FEATURE ARTICLE

NEURODIVERGENCE:

EVIDENCE-BASED CONSIDERATIONS FOR NUTRITIONAL THERAPY AND PERSONALISED LIFESTYLE SUPPORT

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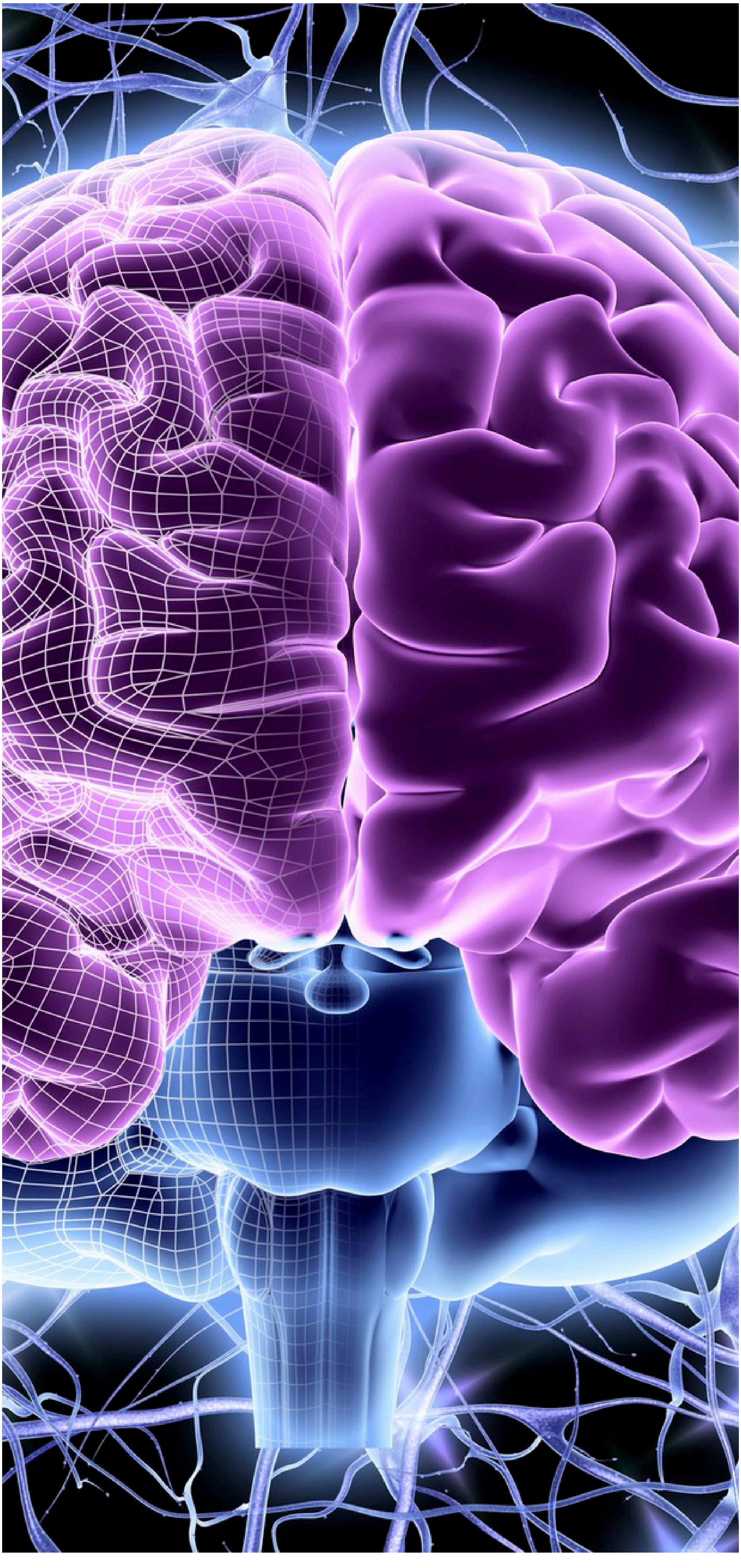

NEURODIVERGENCE:

EVIDENCE-BASED CONSIDERATIONS FOR NUTRITIONAL THERAPY AND PERSONALISED LIFESTYLE SUPPORT

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ABOUT NEURODIVERGENCE

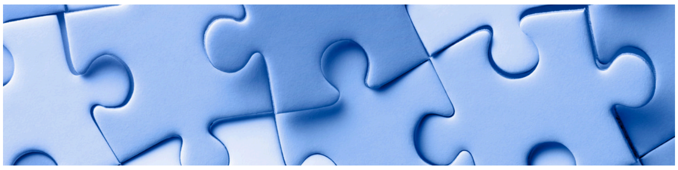
ABSTRACT

Neurodivergent individuals (including autistic individuals and those with ADHD) can sometimes present with gastrointestinal symptoms, nutritional deficiencies and selective eating. Dietary and lifestyle factors may play a role in supporting these individuals. Additionally, various macro and micronutrients, including essential fatty acids, key minerals such as iron, magnesium, and zinc, and vitamins including A, D, and B-complex may be deficient in certain individuals.

Emerging evidence suggests that supplementation, alongside dietary and lifestyle strategies, may support symptom management and wellbeing. Optimising gut health and microbiome balance, alongside personalised lifestyle strategies, may further enhance support. This narrative review summarises current evidence on the role of nutrition in supporting neurodivergent individuals, with the aim of guiding evidence-based therapeutic decision-making in clinical practice.

INTRODUCTION

Neurodivergence refers to a neurocognitive profile that diverges from the majority (1) and encompasses conditions traditionally classified as neurodevelopmental disorders such as attention deficit hyperactivity disorder (ADHD), autism, dyslexia, and developmental coordination disorder (DCD). Globally, prevalence estimates are approximately 1% for autism (3), 6% for ADHD (4), 7% for dyslexia (5), and 5% for DCD (6), indicating that neurodivergence affects a substantial proportion of the population. While these conditions are heterogeneous in presentation, impact, and intervention requirements, they nonetheless demonstrate considerable overlap, frequent co-occurrence, and shared traits (6,7) This supports the value of a broad, integrative approach, particularly in exploring the potential role of nutritional and lifestyle interventions. Terminology used throughout this paper is non-pathologising and non-stigmatising, aligning with recommendations from Dwyer et al. (8) to adopt identity first language (i.e. autistic person) in relation to autism.



Gastrointestinal problems are common in autistic individuals (9), with estimates ranging widely from 9-91% (10,11). Evidence also suggests a higher prevalence of gastrointestinal issues in individuals with ADHD (12) while research on this topic in DCD and dyslexia remains limited. Furthermore, evidence is gathering that the gut microbiota of autistic individuals and those with ADHD may differ to that of typically developing individuals (13–15), suggesting a potential role for the gut/brain axis in these conditions. Nutritional deficiencies have also been reported, across these conditions, in nutrients such as iron and omega-3 fatty acids which play a key role in brain health and development (16,17). Addressing gastrointestinal symptoms and nutritional deficiencies in neurodivergent individuals may help enhance quality of life and wellbeing.

NICE guidelines (17,18) for neurodivergent individuals encourage early-interventions and holistic family-centred care including psychosocial interventions, behavioural therapies, educational support and pharmaceutical interventions with some recognition of the role of healthy dietary choices and individual sensitivities for those with ADHD. Families and individuals often seek integrative ways to support themselves and their children, with the use of nutritional therapy and lifestyle support being increasingly utilised.

It is of critical importance that such interventions are guided by a strong scientific evidence base. Nutritional programmes must be 'personalised and tailored to an individual patient' (18) and it is essential that practitioners have access to rigorous, up-to-date scientific reviews to inform safe and effective care. This narrative review provides an overview of the current evidence for nutritional and lifestyle support and interventions, aimed at supporting nutrition practitioners in making recommendations for neurodivergent clients.

DIETARY INTERVENTIONS

WHAT ARE THE POTENTIAL BENEFITS OF DIETARY INTERVENTIONS FOR NEURODIVERGENT INDIVIDUALS?

Neurodivergent children, particularly those who are autistic or diagnosed with ADHD, may exhibit atypical responses to dietary components such as gluten (found in wheat, barley, oats, and rye), casein (from mammalian dairy), and soy (19).

Adams and colleagues (2018) report higher rates of food hypersensitivity in autistic children compared to neurotypical peers, with gastrointestinal issues, deficiencies in digestive enzymes, limited diets, and food sensitivities significantly correlating with autism severity ($r = 0.59$, $p < .001$) (20). Although some studies suggest an association between ADHD and coeliac disease, findings remain inconsistent (21).

Evidence for the effectiveness of elimination diets remains mixed. A six-week gluten-free (GF) dietary intervention in Iran, involving 76 autistic children, resulted in significant reductions in gastrointestinal symptoms and stereotyped behaviours, as measured by the Gilliam Autism Rating Scale–Second Edition (80.03 ± 14.07 vs. 75.82 ± 15.37; $p < .05$) (22). However, seven other studies of gluten- and casein-free (GFCF) diets in children aged 2–12 years reported no statistically significant effects (23–29). Some research has nevertheless reported improvements in language development, hyperactivity, tantrums (30), and core autistic traits (31). Hafid & Ahami (2018) suggested that positive responses may be limited to children with both elevated urinary peptide levels and gastrointestinal issues. It may therefore be important to identify subgroups most likely to benefit (25). Additionally, GFCF diets have been associated with adverse gastrointestinal effects (31).

The Few Foods Diet (FFD), or oligoantigenic diet, eliminates commonly consumed, potentially reactive foods (e.g., gluten, dairy, citrus), and allows only a limited selection of tolerated foods. Designed primarily as a diagnostic tool rather than a long-term treatment, the FFD has shown potential in small-scale trials. A five-week Randomised Controlled Trial (RCT) involving 24 children aged three–eight years reported a significantly greater reduction in physical and sleep complaints in the diet group (77%) compared to controls (17%) ($p = 0.001$)(32). Similarly, an oligoantigenic intervention in 16 children aged 7–13 years reported significant reductions in Autism Rating Scale scores following a four-week elimination phase (33). A meta-analysis of five RCTs concluded that the FFD significantly reduced ADHD symptoms, with larger effect sizes than other dietary interventions (34). However, the FFD is highly restrictive, difficult to sustain, and its mechanisms remain poorly understood. Less restrictive dietary strategies designed to target the gut microbiome may offer a more feasible and sustainable long-term approach (35).

Ketogenic (KT) diets have also shown promise, with a three-month modified GF KT diet (high-fat, appropriate-protein, and low-carbohydrate), supplemented with medium-chain triglyceride oil, improving core autistic characteristics in 15 children aged 2–17 years (36), while a six-month KT pilot study involving 30 children aged 4-10 years reported significant improvements in the Childhood Autism Rating Scale, of 4.77 (SE 0.89) $p < .001$) (37). Despite promising results, findings for dietary interventions remain heterogeneous and larger, well-controlled trials are needed to determine their therapeutic potential and identify which individuals are most likely to benefit.

Whilst evidence reports behavioural and gastrointestinal symptoms may be alleviated through the removal of specific dietary components, practitioners are reminded of other regimes, which may already be familiar in practice, such as the Mediterranean, low FODMAP and Glycaemic Load Diets (38) as well as the introduction of fermented foods (39) and foods rich in polyphenols. Personalised use of such dietary approaches may be helpful for symptom management and wellbeing for neurodivergent individuals.

NUTRITIONAL SUPPORT

HOW CAN WE SUPPORT NEURODIVERGENT INDIVIDUALS WITH RESTRICTED DIETS AND...

...AVOIDANT/RESTRICTIVE FOOD INTAKE DISORDER (ARFID)?

Avoidant/Restrictive Food Intake Disorder (ARFID) is a feeding and eating disorder that significantly affects nutritional status, weight, and psychosocial functioning (40–44). In contrast to other eating disorders, individuals with ARFID are not concerned about their body shape or weight (41), but their food avoidance typically stems from three primary factors: lack of interest in eating, sensory sensitivity to the characteristics of food and fear of aversive consequences such as vomiting or choking (40–42,45).

Autism and ARFID demonstrate a notable coexistence as autistic individuals frequently display behavioural and cognitive patterns including restrictive eating habits resulting from sensory sensitivities (41,42,45). Mealtime behaviour and eating patterns for neurodivergent individuals are deeply affected by how their sensory processing alters their perception of smell, taste and texture (46,47). These sensory challenges often lead to food selectivity, neophobia, and increased distress during mealtimes which can limit dietary variety and nutritional intake (Nimbley et al., 2022; Cobbaert et al., 2024).

When food selectivity is present, neurodivergent individuals may benefit from adapted support aimed at enhancing their intrinsic motivation and sensory functioning, as well as optimising the physical and social environment, to make their mealtimes more enjoyable (47). A tailored sensory intervention, based on a thorough sensory assessment, may be an effective way to support atypical eating behaviours in neurodivergent individuals (46).

Recent intervention studies, including those evaluating sensory-based therapies, have demonstrated positive outcomes in enhancing oral motor skills, increasing food acceptance, and decreasing distressed behaviours during mealtimes (47). Additionally, cognitive behavioural therapy for ARFID (CBT-AR), especially exposure-based approaches, has shown promising results in reducing food avoidance among neurodivergent children and adolescents by targeting core mechanisms such as sensory sensitivity and fear of aversive consequences (43,44,49).

While CBT-AR can help neurodivergent individuals increase food intake, their parents/caregivers' role is equally important. Their involvement during interventions helps them to better manage their child's behaviour at home, promoting continued progress and encouraging generalisation of learned abilities and the inclusion of new food (44). Interventions that are both sensory-based and family-centred appear to offer the most sustainable support in addressing restrictive eating and broadening food repertoires (50).

Increasing research supports the gut microbiota's involvement in food selectivity and gastrointestinal issues which frequently occur in neurodivergent individuals (51,52). Autistic children often experience gut dysbiosis which can lead to inflammation along with sensory sensitivities and restrictive eating habits (12). Prebiotic and probiotic supplements along with foods abundant in polyphenols and flavonoids demonstrate effective outcomes in inflammation reduction and oxidative stress protection while simultaneously promoting gut health, reducing gastrointestinal issues and enhancing behavioural outcomes (51). Thus, approaches that support the gut–brain axis may act as complementary measures to CBT and parent/caregiver-led interventions when addressing ARFID and related feeding problems (53).

A multidisciplinary approach that addresses ARFID as a multi-faceted eating disorder can produce effective support for food selectivity issues in autistic children (54). Healthcare professionals need to conduct combined evaluations of nutritional status and sensorimotor capabilities to devise tailored interventions which recognise both sensory preference drivers in children and their family environment. Structured desensitisation methods including gradual exposure techniques alongside texture fading and supportive mealtime environments, which are part of multicomponent strategies, may help improve family wellbeing together with nutritional outcomes.

SUGAR & ARTIFICIAL ADDITIVES

WHAT IMPACT DO ARTIFICIAL ADDITIVES AND SUGAR HAVE ON NEURODIVERGENT INDIVIDUALS?

Research on the influence of food additives on neurodivergence dates to the 1970's when Feingold reported that hyperactive children consume larger than typical amounts of food additives (55). This led to the development of the Feingold diet, which excluded the consumption of salicylates (56). Since then, dietary exclusion of food additives for individuals with ADHD has become controversial. Whilst some research has shown positive outcomes with exclusion, others have not. One systematic review and meta-analysis of 54 randomised control trials (RCTs) reported that eight trials looked at an artificial food colour exclusion diet (AFC), which involved adoption of the Feingold diet, or the exclusion of tartrazine, or the exclusion of specific food colours (57). The results showed that positive treatment effects were seen on ADHD symptom severity with the AFC diet (SMD:0.32, 95% CI:0.06, 0.58, p = 0.02). However, more recently a systematic review of six meta-analyses of double-blind placebo-controlled trials looked at diets eliminating AFC, amongst others (58). It reported that although the exclusion of food colours did affect ADHD symptoms, the effect sizes were too small to warrant giving parents and caregivers a list of additives they should eliminate from their child's diet (effect size range 0.08 to 0.44). Yet they are large enough to warrant further research, and any effect may be enough for some parents or caregivers to consider eliminating food additives.

Whilst additive removal may have a small effect, added sugars in foods may have an impact on children. Sugar-sweetened beverage (SSB) consumption before the age of two-years has been shown in one cohort study, to be associated with an increased probability of ADHD development (59). The cohort included 25,305 children from Korea at 24 months of age, who had been exposed to high SSB's from juices and soft drinks (≥200 mL) and 339,931 who had not (<200 mL). Over a mean follow-up period of 9.2 years the incidence of ADHD was higher in those given SSB's compared to the reference group (29.6 and 23.8 per 10,000 person-years) and these individuals had an increased likelihood of developing ADHD (adjusted hazard ratio (HR): 1.17, 95% confidence interval [CI] 1.08–1.27).

This was sustained from the ages of two to three years (HR: 1.14 95% CI: 1.05–1.23). Amongst adults, it has also been shown that SSB's may exacerbate ADHD symptoms (60). This cross-sectional study of 441 medical students reported that daily added sugar intake from beverages higher than 25g/day had a 1.8 times higher probability of ADHD symptoms than students who reported lower consumption (adjusted odds ratio: 1.80, 95% CI: 1.15 to 2.84, $p = 0.011$). Although these data do not establish causality, they warrant further investigation. It is interesting to note that both trials included beverages that have added sugars and other additives and preservatives and a combination of these may be responsible for the heightened response.

Practitioners should be aware that the involvement of food additives in the development and exacerbation of neurodivergent symptoms may be small when excluded in isolation. Foods containing additives are often also high in added sugars and when combined may have a cumulative effect on ADHD development and symptoms. Instead of focusing on specific additives, eliminating or reducing ultra-processed foods may support the reduction of additives and sugar for adults and children with ADHD.

PRE & PROBIOTICS

WHAT DOES THE EVIDENCE SAY ABOUT THE ROLE OF PROBIOTICS AND PREBIOTICS IN SUPPORTING NEURODIVERGENT INDIVIDUALS?

The gut-brain axis has been cited as a potential pathway through which the gut can communicate with the brain. Dysbiosis of the gut microbiota has been seen in autistic children and those with attention deficit hyperactivity disorder (ADHD) and may be associated with the development of neurodivergence. One systematic review and meta-analysis of 18 studies including 493 autistic children and 404 controls showed that autistic children have a microbiota composition dominated by species in the Bacteroidetes, Firmicutes, and Actinobacteria phyla compared to controls ($p = 0.002$, $p < 0.001$, and $p < 0.001$ respectively) (61). This was reflected in higher abundances of Bacteroides ($p < 0.001$), Parabacteroides ($p < 0.001$), Clostridium ($p < 0.01$), Faecalibacterium ($p = 0.04$), and Phascolarctobacterium ($p = 0.02$), and a lower abundance of Coprococcus ($p = 0.004$) and Bifidobacterium ($p < 0.001$). Children with ADHD have shown similar gut dysbiosis to autistic children. In one randomised control trial (RCT) of 75 infants who were followed until adolescence, it was shown that there was a lower abundance of Bifidobacterium species in the first 6 months of life of children who were later in life diagnosed with ADHD (8.26 (1.24) log cells/g than in neurotypical children (9.12 (0.64) log cells/g; $p = 0.03$) (62).

Whilst gut dysbiosis may be present in those with ADHD and autistic children, the use of probiotics to support autistic individuals may be dependent upon whether they are single or multi-strained. One systematic review and meta-analysis of six RCTs with 302 children showed that the use of probiotics had no effect on autistic behaviours as measured by the Aberrant Behaviour Checklist and the Child Behaviour Checklist (63). However, it did improve gastrointestinal symptoms (GI) (MD=-0.59, 95%CI [-1.02,-0.17], $p = 0.006$). Similar results were seen in a second systematic review and meta-analysis of 10 child studies, with no effect of probiotic supplementation on autistic behaviours. However, this study reported that unlike single-strain probiotics, multi-strain probiotics may reduce autistic behaviours (pooled SMD: −0.42, 95% CI: −0.83 to −0.02, $p = 0.04$). Multi-strain probiotics (8x109 CFU of each of L. helveticus, B. animalis ssp. lactis, Enterococcus faecium, B. longum and Bacillus subtilis) have also been shown in one three-month RCT of 60 college students to decrease hyperactivity ($p = 0.012$) but have no effect on attention, timing, or impulsivity (64). Higher academic grades were associated with lower levels of hyperactivity and impulsivity in those who received probiotics ($r_s = 0.554$, $p = 0.005$ and $r_s = 0.520$, $p = 0.009$, respectively).

Timing of probiotics may be important and if given early, probiotics may reduce the likelihood of developing neurodivergence. Pärtty et al. (2015) also showed in their trial that giving a probiotic in early life may decrease the likelihood for the development of ADHD and autism. The 75 infants in this trial were given Lactobacillus rhamnosus GG (1x1010 colony-forming units) or placebo during the first six months of life and at the age of 13, ADHD or autism was diagnosed in 17.1% of children given placebo but in none of the children given probiotics ($p = 0.008$)(62).

To date, prebiotics have also shown limited effects on autistic behaviours. In a recent RCT of 41 autistic children the supplementation of glucooligosaccharides (GOS) (2.4g/day) compared to placebo did not affect social and mealtime behaviour and only marginally affected GI symptoms, despite an increase in Bifidobacterium levels (1.4–5.9%, $p = 0.001$) (66). In contrast, the addition of prebiotics to probiotics has been shown to be beneficial for the management of ADHD symptoms. In one 10-week RCT of 231 adults with ADHD and/or borderline personality disorder (BPD), the supplementation of a synbiotic containing 400 billion lactic acid bacteria/dose in combination with fermentable fibres (2.5g/dose) was shown to improve irritability compared to placebo (OR: 0.2, 95% CI: -6.8 to -0.3; $p = 0.03$) (67). Emotional dysregulation (−3.6, 95 % CI:-6.8 to −0.3; $p = 0.03$), emotional symptoms (−0.6, 95 % CI:-1.2 to −0.05; $p = 0.03$), inattention (−1.8, 95 % CI: −3.2 to −0.4; $p = 0.01$), functioning (−2.7, 95 % CI: −5.2 to −0.2; $p = 0.03$), and perceived stress (−0.6, 95 % CI: −1.2 to −0.05; $p = 0.03$) were also all improved compared to placebo. However, improvements with synbiotics may be limited to individuals with elevated soluble vascular cell adhesion molecule-1 (sVCAM-1), which is a marker for vascular inflammation. In a second RCT of 182 adults and children with ADHD given a lactic acid bacteria (4x1011 CFU) and fermentable fibre (2.5g) synbiotic, no improvements were seen in ADHD symptoms compared to placebo (68). However, in children with elevated sVCAM-1 (>519519.7 pg/mL) at baseline, synbiotics reduced autism characteristicss (95% CI: −0.083, −0.001, $p = 0.044$), and restrictive, repetitive, and stereotyped behaviours (95% CI: −0.199, −0.006, $p = 0.039$). In adults with elevated sVCAM-1 improvements to emotional regulation were observed (95% CI: −17.0, −2.40, $p = 0.011$) especially in the domains of clarity (95% CI: −2.56, −0.088, $p = 0.037$), goals (95% CI: −4.37, −0.291, $p = 0.027$), strategies (95% CI: −5.51, −0.457, $p = 0.002$), and nonacceptance (95% CI: −3.39, −0.125, $p = 0.036$) of the Difficulties of Emotional Regulation Scale-16.

Practitioners may like to consider that gut dysbiosis and lower numbers of Bifidobacterium may be associated with neurodivergence. However, despite this, the supplementation of single strain probiotics may have limited effects on autistic and ADHD behaviours. To better manage hyperactivity, multi-strain probiotics may be beneficial. Given that timing of supplementation may be important and with neurodivergence having a genetic element, neurodivergent parents may like to consider multi-strain probiotics in early life to reduce the likelihood of the development of autistic and ADHD behaviours in children. Synbiotics may be an overall better choice for some adults and children with benefits to emotional regulation. Assessment of sVCAM-1 levels may help to understand who would best benefit from synbiotic supplementation; however further research is required before it is considered a reliable biomarker.

ESSENTIAL FATTY ACIDS

CAN ESSENTIAL FATTY ACIDS SUPPORT THE WELLBEING OF NEURODIVERGENT INDIVIDUALS?

Polyunsaturated omega-3 fatty acids (n-3 PUFAs), including eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), are essential nutrients that the body converts inefficiently and must therefore be obtained through diet (69). DHA, the most abundant omega-3 in the brain, is critical for the development and function of the cerebral cortex and hippocampus, regions essential for learning and memory (70,71). In an RCT, 401 five-year-olds whose mothers received 400 mg/day DHA during pregnancy demonstrated better cognitive outcomes than 397 controls, with lower omission T-scores on the Conners' Kiddie Continuous Performance Test ($p < .01$) (72). Specifically, children in the DHA group had better performance on the Conners' Kiddie Continuous Performance Test, with lower omission T-scores (DHA: 47.6 ± 10.3; placebo: 49.6 ± 11.2; $p < .01$), indicating enhanced attention.

Deficiencies in n-3 PUFAs have been implicated in attention-deficit/hyperactivity disorder (ADHD). Children and adolescents with ADHD show significantly lower red blood cell (RBC) n-3 PUFA levels compared to controls (73,74), with lower levels linked to more severe symptoms (51). A systematic review of seven studies involving 590 children (aged 8–12) reported that 500 mg/day EPA significantly improved inattention ($p < .0001$), and six studies ($n = 551$) found improvements in hyperactivity ($p = 0.04$) (76). However, a recent meta-analysis of 37 trials found only low-certainty evidence for PUFA benefits, with high-certainty evidence showing no effect on parent-rated symptoms (74).

Similar deficiencies have been observed in autism. In a study of 121 autistic children (aged 3–17) and 110 controls, autistic participants had significantly lower RBC levels of arachidonic acid (AA) and DHA (77). An RCT involving 31 preterm autistic infants (18–38 months) showed that supplementation with EPA (338 mg), DHA (225 mg), and γ-linolenic acid (83 mg) led to significant behavioural improvements on the Brief Infant-Toddler Social and Emotional Assessment compared to canola oil controls (difference in change = −2.1 points; 95% CI: −4.1, −0.2) (78).

There may be a potential role for omega-3 fatty acids in the development of reading abilities. In a study of 42 children (25 with dyslexia) positive associations were found between omega-3 blood concentrations and reading performance (79). A similar study in adults (32 with dyslexia and 20 controls) demonstrated higher levels of word reading were associated with higher total omega-3 concentrations across groups, although there were no significant absolute differences in membrane fatty acid levels between those with dyslexia and controls (80). However, a clinical trial assessing supplementation with omega-3 fatty acid (ethyl-EPA, 500 mg/day) and carnosine (400 mg/day) in children with dyslexia, found no benefits compared to placebo (81). In one study, children with DCD ($n = 117$) received daily omega-3 (558 mg EPA, 174 mg DHA), omega-6 (60 mg γ-linolenic acid), and vitamin E. After three months, the treatment group showed improvements in reading ($p < 0.004$), spelling ($p < 0.001$), and behaviour ($p < 0.01$), but not motor skills (82), suggesting that the combination of acids may be important for maximising benefits.

Practitioners should be aware that evidence is mixed with regard to the role of dietary supplementation with n-3 PUFAs for neurodivergent individuals. However, supplementation with EPA and DHA, may offer safe and potentially beneficial support for neural development and function in some individuals with developmental conditions. Further research is needed to determine optimal dosages and fatty acid combinations and to explore whether benefits extend to adults.

MICRONUTRIENTS

HOW CAN MICRONUTRIENT SUPPLEMENTATION WITH MINERALS SUPPORT THE WELLBEING OF NEURODIVERGENT INDIVIDUALS?

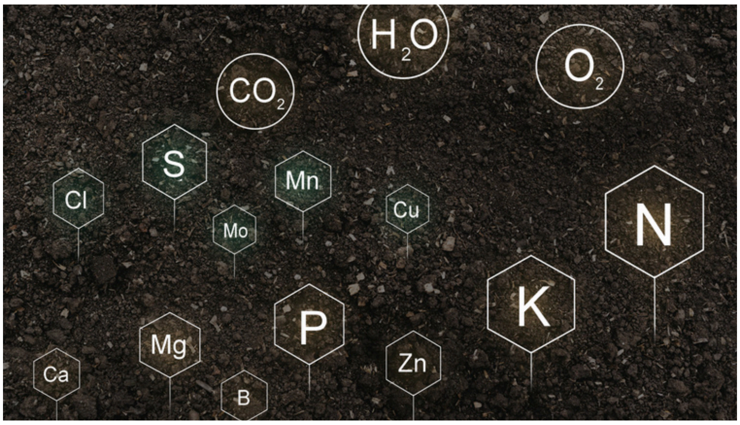
Mineral deficiencies may be an influencing factor in the aetiology and progression of ADHD (83). Autistic children may also have an increased need for minerals due to a range of metabolic issues including increased oxidative stress, mitochondrial disorders, methylation issues and substrate deficiencies (sulfate and lithium) (84). Additionally, feeding issues and ARFID are associated with autism (60), and this may perhaps be reflected in mineral deficiencies often seen in autistic individuals (86).

Iron (Fe)

Iron deficiencies have been noted in patients with hyperactivity (87). Selective eating habits may also lead to deficiencies in autistic children (88). Adequate dietary intake of Fe is essential for neurotransmitter function. It is required for dopamine synthesis which takes place in the prefrontal cortex, a key area of the brain structure that has also been associated with ADHD. Additionally, a reduction in dopamine transporter activity has been associated with the progression of ADHD (87). It has been hypothesised that Fe supplementation could improve characteristics of hyperactivity, impulsiveness and inattentiveness in individuals with ADHD (83). These results were reflected in a 2017 RCT of N=42 non-anaemic children with low serum ferritin diagnosed with ADHD (87). Ferrous sulfate was supplemented as an adjuvant therapy to methylphenidate at a dose of 5mg/kg/day for 2 months. Results showed improved symptoms of inattention, hyperactivity and impulsiveness as reported by parents.

Magnesium (Mg)

It has been reported that a Mg deficiency could be a predictive factor in neurological conditions such as ADHD and autism (89), and individuals with ADHD may have an elevated requirement for magnesium, however, no causal relationships has been established (90). A deficiency in Mg has been associated with cognitive impairment, lack of concentration, mood swings, nervousness and fatigue. Some studies have reported lower levels of Mg in individuals with a diagnosis of ADHD and autism, whilst others have not (91). Research into Mg supplementation has produced mixed results (92). However, an RCT into the combined benefits of supplemental Mg (6mg/kg/day) and vitamin D (50000 IU/wk) reported improvements in behavioural and emotional characteristics including emotional problems, peer problems, total difficulties and internalising ($p = 0.001$) in adolescents with ADHD and low serum baseline levels of vitamin D and magnesium (93).



Zinc (Zn)

Zn is required for cognitive and mental development Zn is involved in the dopaminergic and adrenergic pathways that help regulate attention, memory, mood, stress response (94). Low levels can play a role in depression and anxiety disorders. Serum levels of Zn may be reduced in autistic individuals (95). Deficiencies in zinc have also been found in patients with hyperactivity (83). It has been hypothesised that this may be due to higher levels of Zn wasting as urinary levels have been found to be higher in children with ADHD compared to neurotypical controls (94). Higher levels of pro-inflammatory cytokines often seen in ADHD, could also be due to lower levels of Zn. Zn may act as dopamine reuptake inhibitor and be beneficial as an adjuvant therapy to the stimulant drug methylphenidate used to manage ADHD, and which may contribute to decreased levels of Zn (83). An RCT researching supplementation of 150mg/day of Zn for 12 weeks was found to improve symptoms of impulsivity, hyperactivity and socialisation in 400 patients with ADHD (96).

VITAMINS

WHAT ROLE DO VITAMINS PLAY IN SUPPORTING THE WELLBEING OF NEURODIVERGENT INDIVIDUALS?

Vitamins and multinutrients are required for the optimisation of metabolic health including the methylation pathways and krebs cycle. They are also required as co-factors in multiple enzymatic pathways (97). ADHD has been associated with vitamin deficiencies (93) and in some instances, excess (94). Research has shown that changes in diet and improvement in vitamin status could improve the efficacy of ADHD interventions (83). Additionally, it has been reported that autistic individuals are more susceptible to nutrient deficiencies often due to self-limiting diets, as well as potential increased needs for specific nutrients (84).

Vitamin A

Vitamin A has been found to be low in autistic children compared to neurotypical controls (98). Vitamin A may play a role in the regulation and synthesis of serotonin, a pathway that is often found to be dysregulated in autistic people (95). Deficiencies have been reported to exacerbate autistic characteristics (86). In several studies, supplementation with vitamin A has been shown to improve autistic characteristics, including a study of 33 children diagnosed with ASD which found doses of 0.06mg/kg vitamin A to be effective for improving autistic characteristics (86).

B Complex Vitamins

B complex vitamins (B1, B6, B9, B12) play a vital role in the central nervous system (CNS) function (95). Vitamins B9 and B12 are key in the synthesis of neurotransmitters that affect mood and emotions, such as dopamine (99). Deficiencies in vitamin B12 are also known to contribute to neurological issues including cognitive impairment, motor disturbances, abnormal balance and sensory and memory loss (86). Some studies have associated deficiencies in B12 and B9 (folate) with ADHD, whilst others have not (99). Lower levels have been found in children with ADHD compared to neurotypical controls, and supplementation may improve ADHD characteristics. Conversely, elevated levels of vitamin B6 have been reported in autistic individuals. This may be due to insufficient levels of the enzyme, pyridoxal kinase, required to metabolise vitamin B6 (86).

Vitamin D

Multiple studies have shown a connection between deficiencies in vitamin D and ADHD (100). The relationship between vitamin D and autism is however unclear (101). Vitamin D is needed for neurodevelopment, mental health and CNS function (68). It also has anti-inflammatory properties (95). A recent meta-analysis found that autistic individuals had lower levels of vitamin D compared to neurotypical control groups in 16/19 studies (101). In addition, one study found that that supplementation with vitamin D at a dose of 0.049 mg/kg/day can improve symptoms of irritability and hyperactivity in autistic children (86). Another meta-analysis of 3 studies reported that vitamin D supplementation may be beneficial for hyperactivity but not core autistic characteristics such as sensory issues (102).

Multi-Nutrient Formulas

A recent systematic review and meta-analysis of 16 RCTs reported that multi-nutrient formulas may be more effective for improving characteristics of autism and ADHD than single nutrients alone (97). Practitioners should be aware that vitamin and mineral deficiencies may exacerbate the symptoms of ADHD, autism and neurodivergence but have not been shown to be causative. The correction of identified nutrient deficiencies through diet and supplementation may be beneficial and support management of symptoms.

LIFESTYLE FACTORS

WHICH MODIFIABLE LIFESTYLE FACTORS MAY HELP SUPPORT WELLBEING FOR INDIVIDUALS WITH NEURODIVERGENCE?

Modifiable lifestyle factors, particularly physical activity and sleep are increasingly recognised as effective non-pharmacological strategies for supporting wellbeing in neurodivergent individuals. Physical activity interventions have been associated with improvements in quality of life and sleep outcomes. In autistic children aged 3–18 years, different physical activities significantly improved social functioning (103). A similar study, in autistic children aged 3-18, reported that exercise significantly improved executive function functioning (104) with ping pong (70 minutes 2x/week for 12 weeks) and cycling (60 minutes 5x/week for 2 weeks) showing the greatest benefits. A systematic review of 21 studies in children with ADHD found that physical activity, including ball games, racket sports, mindfulness, and yoga, improved executive function, attention, inhibition, and broader neurobehavioural outcomes, with sessions of at least 20 minutes yielding positive effects (105).

Moderate to intense exercise reduced ADHD characteristics and enhanced neurophysiological function. Tailoring activities to individual preferences (e.g., martial arts or team sports) may enhance adherence and social engagement (105). In children and adolescents with DCD, a systematic review of 13 studies (n = 453) found that high-intensity interval training (HIIT) significantly improved mental health, mood, quality of life, social behaviour, inhibitory control, and physical fitness (106).

In contrast, poor sleep quality is associated with reduced wellbeing in neurodivergent populations. In autism, sleep issues correlate with core traits and behavioural difficulties in children under 18 (107,108). Adolescents with ADHD also show a bidirectional relationship between sleep disturbances and symptom severity (109). A meta-analysis found that autistic adults and those with ADHD experienced poorer sleep than neurotypical controls, including longer sleep latency, reduced efficiency, more awakenings, and worse overall quality (110). Pooled prevalence estimates for insomnia and sleep disorders were 59% and 51% in autism, and 63% and 52% in ADHD, respectively.

Physical activity may mitigate sleep problems. In a meta-analysis of 388 participants with ADHD (ages 6–54), exercise was associated with self-reported sleep quality (111). While objective measures in a smaller subsample (n = 131) showed a non-significant trend toward increased sleep duration, overall findings suggest potential exercise benefits. Possible mechanisms explaining the effect include melatonin regulation, thermoregulation, and vagal nerve function. Interventions ranged from jogging and HIIT to Tai Chi. Although heterogeneity limits standardised recommendations, sessions of 30–50 minutes, 2–3×/week were generally effective.

Liang et al. (2023) identified significantly lower physical activity in autistic children (n = 679; 59 min/day) compared to controls (n = 1573; 77 min/day) (112). Total sleep time was significantly lower for autistic children (461.00 min; SD 34.05) compared to controls (474.54 min; SD 48.76). These findings highlight that many autistic individuals fall short of WHO's recommended 60 minutes/day of moderate-to-vigorous physical activity (113).

Practitioners should be aware of these WHO recommendations and embrace a collective approach to promote exercise in neurodivergent children and adults (112). As physical activity and sleep are intrinsically linked as part of a 24-hour movement framework (114), the 'take home' message is, a wide range of personalised activities should be considered to support sleep, wellbeing and quality of life. Sleep hygiene practices (including sleeping environment, routines, caffeine and alcohol use, and technology habits) should also be encouraged, particularly in adolescents with ADHD (115).

SUMMARY

THE ROLE OF NUTRITION PRACTITIONERS IN SUPPORTING NEURODIVERGENT INDIVIDUALS

Nutrition practitioners are uniquely positioned to support the wellbeing of neurodivergent individuals through food-based strategies that address both physiological needs and lifestyle factors. This review provides an evidence-base for evaluating different interventions aimed at supporting safe and effective care. Research suggests that dietary patterns and nutrient intake can influence brain development and behaviour, highlighting the importance of a personalised, whole-food approach to care. Nutritional therapists can play a key role in identifying and addressing dietary insufficiencies, supporting digestive health, and helping individuals and families navigate selective eating patterns or ARFID whilst reducing the intake of ultra-processed food.

Evidence points to the potential benefits of optimising intake of essential fatty acids, vitamins, and minerals in supporting neurodiverse individuals. While much research has explored the impact of supplementation and this could certainly be useful for some individuals, practitioners may also wish to encourage nutrient-dense food choices that supply omega-3 fatty acids, magnesium, zinc, iron, and B vitamins. Emerging evidence highlights that autistic individuals and those with ADHD show differences in gut microbiota compared to typically developing individuals. These differences may account for the higher prevalence of gastrointestinal issues but could equally arise as a consequence of them, and therefore recommendations to mitigate this difference need to be carefully considered. It is also important to acknowledge the role of lifestyle factors, particularly physical activity and sleep, which are increasingly linked to improvements in executive function, emotional wellbeing, and quality of life in neurodivergent individuals.

By integrating nutritional and lifestyle interventions into a personalised plan, practitioners can support neurodivergent individuals in ways that complement existing medical, psychological and therapeutic care. A collaborative, strengths-based approach, focusing on both symptom management and overall health, allows nutrition practitioners the chance to contribute meaningfully to the wellbeing and daily functioning of this diverse population.

KEY PRACTICE POINTS FOR NUTRITIONAL THERAPISTS

- **Personalise support:** Tailor dietary advice to individual needs, preferences, and sensory sensitivities common in neurodivergence.
- **Focus on whole foods:** Encourage nutrient-dense sources of omega-3s, B vitamins, magnesium, zinc, and iron, while being mindful of selective eating and ARFID.
- **Address lifestyle factors:** Promote physical activity and good sleep hygiene as part of a 24-hour movement and recovery framework.
- **Work collaboratively:** Integrate nutritional support with existing medical, psychological and therapeutic interventions for a holistic approach.
- **Support families and carers:** Provide practical strategies to improve diet quality and reduce stress around mealtimes.

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KL conceived of the review, wrote the introduction, contributed to all sections of the article, provided comments to authors and revised the content. GB, CS & MH each researched and wrote two sections of the article. SC, WK & KB each researched and wrote one section of the article. MB contributed to planning, design and revising the final content. All authors reviewed and accepted the final manuscript.

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