ALBION MINERALS
Human Nutrition

RESEARCH NOTES

A COMPILATION OF VITAL RESEARCH UPDATES ON HUMAN NUTRITION

June, 2019 Volume 28, No 2

Lifelong Benefits of Choline in Pre-Natal Nutrition

In the June 2018 Research Notes (v. 27, no. 2) the topic was prenatal nutrition that supported the health of the mother and consequently, the health of the baby. It was discussed that maternal nutrition could also have significant impact on the baby, perhaps for years to come. As part of the Research Note, both choline and its major functions within the body were introduced. These are summarized in Figure 1 taken from that Research Note.

There is considerable evidence pointing to choline's significance in fetal development. Choline is transferred across the placenta from the mother to the fetus, despite the opposition of a significant concentration gradient. The typical concentration of choline in amniotic fluid may be 15 times that of maternal blood, and the placenta itself may have up to 50 times more choline than in maternal plasma, with large quantities stored in reserve as acetylcholine[1].

Choline is needed before birth as a precursor of the structural phospholipids needed to construct the membranes of cholinergic neurons. It has been observed that prenatal choline is essential to the neurophysiological development of hippocampus, the so-called "memory center" of the brain[2,3]. Choline is needed after birth, as well, as part of the synaptic connections which continue to be formed in the hippocampus and basal forebrain after birth[2,3].

The benefits of pre-natal choline availability have resulted in improved cognitive performance in offspring. In a review of 34 animal studies, *McCann, et al.*[4], concluded that the evidence suggested that choline supplementation during pregnancy had the following benefits:

- Enhanced cognitive performance, particularly with difficult tasks

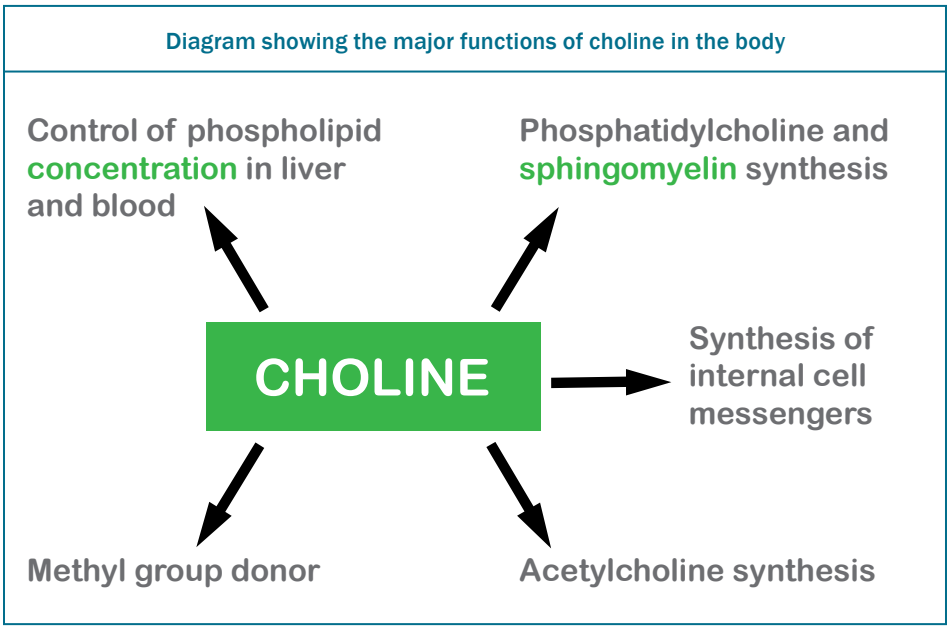

Figure 1. Major functions of choline in the body. From Albion Research Notes June 2018

- Increased electrophysiological responses
- Increased size of neurons
- Protection against adverse effects of some neurotoxins.

The pre-natal benefits seen appear to have lifelong impacts. In another review of animal studies by Meck and Williams[5], they described several studies that they reviewed throughout the life-cycle of a rodent. In one aspect they showed that the spatial memory task improvement seen with pre-natal supplementation was due to brain changes in the prenatal development since the rat pups were removed from their birth mothers at birth and raised by non-supplemented dams. They also showed that this initial memory advantage persisted into adulthood by describing studies that show that in maze searching tests, adult rats who received pre-natal choline performed better than rats who did not. Additional supplementation as an adult did not have an effect. They hypothesized that the aged brain cholinergic conversion pathways can decrease with age, limiting benefits. Meck and Williams concluded that the supplementation of choline during pregnancy can result in "metabolic imprinting," which is a relatively permanent modification of cholinergic synaptic response[5].

Based upon the conclusion of Meck and Williams, is logical to propose that there must be a specific period in the pre-natal development process where it is likely for this "metabolic imprinting" to occur. *Albright, et al.*[6], reported a study to address this. In their study they fed timed-pregnant rats deficient, adequate or supplemented levels of choline beginning on embryonic day 12 for six days. At the end of the feeding period, fetal brain tissue was evaluated, and it was found that the supplemented group had significantly more TOAD-64 protein, which is a marker of early neuronal differentiation. *Li, et al.*[7], performed a similar feeding trial, but evaluated the brain tissue as juveniles (ages 20-25 days). They found that the prenatal choline supplementation positively altered both the electrophysiology, and the morphology of hippocampal pyramidal cells. These two studies provide the mechanism for the lasting behavioral and memory effects that others reported and supports Meck and Williams' notion of "metabolic imprinting."

The cognitive and behavioral benefits to the offspring of choline supplementation to the mother during pregnancy is well documented in animal models. Recent research indicates that the benefits are present in humans as well. *Caudill, et al.*[8], from Cornell University, conducted a double-blind controlled feeding trial in which mothers entering the third trimester of pregnancy consumed either 480 or 930 mg of choline, as choline chloride, daily for the remainder of the pregnancy. After delivery, the infants were evaluated at ages 4, 7, 10, and 13 months of age for information processing speed and visuospatial memory using flashing images and measuring rapid eye movements (sac-

Folic acid, Iron & Choline can have significant life-long impacts on the health of the mother and the gestating child.

cades) to detect and/or predict locations to the images. They found that the mean reaction times from both groups significantly reduced with age. Most interestingly they found that there was a significant difference at the initial testing age of 4 months between treatment groups that persisted throughout the testing period. Those infants born from mothers who consumed 930 mg of choline had significantly faster ($p<0.05$) reaction times to the flashed images than those who consumed 480 mg of choline. The authors concluded that increasing maternal consumption of choline may be a nutritional strategy for lifelong cognitive benefit. They further postulated that based upon rat models that have been previously described may result in improved incidences of age-related cognitive decline.

In conclusion, like with other well-known prenatal nutrients such as folic acid, iron, and choline can have significant lifelong impacts on the health of the mother and the gestating child. Balchem is a leading manufacturer of choline salts for nutritional purposes and offers the branded Vitacholine® as a dietary ingredient along with Ferrochel®.

References

1. *Hersh LB, Peet M. Re-evaluation of the kinetic mechanism of the choline acetyltransferase reaction. J Biol Chem 1977;252(14):4796-802.*

2. *Li Q, Guo-Ross S, Lewis DV, Turner D, White AM, Wilson WA et al. Dietary prenatal choline supplementation alters postnatal hippocampal structure and function. J Neurophysiol 2004;91:1545-55.*

3. *Albright CD, Tsai AY, Friedrich CB, Mar MH, Zeisel SH. Choline availability alters embryonic development of the hippocampus and septum in the rat. Brain Res 1999;113:13-20.*

4. *McCann JC, Hudes M, Ames BN. An overview of evidence for a causal relationship between dietary availability of choline during development and cognitive function in offspring. Neurosci Behav Rev 2006;30:696-712.*

5. *Meck WH, Williams CL. Metabolic imprinting of choline by its availability during gestation: implications for memory and attentional processing across the lifespan. Neurosci Biobehav Rev 2003;27:385-99.*

6. *Albright CD, Tsai AY, Friedrich CB, Mar MH, Zeisel SH. Choline availability alters embryonic development of the hippocampus and septum in the rat. Brain Res 1999;113:13-20.*

7. *Li Q, Guo-Ross S, Lewis DV, Turner D, White AM, Wilson WA et al. Dietary prenatal choline supplementation alters postnatal hippocampal structure and function. J Neurophysiol 2004;91:1545-55.*

8. *Caudill MA, Strupp BJ, Muscalu L, Nevis JEH, Canfield RL. Maternal choline supplementation during the third trimester of pregnancy improves infant information processing speed: a randomized, double blind, controlled feeding trial. FASEB J 2018;32:2172-2180.*

VitaCholine®

FERROCHEL®

67 South Main Street, Suite 200
Layton, UT 84041

The Mineral People®

ALBION® Research Notes

Albion Research Notes
is a publication of
BALCHEM
Human Nutrition & Pharma

©2019 Albion Laboratories Inc. All rights reserved.

June, 2019 Volume 28, No 2

Research Notes