The relation of human milk lutein, choline, and docosahexaenoic acid content to recognition memory abilities of 6-month-old breastfed infants

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Background

- Empirical evidence of a relation between nutrient intake and brain function has been elusive. The difficulty in documenting nutritional effects on brain could be because most research is focused on a single nutrient.
- Early choline status has been shown to be important for later adult memory in animal models. When early choline was tested in relation to early cognition, the results were mixed. Animal models show the integrity of the hippocampus is related to choline intake.
- Researchers report mixed results when supplementing infant diets with docosahexaenoic acid (DHA): fewer than 40% of trials find an effect on cognition in fullterm infants. DHA is high in the structures that underlie cognitive abilities, specifically the eye, the hippocampus, and the frontal brain areas. Importantly, DHA is co-localized with choline in the brain and liver.
- Choline is deposited into the macula (which is the most immature structure of the eye) at birth. It is possible that higher choline allows for a higher rate of DHA transfer.

Participants and Method

- Breastfeeding dyads were enrolled when the infants were 3-4 months old. Exclusive breastfeeding was defined as no more than 10% supplemented. All but two of the infants were 100% breastfed; the two met criteria. Milk samples were obtained by expressing the milk from one breast and providing aliquots that contained a mix of fore- and hindmilk.
- In the NORC, breastmilk samples were analyzed for fatty acid content. Lipids were extracted and saponified, with resulting fatty acids trans-methylated to methyl esters which were analyzed using capillary gas chromatography.
- Free choline and betaine were assayed in the Innis lab as detailed in Innis and Hassman, and lutein content was determined using a liquid-liquid extraction method as in Yuhas et al.
- At 6 months of age, a random selection of participants were invited back for an electrophysiology session. Infants were fitted with a 128-channel HydroCel Geodesic Sensor Net (Electrical Geodesics, Inc). The infants were habituated to a picture of a wooden toy. Then, they participated in a 70-30 oddball paradigm that included a random presentation of 70 of their familiar picture and 30 trial-unique pictures.
- Data were manually examined for artifacts, and video was viewed frame by frame to identify segments in which the infants were looking at the stimuli. Only artifact-free trials in which infants were attending to the stimuli were included. Participants who provided at least 10 trials (n = 18, range 10-40) in each condition were included in the analyses (n=55).
- Trials were averaged across condition; novel were subtracted from familiar data. Resulting data were averaged in sensor groupings as shown. Latency to peak amplitude, peak amplitude, and mean amplitude were analyzed in full model multivariate regressions in SAS 9.2.
- Stepwise regressions were undertaken to build models. Significant interactions were followed up with simple slopes analyses.

Results of Full & Reduced Model Analyses

- **Full model:**
  - FzF8-Fr6i, Fr8-Cnt8, Pr2T, M8 = Intercept + DHA + Cho + Lut + ChoXl + ChoXDHA + En + Inc
  - No variable predicted mean or peak amplitude at any sensor grouping.
  - Latency to peak amplitude was predicted by choline at frontal right leads (p<0.05) and by choline (p=0.01) and lutein by choline interaction (p<0.05) at the central leads.
  - **Reduced Choline model** predicting latency to peak amplitude:
    - Frontal Left: -3.12 + 0.99 DHA + 1.73 Choline - 0.07 DHA X Choline Model p < 0.05 R-sq= 0.21
    - Central Z: -3.12 + 0.99 DHA + 1.73 Choline - 0.07 DHA X Choline Model p < 0.05 R-sq= 0.21
    - **Reduced Lutein model** predicting latency to peak amplitude:
      - Frontal Left: -3.0 + 0.74 Lutein + 0.36 Choline - 0.05 Lut X Choline Model p < 0.01 R-sq= 0.33
      - Central Z: -3.0 + 0.74 Lutein + 0.36 Choline - 0.05 Lut X Choline Model p < 0.01 R-sq= 0.33

Discussion

- **Recognition memory abilities are supported by high DHA and choline as well as high lutein and choline. Importantly, there was no significant relation between DHA or lutein and the cognitive measures.** Thus, the nutrients are needed together to support memory.
- The relation was found only in latency to peak amplitude. There was no significant association with mean amplitude or peak amplitude. Moreover, the significant relations were confined to the central and frontal areas of the scalp.
- **Latency to peak amplitude is interpreted as a measure of sustained processing. When the difference between activity in response to novel and familiar stimuli is large, we infer recognition memory. If a stimulus is remembered, it does not require processing.**

Simple Slopes Models: Latency at Frontal & Central Sensors

- **When DHA and choline are high, recognition memory is better.**

Acknowledgments: The authors would like to thank the families that made this research possible. This project was funded by NIH grant #DK56350 to the University of North Carolina at Chapel Hill Nutrition Research Institute. Correspondence and requests for reprints can be addressed to Carol L. Cheatham, Ph.D., Nutrition Research Institute, 500 Laureate Way, Rm 1101, Kannapolis, NC 28081. carol_cheatham@unc.edu