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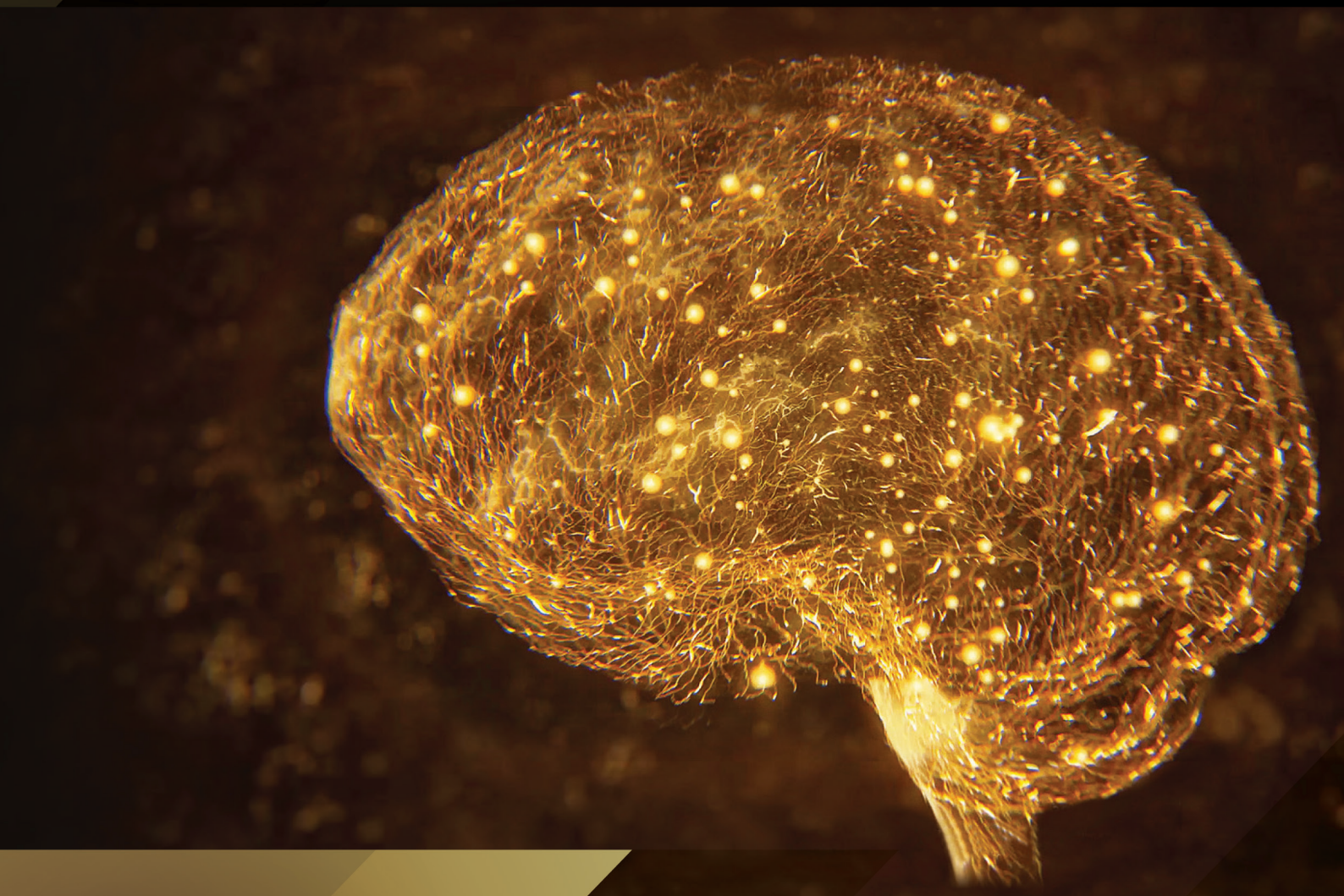

THE CRUCIAL ROLE OF PHOSPHOLIPIDS IN CHILD BRAIN DEVELOPMENT:

From Diet to Cognition

During early years, the human brain undergoes remarkable growth, increasing from ~27% of adult weight at birth to ~80% by age 2.[1] This profound transformation is characterized by the deposition of crucial building blocks in the brain, predominantly phospholipids. Beyond their structural role in neural tissues, phospholipids also play a pivotal role in neurodevelopment and cognition. Among phospholipids, sphingomyelin is the most abundant sphingolipid, particularly enriched in the myelin sheath that insulates the axons of the central nervous system.[2]

Myelination and Cognitive Development

Myelination is an intricate, highly coordinated neurodevelopmental process where nerve fibres (axons) acquire a lipid-rich sheath, acting like electrical wire insulation. This sheath, primarily composed of phospholipids, facilitates a critical function: the rapid transmission of electrical signals across the different brain regions. The insulating myelin sheath enables signals to travel along axons at significantly faster rates, with myelinated axons conducting signals up to 100-fold faster than unmyelinated ones.[3]

From mid-gestation to the first year of life, the central nervous system undergoes dramatic myelination.[4] MRI studies have shown that myelination advances in a posterior-to-anterior direction, following the general pattern of maturation of neural circuits, i.e. sensory pathways myelinate first, followed by motor pathways, and then association areas; myelination reaches the furthest portions of the frontal lobes between 7 and 11 months of age.[4]

Evidence suggests that the progression of myelination coincides with the emergence of fundamental cognitive skills and behavioural skills and abilities in infants and young children.[5] In particular, myelination has been linked to various cognitive domains, including:

Processing Speed: Faster signal transmission due to myelination translates to improved processing speed, underpinning various cognitive functions.[6]

Cognitive Performance: Studies have shown associations between myelination and enhanced performance in language and reading,[7,8,9] and working memory.[10]

Executive Functions: Early childhood development of executive functions, crucial for skills like planning and self-regulation, has been linked to increased myelination and synaptogenesis (formation of neuronal connections) in frontal brain regions.[11]

Social-Emotional Development: Myelination in the cerebral regions underlying social processing was significantly associated with children's social-emotional development scores, offering insights into the neural underpinnings of social behaviour. [12]

Dietary Interventions: Shaping the Future Brain

The coincident timing of peak phospholipid deposition, myelination, and brain network maturation suggests that phospholipids act as crucial fuel for neurodevelopment, establishing the structural and functional groundwork for information processing and cognition. Studies have shown that infant nutrition — particularly the provision of adequate dietary fat — may impact myelination and subsequent cognitive development.

Breastfeeding has been associated with increased white matter development in brain regions commonly associated with higher-order cognition, such as executive functioning, planning, social-emotional functioning, and language.[13] In a study that tracked the longitudinal trajectories of brain and neurocognitive development, exclusively breastfed children showed significantly improved overall myelination, accompanied by increased general, verbal and non-verbal cognitive abilities. while the exact mechanism that underlies this enhanced myelination in breastfed children was unclear, findings suggest that long-chain fatty acids, iron, choline, sphingomyelin and folic acid were significantly associated with early myelination trajectories.[14]

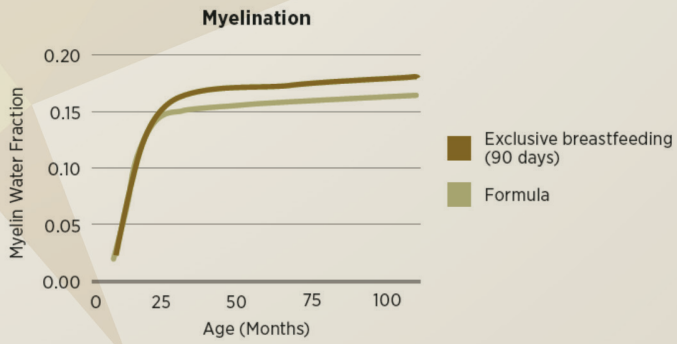

Figure 1. Longitudinal myelin curve for the corpus callosum (body) (largest white matter structure of the brain) brain region between the exclusively breastfed and formula-fed infants. Adapted from Deoni SC, et al. (2018).[14]

Studies suggest that nutritional interventions, e.g. with formula enriched with certain phospholipid and protein compounds[15] or sphingomyelin[16] may aid neurodevelopment during infancy. More recently, a randomized controlled trial investigated how early dietary intervention with a "myelin nutrient blend" may impact brain development in young children.

The study compared a specific blend of nutrients (DHA, ARA, iron, vitamin B12, folic acid, and phospholipids including sphingomyelin) to a control formula in well-nourished infants.[17] At 6 months, children receiving the nutrient blend showed significantly increased myelination in various brain regions crucial for sensory, motor, and language skills compared to the control group.[17] However, no statistically significant differences were found for early behaviour and cognition scores.

The investigation was extended to compare the effects of 12-month supplementation of the nutrient blend with a standard formula and to a reference group of breastfed infants on developmental myelination in children.[18] Children receiving the supplementation with the "myelin nutrient blend" exhibited enhanced brain development, including greater myelination and gray matter volume throughout the two-year study period (Figure 2).[18] Additionally, these children experienced improved sleep patterns and reduced social fearfulness compared to the control group.[18]

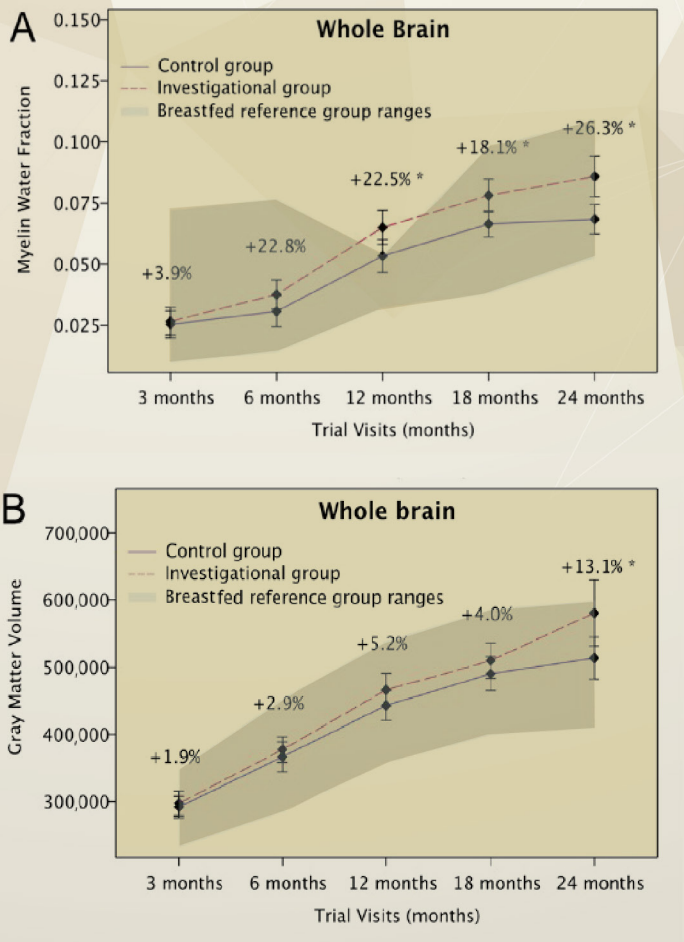

*Figure 2. Effect of supplementation with the "myelin nutrient blend" on the myelination (A) and gray matter volume (B). The % values indicate the estimated change between the investigational (the "myelin nutrient blend") and the control groups using least square mean point estimates, *p≤0.05. Adapted from Schneider N, et al. (2023).[18]*

Overall, the results provide compelling evidence that early life nutrition plays a significant role in shaping brain development, particularly myelination, which lays the foundation for later cognitive and social abilities. More research is needed to fully understand the long-term implications of these findings, but these studies offer promising insights into the potential of targeted nutritional interventions to enhance early brain development and potentially improve future outcomes.

Summary

Studies reveal a close link between specific nutrients, myelination, and how children develop the ability to learn and think. Ongoing research delves deeper into the mechanisms underlying these interactions, paving the way for potential dietary strategies to optimize children's cognitive potential. While further studies are warranted to establish their long-term efficacy and safety, current evidence suggests that such interventions may have a promising role in supporting crucial neurodevelopmental processes and promoting positive cognitive outcomes in early childhood.

The Crucial Role of Phospholipids in Child Brain Development: From Diet to Cognition

- The coincident timing of peak phospholipid deposition, myelination, and brain network maturation suggests a critical role for phospholipids in neurodevelopment.
- Evidence shows significantly improved overall myelination in breastfed children, accompanied by increased general, verbal and non-verbal cognitive abilities compared to children who were exclusively formula-fed.
- Supplementation with a formula containing a "myelin nutrient blend" of DHA, ARA, iron, B vitamins, and phospholipids including sphingomyelin significantly increased myelination in brain regions important for sensory, motor, and language skills at 6 months.
- At the end of the 2-year study, these children continued to exhibit enhanced brain development, including greater myelination and gray matter volume. Additionally, these children experienced improved sleep patterns and reduced social fearfulness compared to the control group.
- These data provide insights into the role of key nutrients in myelination, a key process for learning and thinking in children.

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