load (Todd and Botteron, 2001).

Dietary sugar provokes insulin production which may cause a reactive hypoglycemia, and furnishing of glucose to brain may be hampered.

Conclusion

The evidences cited above do suggest a role of fatty acids, especially, essential fatty acids and long chain PUFA in ameliorating the symptoms of ADHD in children, but due to variations in the supplementation pattern (quantity, time and combination) the recommended allowance for fatty acids for ADHD subjects cannot

be made. The studies discussed also brings into focus that ADHD is not triggered by the intake of sugar but consumption of sugar may increase the severity of ADHD symptomatology. At the same time there are studies which emphasizes that there is no relationship between the sugar intake and increase in the symptoms of ADHD. This makes the entire role of sugar in ADHD contentious.

Therefore, more controlled studies on the dosages and duration of the discussed macro nutrients supplementation are required to draw a conclusive opinion regarding their debatable status.

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