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Nourishing Neurodivergent Minds

What the Science Says

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Introduction: Neurodiversity



- Neurodiversity, including attention-deficit hyperactivity disorder (ADHD) and autism spectrum disorder (ASD), affect **learning, behaviour, and long-term health**.
- Complex, heterogeneous, and multifactorial
- Emerging evidence links **diet quality, dietary patterns, and micronutrient status** to symptom severity and functional outcomes.
 - Key nutrients:** omega-3 fatty acids, vitamin D, iron, zinc, magnesium, probiotics
 - Dietary patterns:** "healthy" vs. Western/junk-food patterns

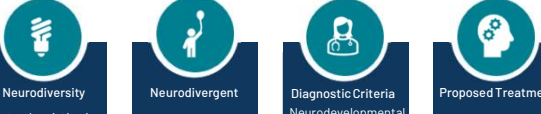
Optimising diet and key nutrients may support brain function, behaviour, and outcomes in neurodiverse children and adults.

Large et al. 2023

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Defining and Diagnosing Neurodiversity

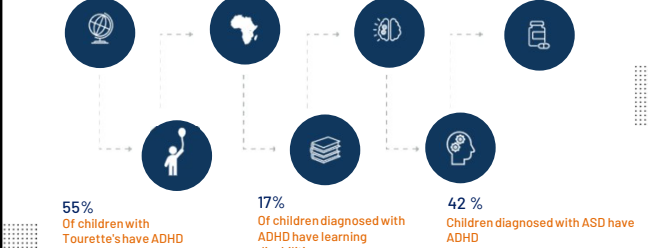


Neurodiversity	Neurodivergent	Diagnostic Criteria	Proposed Treatment
Natural variation in brain development Includes ADHD, autism, dyslexia, etc	Individuals whose brain functions differ from the typical	Neurodevelopmental disorders are clinically diagnosable conditions DSM-5 Clinical rating scales	Pharmacological Lifestyle Psychological

Pinto et al. 2022

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6 - 7% Global prevalence of ADHD

5% Prevalence of ADHD in South Africa

78% Of children with ADHD have co-occurring conditions

4 in 10 Children with ADHD have anxiety

55% Of children with Tourette's have ADHD

17% Of children diagnosed with ADHD have learning disabilities

42% Children diagnosed with ASD have ADHD

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Pathophysiology of Autism Spectrum Disorder (ASD)



- Collection of neurodevelopmental disorders marked by challenges in **social interaction, communication, and the presence of repetitive behaviours**
- Highly heritable condition**
> 100 genes implicated in autism
- Pathophysiology not well understood**
Oxidative stress, mitochondrial dysfunction, immune dysregulation, gut-brain axis.
- Origins of ASD are complex with various elements potentially contributing: **genetics, environmental and nutrition**

Marijnev et al (2024): Micronutrient deficiencies in children with autism spectrum disorders compared to typically developing children - A scoping review

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Pathophysiology of Autism Spectrum Disorder (ASD)

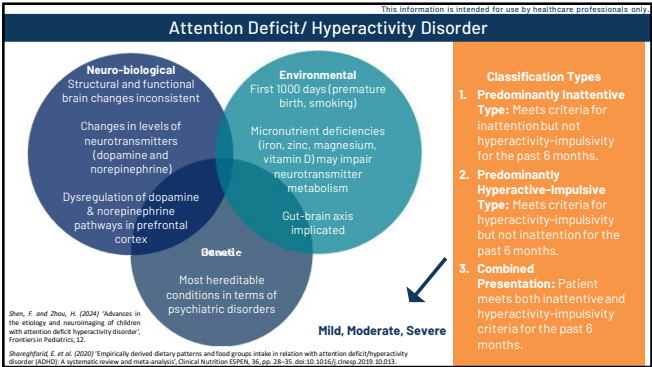


- Micronutrients are pivotal for a range of physiological processes:**
Structural elements of the CNS, stimulate nerve cell development, migration and differentiation
- Pre-natal nutrition influences risk of autism**
Folate, iodine, vitamin D, vitamin b12, iron
- Children with ASD exhibit **unique dietary patterns, preferences and aversions** which may predispose to nutritional imbalances
- Sensory sensitivities:** restrictive eating habits, limiting intake of nutrient-rich food
- GIT concerns:** affect nutrient absorption and metabolism

Elevated the risk for micronutrient deficiencies which may further influence or intensify ASD-related symptoms and challenges

Marijnev et al (2024): Micronutrient deficiencies in children with autism spectrum disorders compared to typically developing children - A scoping review

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Tool / Framework		What It Does	Key Point
DSM-5	Core classification systems	Diagnoses neurodevelopmental conditions (ASD, ADHD, learning disorders)	Symptom-based; categorical yes/no; widely used
ICD-11		International medical diagnostic standard	Broader descriptions; aligns better globally & dimensionally
ADOS-2	Gold standards for autism	Autism assessment via observation	Directly observes social interaction, play, communication
ADI-R		Parent/caregiver interview for autism	Focus on early development, language, social skills; used with ADOS-2
Conners Rating Scales			Questionnaires for parents, teachers, self-report
Vanderbilt ADHD Scales		Most used for ADHD	Performance & behaviour items; practical for schools
SNAP-IV			Short DSM-based rating scale; reliable & widely used
SDQ	General behavioural/ emotional screening		Covers emotional, conduct, hyperactivity, peer & prosocial behaviour

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Diagnostic and Statistical Manual of Mental Disorders (DSM-5)

DSM-5 is the **gold standard** for diagnosing neurodevelopmental conditions like autism spectrum disorder (ASD), ADHD, and learning disorders.

- Symptom-based criteria**, age of onset, and impairment in daily life.
- Symptoms and/or behaviours that have **persisted ≥ 6 months** and in **≥ 2 settings** (e.g. school, home, church)
- Symptoms have **negatively impacted academic, social and/or occupational functioning**
- Validity:** Widely validated but criticized for categorical (yes/no) approach which may not reflect neurodiversity spectrum.

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders (DSM-5)*. American Psychiatric Publishing.

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Diagnostic and Statistical Manual of Mental Disorders (DSM-5)

Inattention (IA) Symptoms	Hyperactivity-Impulsivity (HY/IM) Symptoms
<i>At least 5 for adults / 9 for children</i>	<i>At least 5 for adults / 9 for children</i>
❑ Fails to give close attention to details or makes careless mistakes. ❑ Has trouble holding attention on tasks or play activities. ❑ Often does not seem to listen when spoken to directly. ❑ Does not follow through on instructions or fails to finish tasks. ❑ Has trouble organizing tasks and activities. ❑ Avoids, dislikes, or is reluctant to engage in tasks that require sustained mental effort. ❑ Often loses things necessary for tasks or activities. ❑ Is easily distracted by extraneous stimuli. ❑ Is often forgetful in daily activities.	❑ Fidgets with or taps hands or feet, or squirms in seat. ❑ Often leaves seat in situations where remaining seated is expected. ❑ Runs about or climbs in situations where it is inappropriate (in adolescents or adults, may be limited to feeling restless). ❑ Is often unable to play or engage in leisure activities quietly. ❑ Is often "on the go," acting as if "driven by a motor." ❑ Often talks excessively. ❑ Often blurts out an answer before a question has been completed. ❑ Has trouble waiting his or her turn. ❑ Often interrupts or intrudes on others

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders (DSM-5)*. American Psychiatric Publishing.

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Pharmacological: Common Medications Used	STIMULANTS	NON-STIMULANTS
	Indicated ▪ First line treatment (70 – 80% of patients) ▪ Treats moderate and severe ADHD ▪ Gold standard Action ▪ Methylphenidate inhibits the reuptake of dopamine and norepinephrine ▪ Amphetamine increases the release of these neurotransmitters Onset ▪ Within 30 – 60 minutes Dosing frequency ▪ Immediate release: 2-3 x per day (lasts 3 – 5 hours) ▪ Extended release: 1x per day (lasts 10 – 14 hours) Benefits ▪ Most effective ▪ Quick relief Side-effects ▪ Decreased appetite, weight loss, insomnia, headache, irritability, jitteriness and tics Examples ▪ Methylphenidate: Ritalin, Concerta, Contramyl, Medikinet ▪ Dextroamphetamine and amphetamine: Adderall	Alternative when stimulants are ineffective or contraindicated ▪ Work more gradually and affect other brain pathways (not just dopamine) ▪ Atomoxetine: Selective norepinephrine reuptake inhibitor ▪ Bupropion: Norepinephrine-dopamine reuptake inhibitor Takes 5 – 7 days to see benefits

PharmJST. (2017). 'Pharmacological Management of ADHD', pp. 3-10. Springer.

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Changes in Meal Timing and Intake Patterns

Appetite Suppression	Irregular Mealtimes	Medication Breaks	Drug-Nutrient Interactions
▪ Especially stimulant medication ▪ Most evident during daytime peak ▪ Missed meals ▪ Reduced energy intake ▪ Poor dietary quality related to skipped meals and overeating ▪ Reduced intake of key nutrients	▪ Compensatory eating in the evening once medication wears off ▪ Overeating at night leading to sleep and GIT disturbances	▪ Holidays and weekends ▪ Irregular eating behaviours ▪ Difficulty regulating appetite	▪ Caffeine can intensify effects of meds ▪ Vit C and acidic foods can lower efficacy of amphetamines ▪ High fat meals can delay absorption (some studies) with Adderall, not with Concerta

Pharo, E., Gonzalez de Sa, T., Damagosa, M., B., Wassenaar, C., Mervin, R., Pereira, C., et al. (2023). Eating Patterns and Dietary Interventions in ADHD: A Narrative Review. *Nutrients*, 2023 Dec; 16(4):6321-6332. doi: 10.3390/nu16046321. PMID: 36279703; PMCID: PMC10080000.

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Picky Eating and Feeding Challenges



Behavioural

- Impulsivity: binge eating
- Attention-deficit: grazing, forgetting to eat, distraction during meal/snack times
- Hyperactivity: mealtimes disrupted, inability to sit still



Food-Related

- Food selective: limited variety, picky eating
- Sensory: textures, smell aversions
- External



Medication

- Mealtime stress: family conflict
- Executive dysfunction: skipped meals and snack reliance



NIH/NES, Reid et al. 2015

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Anthropometric Concerns and Considerations in Neurodiversity



Undernutrition (Underweight)

- Appetite suppression from medications
- Hyperfocus or inattention can cause meal skipping
- Missed hunger cues due to chaotic routines or poor interoception



Overnutrition (Overweight/Obese)

- More prevalent when off medication
- Impulsive eating or emotional eating
- Ultra-processed preference
- Poor self-regulation of hunger and fullness
- Screen-time distractions
- Compensatory overeating

Sahar H, Mohammad MH, Mousa R, Montazeri LA, Rezaei A, Gholizadeh MA. Nutrient intake, dietary patterns, and anthropometric variables of children with ADHD in comparison to healthy controls: a case-control study. *BMC Pediatr*. 2022 Jan 26;22(1):75. doi: 10.1186/s12936-022-03523-6. PMID: 35080326.

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Sensory Support Strategies

Driven by OTs:

- Sensory-based feeding
- "Just-right" environment
- Seating & posture aids
- Oral-motor tools
- Visual system
- Collect into a sensory diet

- Identify red flags
- Collaborate with DTs for integrated feeding plans
- Reinforce sensory strategies
- Ensure that food exposure goals align with sensory tolerance



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Nutrient Concerns in Neurodiversity

Iron	Omega-3s	Zinc
• Systemic iron findings mixed • 10/18 studies found lower serum ferritin. • Only 2/10 studies found differences in serum iron. • Brain iron appears more relevant (MRI studies reported lower thalamic iron in children with ADHD) • Iron deficiency at 12–18 months predicted ADHD and sluggish cognitive tempo symptoms at 5, 10, and 16 years. • Improvements have been seen in ADHD with iron-zinc supplementation (more related to zinc). Benefits more evident in subgroups with low baseline iron/zinc. Current research: Treat if there is a deficiency. (Cheng, 2020; Pictet et al 2022 & Lange et al., 2023)	• Association between poor maternal diet and ADHD development (low omega-3, high omega-6). • Children with ADHD have lower blood levels of omega-3s and higher omega-6/omega-3 ratio • Lower omega-3 levels are linked to greater ADHD symptom severity. • Dosage: No conclusive evidence. Shortcomings in studies due to < 16 weeks and <500mg EPA. • Positive correlation when EPA > 500mg, but guidelines show that it must be individualized. Current research: Supplement omega-3 with >500mg EPA and > EPA : DHA ratio. (Lange et al., 2023)	• Early or present zinc deficiency may increase ADHD risk. • Sensitivity analysis suggested for ADHD with lower circulating zinc, symptoms improved with supplementation. • Linked to hyperactivity and impulsivity, but not inattentiveness. • Zinc supplementation shown small but significant improvement in overall ADHD scores. Best results seen with longer supplementation duration (6–12 weeks). Current research: Treat if there is a deficiency. (Elvén et al., 2022 & Sage et al., 2022)

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Nutrient Concerns in Neurodiversity

Magnesium	Vitamin D	Probiotics
• People with ADHD may have lower magnesium levels, possibly due to inadequate intake or increased need • Symptoms may improve with supplementation • Magnesium L-threonate showed symptom improvement in adults in a small open-label study (no placebo group) • Double-blind RCT: magnesium + vitamin D supplementation over 8 weeks led to significant improvements in emotional, behavioural, and social symptoms in children with ADHD • Further large-scale, placebo-controlled trials are needed to confirm these findings and guide clinical use. Current research: Treat if there is a deficiency (Mg Glycinate, Citrate or L-threonate). (Philo et al., 2023; Lange et al., 2023 & Henning et al., 2020)	• Early vitamin D deficiency, especially in the newborn period, identified as a risk factor for developing ADHD later in childhood. • Brain development, neuroprotection, and dopamine regulation (all relevant to ADHD pathophysiology) • Low maternal or neonatal vitamin D levels may disrupt early brain development, contributing to altered behaviour and attention control. • Several observational studies have linked lower vitamin D levels in children with increased ADHD symptom severity, and vitamin D supplementation to reduced symptoms. Current research: Not a standalone treatment, treat if there is a deficiency. (Korostoff et al., 2024 & Kocot et al., 2020)	• Gut-brain axis may influence brain function, behaviour, and mental health • Microbiome differences seen in individuals with ADHD. Findings inconsistent Improvements have been shown with hyperactivity and difficulty to focus. • <i>Lactobacillus rhamnosus</i> • <i>Lactobacillus acidophilus</i> • <i>Bifidobacterium bifidum</i> • Larger, high-quality trials needed to confirm the role of probiotics in ADHD treatment. Current research: treat if gut-problems. (Korostoff et al., 2023; Pictet et al 2022 & Sage et al., 2022)

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Guidelines for Correcting Nutrient Deficiencies in Children

Nutrient	Guidelines
Omega-3	No standardized guidelines • Up to 1500mg per day (1 – 8 years). Aim for EPA > 500mg. Ratio suggestion 9:3:1 EPA:DHA:GLA
Iron	• 6 – 23 Months: 10 – 12.5 mg elemental iron daily for 3 months • 24 – 59 Months: 30mg elemental iron daily for 3 months • 5 – 12 Year: 30 – 60mg elemental iron daily for 3 months
Zinc	• Birth – 6 months: 2mg • 7 – 12 months: 3mg • 9 – 13 years: 8mg • 14 – 18 years: 9 – 11mg
Vitamin D	American Academy of Pediatrics recommends: • 400 IU for breastfed infants and children who consume < 1L vitamin-D fortified milk daily • Correcting deficiency: if < 30 ng/mL, 2000 IU daily or 50 000 IU once weekly for 6 weeks. • Once > 30 ng/mL, maintenance dose of 1000 IU is recommended.
Magnesium	No standardized guidelines available. Upper limits of magnesium only from dietary supplements: • Children 1 – 3 years: 65 mg • Children 4 – 8 years: 110 mg • Children 9 – 18 years: 350 mg

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How the Type of Diet Influences Risk of Developing ADHD

Meta-analysis: 6 dietary-pattern studies (n= 8 816 children) examined adherence to different dietary patterns ("healthy," "Western," and "junk food") and the relationship with ADHD risk.

↑ "Junk food" pattern
(sweetened beverages, desserts)
50% higher risk
 $p = 0.02$

↓ "Healthy" pattern
(vegetables, fruits, legumes, fish)
37% lower odds of ADHD

↑ "Western" pattern
(red/processed meats, refined grains, hydrogenated fats): **near-doubled risk**
 $p = 0.016$

Healthy diets are associated with reduced ADHD risk and unhealthy diets associated with increased ADHD risk.

While informative, the data are observational: **causality cannot be confirmed.**

Shanahan, E. et al. (2020) Empirically derived dietary patterns and food groups intake in relation with attention deficit/hyperactivity disorder (ADHD): A systematic review and meta-analysis. Clinical Nutrition ESPEN, 36, pp. 28-35. doi:10.1016/j.clnesp.2019.10.012.

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Dietary Patterns vs Single Nutrients

Recent evidence suggests that certain dietary patterns and whole diets (as opposed to single, isolate nutrients), have been suggested to be helpful in the management of ADHD.

Dietary patterns linked to ADHD risk

- Higher intake of **sweets, ready-made meals, and low micronutrient intake** associated with ADHD.
- Western-style diets** positively associated with ADHD, while **healthy dietary patterns** (fruits, vegetables, lean proteins) show protective associations.
- Diets richer in **vegetable protein, zinc, calcium, and phytochemicals** correlate with fewer ADHD symptoms.
- Sugar intake:** Evidence is inconsistent; while some studies suggest high sugar intake in ADHD, prospective data show **no causal link**.
→ Increased sugar intake may be a consequence rather than a cause.

Maternal diet quality
Better maternal diet during pregnancy is associated with lower ADHD risk in offspring, but child diet quality at age 3 showed no link with ADHD at 8 years.

Pinto, S. et al. (2022) Eating Patterns and Dietary Interventions in ADHD. A Narrative Review. Nutrients, 14(2), 4322. https://doi.org/10.3390/n14124322

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Dietary Patterns vs Single Nutrients

The adherence to a Mediterranean diet (↑ fruits, vegetables, whole grains, legumes, fish) associated with lower ADHD odds

- Chronic inflammation** associated with some individuals in ADHD
- Exposed to stress early on in childhood
- ADHD also associated with **auto-immune and inflammatory disorders**, e.g. asthma, diabetes, allergic rhinitis, maternal autoimmune diseases and maternal stress
- Possible mechanisms:**
 - HPA axis dysregulation and altered levels of cortisol.
 - Gut dysregulation associated with increased inflammation and anxiety or hyperactivity.
→ **anti-inflammatory diets / diets high in polyphenols** (i.e. Mediterranean diet)

Pinto, S. et al. (2022) Eating Patterns and Dietary Interventions in ADHD. A Narrative Review. Nutrients, 14(2), 4322. https://doi.org/10.3390/n14124322

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The Few-Foods Diet

Recent evidence suggests that there is a role of food hypersensitivities in ADHD.

Few-Foods Diet: short-term elimination of most foods → stepwise reintroduction to identify triggers

- ~60% of children show symptom improvement within 4 weeks.
- Common triggers: milk/dairy, cocoa, peanuts, grains, corn.
- Benefits extend to physical complaints (e.g., headaches, GI, sleep)
- May reduce need or dosage for ADHD medication
- Long-term improvement possible (up to 3.5 years)

Mechanism: whole-brain analyses demonstrated a correlation between the decrease in ADHD symptoms and an increase in precuneus activation.

Available findings regarding the few foods diet confirm the hypothesis that food intolerances are a possible cause of ADHD, but this requires careful application and more RCTs.

Pinto, S. et al. (2022) Eating Patterns and Dietary Interventions in ADHD. A Narrative Review. Nutrients, 14(2), 4322. https://doi.org/10.3390/n14124322

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Dietary Patterns vs Single Nutrients

DASH-Style Diet
A DASH-style diet **improved hyperactivity and conduct problems** in an RCT

Direction of association
ADHD symptoms may predict poorer diet quality rather than diet influencing ADHD risk

Lifestyle factors
Children with ADHD are **nearly twice as likely to have fewer healthy lifestyle behaviors** (diet, activity, sleep, screen time) than peers
Highlights the need for **multifaceted lifestyle interventions**

Shanahan, E. et al. (2020) Empirically derived dietary patterns and food groups intake in relation with attention deficit/hyperactivity disorder (ADHD): A systematic review and meta-analysis. Clinical Nutrition ESPEN, 36, pp. 28-35. doi:10.1016/j.clnesp.2019.10.012.

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Alternative Nutrient/ Supplements for Neurodiversity

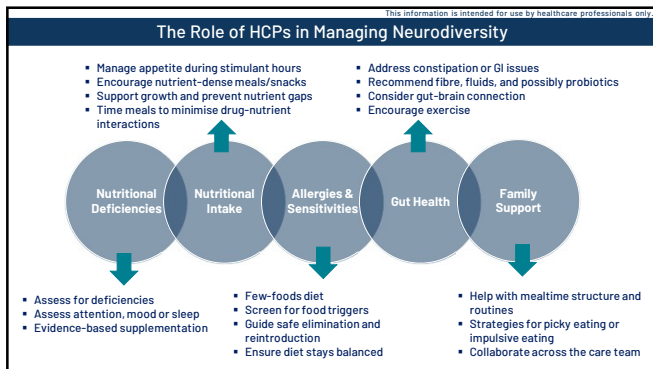
L-Tyrosine
May support dopamine pathway. Only mild benefit, unless there is a deficiency
Studies done in 1980's

NAC (N-Acetylcysteine)
↑ glutathione → dec inflammation. Small studies show improvements in emotional regulation.
Smaga et Al, 2021

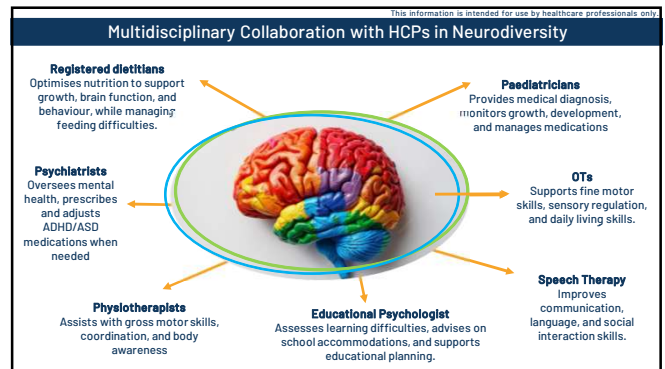
Citicoline / CDP-Choline
Increasing acetylcholine and dopamine: mild improvements
Hubner et Al, 2024

Saffron Extract
Studies show works similarly to Ritalin but without side effects, not sufficient research. Blasco-Fontecilla et Al, 2022

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Conclusion

- Neurodiversity is a **dynamic, complex** group of neurodevelopmental condition with **multifactorial** influences, including nutrition
- Dietitians play a vital role in supporting growth, behaviour, and overall health
- Key areas of focus include:
 - Nutrient adequacy** (especially iron, zinc, omega-3s, vitamin D)
 - Managing **medication-related appetite changes**
 - Addressing feeding challenges and picky eating**
 - Considering **dietary patterns, additives, and sensitivities**
 - Supporting **gut health and regularity**
- Nutrition care should be **individualised, practical, and family-centred**
- Ongoing collaboration with families and multidisciplinary teams** is essential for meaningful impact
- Research is still currently limited, but this is an area of growth

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