



Dietary Management of ADHD



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Attention deficit hyperactivity disorder (ADHD) is a neurodevelopmental disorder characterised by persistent, impaired and developmentally inappropriate levels of impulsivity, inattention and/or hyperactivity.^{1, 2} There are three sub-types of ADHD, diagnosed depending on what type of ADHD symptoms present more dominantly in the individual: hyperactive type, inattentive type or combined type.³ ADHD affects around 8% of children globally.^{1, 2}

The main treatments for ADHD include psychological and pharmaceutical therapies, including the use of stimulant medications.⁴ Yet, stimulant medications are not suitable for all, with many citing non-effectiveness or side effects, such as headaches, nausea and reduced appetite, as reasons for discontinuation.^{5, 6} Some families prefer not to use pharmaceutical treatments and choose alternative and complementary treatments instead, which include dietary adjustments and supplements.⁶ This article aims to review the current evidence surrounding the dietary management of ADHD.

Elimination diets

Historically, ADHD symptoms were thought to be linked to excessive sugar intake or E numbers, which is a message still perpetuated in the media.⁷ Elimination diets have generated attention for this reason, with many opting to restrict sugar and additives in their child's diet.^{8, 9} However, a systematic review reported no relationship between dietary sugar consumption alone and ADHD symptoms.¹⁰ In 2013, the European ADHD Guidelines Group completed a meta-analysis of 8 studies and found that excluding food colourings significantly improved ADHD symptoms, however the effects may be limited to those with food sensitivities.¹¹ Although, their 2021 guidelines suggest there is less evidence to exclude food colourings.¹² Additionally, the National Institute for Health and Care Excellence (NICE) guideline does not recommend the exclusion of additives or artificial colours from children's diets as a treatment for ADHD.⁴

Interestingly, elimination diets may also include restricting common food allergens, due to a hypothesis that some

children with ADHD exhibit food hypersensitivities.¹³ Elimination diets can vary in extremes, with some advising just a single food exclusion, whereas others encourage a 'few-foods' or oligoantigenic diet, which restricts the diet to a few low allergenic foods, such as lamb and rice for example.⁸ An initial elimination period helps determine whether food triggers ADHD symptoms, with children that respond to an oligoantigenic diet demonstrating improvements in behaviour or cognition.¹⁴ Allergens are then reintroduced, one at a time, to assess their impact on ADHD symptoms. Allergens that appear to worsen symptoms are then re-eliminated.⁸ Although statistically significant results have been shown in studies, the evidence for elimination diets is very limited due to the number of studies and their sample sizes. NICE guidance also flagged the lack of evidence for both short and long-term effectiveness.⁴ Additionally, there is concern that elimination diets could lead to nutritional deficiencies or poor growth.^{8, 14}

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Healthy eating

Children with ADHD are less likely to follow healthy eating patterns, often having an increased consumption of sugary drinks and lower consumption of fruits and vegetables.^{8, 15, 16} Multiple studies have identified that a 'Western diet' is associated with a higher risk of developing ADHD,¹⁷ with one randomised controlled trial (RCT) showing that children with a lower intake of fruits and vegetables were likely to have more severe inattentive symptoms.¹⁷ This has fuelled research into whether diets focused on improved dietary quality, such as the DASH (Dietary Approach to Stop Hypertension) diet, can improve ADHD symptomology.

The DASH diet was originally designed as the name suggests, to be a treatment for high blood pressure.¹⁸ It focuses on a high intake of fruits and vegetables, low fat dairy, nuts, legumes, whole grains and a low intake of salt, sweetened beverages and red and processed meats.¹⁸ A 12-week RCT completed in 6-12 year olds is the only study that evaluates whether the DASH diet has beneficial impacts on individuals with ADHD.¹⁹ This study reported, when compared to controls, children following the DASH diet had improvements in their ADHD symptoms, including emotional symptoms, prosocial behaviours and hyperactivity.¹⁹

It is vital to note the NICE guidelines recommend those with ADHD follow a healthy, balanced diet.⁴

Omega-3 and 6 fatty acids

Rather than focusing on the quality and balance of the diet, most studies have researched individual nutrient supplementation, with a large proportion of studies investigating the effects of fatty acids on ADHD.

Higher omega-3 concentrations in cell membranes positively affect serotonin and dopamine neurotransmission and with elevated levels of oxidative stress observed in ADHD, omega-3 may be of benefit with its anti-inflammatory role.⁶ As omega-3 cannot be synthesised by our bodies, it needs to be obtained via diet.⁶

Several studies have compared omega-3 supplementation against placebos in children with ADHD and found small but significant effects on ADHD symptoms. However, when these studies were analysed by systematic reviews, they were often limited by sample sizes and variability in methodology and participant selection criteria.²⁰ Additionally, the clinical significance of the benefits from omega-3 is unclear, with systematic reviews drawing several conclusions, including nil improvement in memory or information

processing or behavioural difficulties.^{8, 21} The efficacy of omega-3 supplements is lower when compared to ADHD medication and there is no consensus on the optimal dosing of omega-3 supplements, or whether omega-6 is more beneficial.^{6, 8} Interestingly, the NICE guidelines do not recommend fatty acid supplements for treating ADHD in children. However, these guidelines have not been updated since 2019 and research into fatty acid supplementation has skyrocketed since publication.⁴

Carnitine

Carnitine is derived from amino acids and is an essential cofactor that helps transport long-chain fatty acids into the mitochondria, so they can be oxidised, producing energy as adenosine triphosphate (ATP).²²

Several RCTs have shown no benefit compared to placebo in supplementing acetyl-L-carnitine or L-carnitine.⁶

Probiotics & prebiotics

Interest in the microbiome and its role in the gut-brain axis is growing, especially in regards to neurodevelopmental conditions.⁸ Research has shown neurotransmitters, which play roles in sensory processing pathways, mood and behaviour, including serotonin and dopamine, can be produced and regulated by the microbiome.^{23, 24} The microbiome may be atypical in children with ADHD compared to neurotypical children, with differences in bacterial diversity even observed between those with ADHD taking stimulant medication and those who are unmedicated.^{25, 26} Associations have been documented between ADHD symptoms and gut microbiome features.⁸

As previously mentioned, those with ADHD may struggle to maintain healthy dietary habits, which help to promote diversity and abundance in the microbiome, such as adequate fruit and vegetable intakes.¹⁵ No studies exist looking solely at prebiotics and their effects on ADHD, whilst only 2 studies investigate synbiotics and 7 studies explore probiotics.²⁷ *Lactobacillus rhamnosus* GG (LGG) is the only probiotic shown in systematic reviews to improve emotional, physical, social and school functioning.^{8, 27} Whereas there is very limited evidence that synbiotics improve ADHD symptoms.²⁷

Trace elements

Iron is a cofactor for tyrosine hydroxylase, which is critical in dopamine and noradrenaline production.⁶ In addition, zinc and iron both act as dopamine reuptake inhibitors, which is the same mechanism of action as stimulant medications used in treating ADHD.⁸

Lower dietary intakes of micronutrients, including zinc, have been observed in children with ADHD.⁸ Therefore, it may be no surprise that multiple studies have identified that children with ADHD have reduced serum levels of trace elements, including iron, magnesium, zinc, copper and selenium, which are essential for brain development and functioning.⁸ Interestingly, symptoms of zinc deficiency are similar to ADHD symptoms, including delayed cognitive development, inattention and poor memory.^{6, 28} Trials have been completed investigating zinc supplementation, iron supplementation and combined zinc and iron supplementation.

Both zinc and iron supplementation improve overall ADHD symptoms, but with limited effects on hyperactivity or impulsiveness.^{8, 14} The evidence for zinc supplementation is stronger than the evidence for iron.²⁸ Studies have struggled to establish any correlation between baseline serum levels of trace elements and ADHD outcome measures, so it is unclear if those who are most deficient at baseline benefit the most from supplementation.^{8, 28} Additionally, no consensus on the optimal dosing or duration of zinc or iron supplementation has been achieved.¹⁴

Vitamin D

Similar to the research into trace elements, vitamin D has been of focus due to significantly reduced vitamin D levels in those with ADHD compared to those without.¹⁴ Remarkably, no research exists into other vitamins and ADHD.

In a systematic review, vitamin D supplementation, when used alongside stimulant medication, showed a statistically significant, but small, improvement in behaviour, hyperactivity, inattention and ADHD total scores. However, the effects of vitamin D were limited by the low quality of evidence provided by the original studies.²⁹ Additionally, only one study that was included in the systematic review checked serum vitamin D levels at baseline. This study showed children who had vitamin D sufficiency at baseline did not demonstrate improvements in ADHD symptoms following supplementation, which could indicate supplementation is only beneficial in those who have insufficient or deficient vitamin D levels.⁸

In one RCT, participants had significantly reduced emotional problems and improvements in their prosocial score, following 8 weeks of paired vitamin D and magnesium supplementation.⁸

Multinutrient supplements

Several studies, although not ADHD specific, have suggested that broad-spectrum micronutrient or 'multinutrient' treatments are more beneficial than single nutrient treatments for mood and behaviour.³⁰ This led to the rise of several RCTs investigating 'multinutrient' supplement use in ADHD. An example of this is the MADDY study, which investigated improvements in emotional dysregulation in children with ADHD who were supplemented for 8 weeks with a mixture of antioxidants, amino acids, vitamins and minerals.³¹ The levels of nutrients provided were above the Recommended Dietary Allowance (RDA) (the American equivalent of Recommended Nutrient Intakes [RNI]). Regardless of dietary quality at baseline, the study found that three times as many children had improvements in their behaviour and emotional regulation compared to those receiving a placebo.³¹

A similar study, completed between 2013-2016 in unmedicated children with ADHD, demonstrated that those receiving a supplement containing 13 vitamins, 17 minerals and four amino acids had an improved overall function, inattention, emotional regulation and reduced impairment and aggression. However, there was no change in hyperactive or impulsive symptoms.³⁰

Conclusion

It is hard to draw any firm conclusions on the dietary management of ADHD due to the grand variation between studies in their methodology – for example, population age, country of origin, medicated status or the outcome measures used to measure improvement in ADHD symptoms, including Conners scale, Clinical Global Impression-Improvement scale or self-reported, teacher reported, and parent reported scores. It may be suggestable to advise patients to follow a healthy balanced diet, and where clinically indicated by clinical concerns or reported dietary intake, to check serum levels and/or supplement with micronutrients. In particular, more research is needed regarding optimal nutrient supplementation, duration and efficacy.

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