THE LEARNING LEAD
Breakthrough nutrition and development news, now
Wyeth Nutrition SCIENCE CENTER
VOLUME 6 | ISSUE NO. 1 2018

Sphingomyelin in brain and cognitive development

Preliminary data

Introduction

Myelin is the coating around nerve fibers, which enables fast and efficient transmission of nerve impulses (Fields, 2008). Ensuring efficient transmission is important in the maturation of the infant brain networks, information processing and ultimately, to cognitive performance in infants and children (O'Muircheartaigh et al., 2013). The abundant levels of SM in the CNS and its presence in maternal breast milk (Bitman, Wood, Mehta, Hamosh, and Hamosh, 1984) suggest it has an important role in infant nutrition and in particular in infant brain development.

Preclinical studies have provided insight on the role of SM in CNS development under compromised conditions (Oshida et al., 2003). But the impact of SM intake from diet as well as any potential mechanisms for positive effects are unknown, especially in healthy infants and children.

In this preliminary study, we investigated the link between early life SM obtained from the diet (extracted from parent reporting and the reported formulas analyzed retrospectively) with later brain development, brain structure (as measured by brain imaging) and cognitive function in a group of healthy children. Second, we examined the mechanism behind these effects using in vitro models of brain development.

Key Points

The presences of sphingomyelin (SM) in breast milk suggests it has a role in infant nutrition and its abundance in the CNS indicates a potential role in infant brain development.

In this preliminary study, we investigated the link between early life SM obtained from the diet (extracted from parent reporting and the reported formulas analyzed retrospectively) with later brain development, brain structure (as measured by brain imaging) and cognitive function in a group of healthy children. Second, we examined the mechanism behind these effects using in vitro models of brain development.

Our preliminary findings in children indicate a positive association between early SM intake (0-3 months) and later brain structural development as well as learning. The structural development results are supported by findings obtained in our in vitro models.

Results

Brain regions with a significant relationship between formula SM content (consumed in the first 3 months of life) and myelin water fraction (MWF – a surrogate imaging measure of myelin content) between 12 and 24 months of age is shown in figure 1. (Presence of colour indicates a statistically significant result for that particular brain region, shading of the colour (red – yellow) indicates strength of relationship i.e. low to high).

The trajectory of brain myelination is represented in figure 2. These trajectories are different for children who received a formula composition with high SM content (71mg/L) versus a lower SM content (28mg/L) composition.

As well as the differences in myelination our observational data indicated that SM levels were also positively correlated with cognitive performance within normal ranges of development (using the Mullen Scales of Early Learning).

Experiments using in vitro models of myelination suggested a potential mechanism for the noted effects, where SM supplementation resulted in dose-dependent significantly improved myelination and neuronal network growth.

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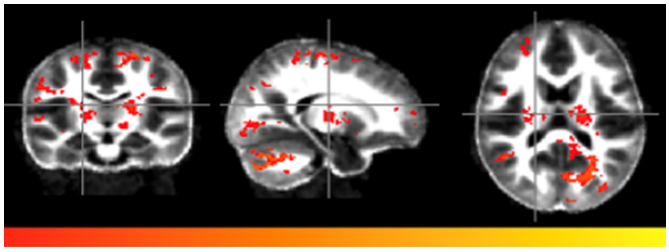

Figure 1: Brain regions with a significant relationship between formula SM content and MWF between 12 and 24 months of age.

Discussion

This is the first study in healthy children that links dietary SM intake from the diet (in the form of infant formula in the first 3 months of life) to cognitive development and brain myelination in early childhood.

Higher levels of SM in the first 3 months of life were associated with higher levels of brain myelin content in the second year of life, particularly in the cerebellum, occipital lobe, visual cortex, internal capsule, parietal lobe and motor cortices – areas of the brain involved in vision, movement and learning.

Our findings also indicate an impact of SM on the pattern of developmental myelination in favor of a later onset as well as a more prolonged rate of myelination (figure 2).

As well as the differences in myelination our observational data indicated that SM levels were also positively correlated with cognitive performance. Specifically, the data suggested verbal functioning (e.g. auditory comprehension and memory, speaking ability and language formation) to be more sensitive to early life SM intake than non-verbal functioning (e.g. visual processing and visual memory, motor control and coordination skills).

Through use of in vitro models we explored the potential mechanism behind SM related effects on myelination. Our results suggest it may be mediated through increasing the proliferation, differentiation and maturation of myelination promoting cells known as oligodendrocytes. Further experiments are needed to characterize the exact mechanism of SM in myelination.

Despite the promising first results, this study has several limitations including observational (not interventional), small sample size, the absence of SM bioavailability data, retrospective analysis of the infant formula, a delay between SM feeding through infant formula and effects on myelination and cognition. Given these time-related limitations, changes in nutritional composition of the formula as well as the impact of other environmental influences on myelination and cognition (e.g. parent-child interaction, nutrition, physical activity, sleep) cannot be excluded.

Nevertheless, our findings are the first to report a positive association between SM and brain structure as well as learning in healthy children, and structural development results are further supported by in vitro models.

Future studies need to investigate this area further to build on the findings of this preliminary work.

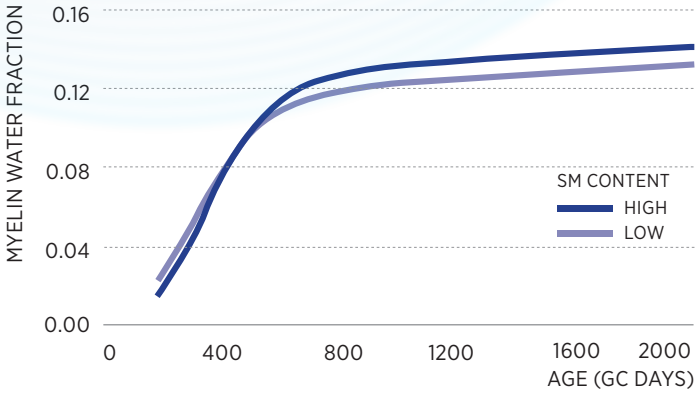

Figure 2: Representative whole-brain white matter myelination trajectories for children who received a formula composition with high SM content (71mg/L) versus a lower SM content (28g/L) composition.

Reference

Babin, F., Sarda, P., Limasset, B., Descomps, B., Rieu, D., Mendy, F., & Crastes de Paulet, A. (1993). Nervonic acid in red blood cell sphingomyelin in premature infants: an index of myelin maturation? Lipids, 28(7), 627-630.

Bitman, J., Wood, D. L., Mehta, N. R., Hamosh, P., & Hamosh, M. (1984). Comparison of the phospholipid composition of breast milk from mothers of term and preterm infants during lactation. Am J Clin Nutr, 40(5), 1103-1119.

Fields, R. D. (2008). Oligodendrocytes changing the rules: action potentials in glia and oligodendrocytes controlling action potentials. Neuroscientist, 14(6), 540-543. doi:10.1177/1073858408320294

O'Muircheartaigh, J., Dean, D. C., 3rd, Dirks, H., Waskiewicz, N., Lehman, K., Jerskey, B. A., & Deoni, S. C. (2013). Interactions between white matter asymmetry and language during neurodevelopment. J Neurosci, 33(41), 16170-16177. doi:10.1523/JNEUROSCI.1463-13.2013

Oshida, K., Shimizu, T., Takase, M., Tamura, Y., Shimizu, T., & Yamashiro, Y. (2003). Effects of dietary sphingomyelin on central nervous system myelination in developing rats. Pediatr Res, 53(4), 589-593. doi:10.1203/01.PDR.0000054654.73826.AC

Pierre, M. (1984). Myelin (Second Edition ed.): Springer US.