Interactions of iron and n-3 fatty acid deficiencies in rats: effects on metabolism and cognition

Project: 385

Jeannine Baumgartner
Laboratory of Human Nutrition, Institute of Food, Nutrition and Health, ETH Zentrum, 8092 Zürich

Both, iron (Fe) and n-3 fatty acids (FAs) are essential for normal brain development. Combined deficiencies in Fe and n-3 FAs may have interactive or additive effects on the structure and function of the central nervous system.

This study investigated the effects of Fe and n-3 FA depletion and repletion, alone and in combination, on Fe and FA metabolism and spatial learning and memory function in rats.

During a 5 week depletion period, male Wistar rats at 3 weeks of age were fed either a control, an iron deficient (ID), an n-3 fatty acid deficient (n-3 FAD) or an ID + n-3 FAD diet. After 5 weeks, part of the ID + n-3 FAD rats were allocated into 6 repletion groups receiving either an ID + α-linolenic acid/linoleic acid (ALA/LA) sufficient, an Fe + ALA/LA sufficient, an ID + DHA/EPA sufficient, an Fe + DHA/EPA sufficient, an ID + n-3 FAD or Fe sufficient + n-3 FAD diet for another 5 weeks. Spatial learning and memory was assessed at the end of both periods using the reference- and working-memory version of the Morris Water Maze (MWM) task. Total phospholipid (TPL) FA composition and Fe concentration were examined in various brain regions, red blood cells (RBC) and plasma at 5 and 10 weeks.

Fe concentrations were significantly decreased in the hippocampus of n-3 FAD rats. In the cerebellum, an ID + n-3 FAD diet resulted in significantly lower Fe concentrations compared to an ID diet alone. Additionally, Fe given in combination with DHA led to significantly greater Fe repletion in the olfactory bulb. Hemoglobin concentrations were significantly decreased by ID, and combined ID + n-3 FAD resulted in a further decrease. The long-chain n-3 FAs DHA and EPA, as well as the n-6 FA arachidonic acid (ARA), were significantly decreased in plasma and red blood cells by ID alone, and in combination with n-3 FAD after depletion, while the precursor n-3 and n-6 FAs ALA and LA accumulated. On the other hand, dietary ALA given in combination with Fe tended to be more effective in repleting DHA levels, than in combination with ID. Working memory was impaired in rats receiving an ID or n-3 FAD diet alone, but not in the combined group, during the depletion period. During repletion, the rats fed an ID diet in combination with DHA or ALA, but not with n-3 FAD, showed impaired working memory.

Confirming and extending previous studies, TPL analysis suggests iron deficiency impairs n-3 FA status in some brain regions and in the periphery, most probably by affecting FA desaturation. This is the first study to show that n-3 FA status modulates brain iron concentrations. In the MWM task, combined deficiency seems to ameliorate the effects of the single deficiencies. However, the underlying mechanism remains unclear and needs further investigation.

Publications based in these data are currently in preparation.