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DHA, Choline, and Lutein Intakes are Associated with Cognitive Performance in School Age Children

Docosahexaenoic acid (DHA), choline, and lutein are examples of nutrients that may have either functional or structural roles in the areas of the brain:

- **DHA** is a major structural lipid deposited in neuronal membranes of the central nervous system[1,2] and plays a critical role in normal retinal and brain development in infants and toddlers.[3]
- **Choline** is an essential constituent of membrane phospholipids in the developing brain.[1]
- **Lutein**, a key antioxidant in neural tissue, has been found to be present in regions of the infant brain relating to learning and memory.[4]

In 2015, a University of North Carolina observational study among breast milk-fed infants around 3 months of age found associations between nutrient combinations (ie, higher DHA and choline levels, higher choline and lutein levels) and improved recognition memory at 6 months.[5] This was the first study to suggest an interaction between these breast milk nutrients and their positive influence on the cognitive abilities of *young infants*. Recently, another observational study at the University of British Columbia has suggested that higher concurrent intake of DHA, choline, and lutein is associated with better short-term memory and general mental processing ability in *school age children*.[6]

Recent observational study from the Research Institute of British Columbia Children's Hospital in Canada shows positive associations between higher concurrent intake of DHA, choline, and lutein and cognitive performance among children

This observational study by Mulder et al. investigated the association between DHA, choline, and lutein intake with cognitive performance in fifty-nine healthy, school age children (median age of 5.8 years). Dietary intake data was collected along with measures of cognitive performance (short- and long-term memory, visual processing, learning ability, and general mental processing ability). The relationship between concurrent nutrient intakes and cognitive performance was explored by stratifying the children into 4 groups by higher versus lower concurrent nutrient intakes.

- G1 (intakes of all 3 nutrients above cohort medians; n = 15)
- G2 (intakes of any 2 nutrients above cohort medians; n = 14)
- G3 (intake of any 1 nutrient above cohort median; n = 15)
- G4 (intakes of all 3 nutrients at or below cohort medians; n = 15)

In this study, the median (interquartile range) intakes of DHA, choline, and lutein in these particular children were 76 (40–127) mg/d, 311 (238–400) mg/d, and 2300 (1100–4100) mcg/day, respectively.

Study results:

- Intake of each of the 3 nutrients was significantly correlated with short-term memory.
- Intakes of DHA and choline were each significantly correlated with general mental processing ability.
- Children with dietary intakes of all 3 nutrients above cohort medians (G1) had significantly better short-term memory and general mental processing ability compared to children with DHA, choline, and lutein intakes below cohort medians (G4).
- Short-term memory scores were also significantly higher in G1 compared with G2 and tended to differ in G1 compared with G3.
- No other subgroup differences were detected.

Overall, these results suggest that higher concurrent intakes of DHA, choline, and lutein are associated with higher scores of short-term memory and general mental processing ability in school age children.

DHA, choline, and lutein may work together in the brain

Figure 1: Possible mechanisms of action of DHA, choline, and lutein working together in the brain

A substantial amount of *in vitro* and preclinical animal studies have revealed that DHA and choline are critical nutrients supporting neuronal and brain development.[7-14] As indicated in **Figure 1**, DHA is a part of the neuronal membrane and influences membrane integrity and fluidity[7,9];

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it influences oxidative stress and reduces inflammation[7]; it modulates cell growth and survival, and facilitates neuronal communication.[7,9] Existing literature on choline also suggest that it has an impact on all these processes (Figure 1)[8,10-15], and in some instances, may have a more direct effect. Lutein is widely accepted as an important nutrient for eye development and function, and as an antioxidant, may reduce oxidative stress and inflammation.[16,17] Emerging data also demonstrate that lutein is accumulated in brain tissues critical for cognitive functions, such as the hippocampus.[4] *Collectively, these three nutrients may work together[5,18,19] in impacting neurocognitive development via its unique pathways and/or shared biological processes. Additional studies are warranted to determine causality and further investigate the potential mechanism of these nutrients working together.*

Figure 2 shows the average reported intake of DHA, choline, and lutein from available worldwide data (right) in the context of the current dietary recommendations for these nutrients (left). Although the evidence from the UBC data suggests the importance of DHA, choline, and lutein intake in cognitive performance in children and perhaps that consuming an optimum amount of these nutrients concurrently could provide benefit, we must remember that the populations and dietary intake methods and analyses differed between the UBC data and other reported dietary intake surveys, and more data is required to draw conclusions. It is clear and remains important however, that a child gets appropriate amounts of DHA, choline, and lutein through a healthy, well-balanced diet and/or nutritional supplements.

Figure 2: Dietary recommendations and the reported average intakes of DHA, choline, and lutein

Nutrient	Recommended Dietary Intake	Examples of Known Nutrient Gaps vs Recommendations
DHA	**2–4 years old:** 100–150 mg/day* **4–6 years old:** 150–200 mg/day* **6–10 years old:** 200–250 mg/day*[20] *(DHA+EPA)	• Median DHA intake across 76 developing countries (17 upper middle income, 34 lower middle income, 25 low income) was found to be **48.9 mg/day**[21] • A study reported a DHA intake with a mean of **54.1 mg/day** in Canadian children 4–8 years old[22]
Choline	**1–3 years old:** 200 mg/day **4–8 years old:** 250 mg/day[23]	• Choline intake as assessed in European population showed **151–210 mg/day** among toddlers and **177–304 mg/day** among other children (3 to ≤ 10 years old)[24] • National Health and Nutrition Examination Survey (NHANES) from US showed **suboptimal intakes** of choline (92.9% in children aged 2–3 years and 45.4% in 4–8 years)[25]
Lutein	No recommended daily intake for lutein	• US NHANES data reported intake of lutein (**279 mcg/day** for 1–3 year olds and **311 mcg/day** for 4–8 year olds)[26] • FITS reports 30% of preschoolers do not consume a daily serving of vegetables[27]

KEY TAKEAWAYS

- These cohort findings report that higher concurrent intakes of DHA, choline, and lutein are associated with better cognitive performance in school age children.
- DHA, choline, and lutein may be working together in the brain to support a child's cognitive performance.
- Evidence suggests that current DHA, choline, and lutein intakes among toddlers and school age children may not be enough, based on experts' recommendations and suggestive findings in the scientific literature.
- It is important that a child gets the appropriate amount of DHA, choline, and lutein through a healthy, well-balanced diet and/or nutritional supplements.

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