Early Nutrition as a Major Determinant of ‘Immune Health’: Implications for Allergy, Obesity and Other Noncommunicable Diseases

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Early-life nutritional exposures are significant determinants of the development and future health of all organ systems. Modern humans show many hallmarks of animals living in captivity, prone to obesity and inflammation. The low-grade inflammation that characterizes virtually all noncommunicable diseases suggests a central role of the immune system in the risk and pathogenesis of these conditions. Indeed, there is increasing evidence that our propensity for inflammation in adulthood [higher baseline C-reactive protein (CRP)] is determined by early-life conditions, including nutrition, poverty, breastfeeding, pollutants and more hygienic environmental conditions. This increases the risk of heart disease, diabetes and all-cause mortality. This appears to be the result of a complex interplay between immune and metabolic pathways through adipokines [such as leptin – a member of the interleukin (IL)-6 family] which, in addition to effects on appetite and energy homeostasis, also promote inflammation through innate and T-cell activation. In particular, the dramatic rise in infant immune diseases, most notably allergy, indicates the specific vulnerability of the immune system to early environmental changes.

Dietary changes are also at the center of the emerging epigenetic paradigms that underpin the rise in many modern inflammatory and metabolic diseases. There is growing evidence that exposures in pregnancy and the early postnatal period can modify gene expression and disease susceptibility. Although modern dietary changes are complex and involve changing patterns of many nutrients, there is also interest in the developmental effects of specific nutrients. Oligosaccharides (soluble fiber), antioxidants, polyunsaturated fatty acids, folate and other vitamins have documented effects on immune function as well as metabolism. Some have also been implicated in modified risk of both
obesity and allergic disease in observational studies. Intervention studies are largely limited to trials with polyunsaturated fatty acids and oligosaccharides, showing preliminary but yet unconfirmed benefits in disease prevention.

As well as progressively ‘cleaner’ environments, nutritional changes may also be influencing gut biodiversity. The high-fat, low-fiber ‘western’ diet also adversely changes the gut microbiome, with recognized implications for immune development and increased risk of allergic disease. There are also associated effects on gut barrier function, increasing systemic antigenic load and low-grade endotoxemia – as driving factors for insulin resistance, obesity and diabetes. This is associated with increased CRP and higher levels of circulating IL-1, tumor necrosis factor, IL-6 and adiponectin as evidenced by increased low-grade systemic inflammation. This provides new perspectives on how modern dietary patterns may be increasing the risk of both immune and metabolic diseases. This is a major factor contributing to the more proinflammatory conditions of the modern lifestyle. These effects begin in uterine life and may offer important opportunities for noninvasive prevention strategies using nutritional measures.

Understanding how environmental influences disrupt the finely balanced development of immune and metabolic programming is of critical importance. Diet-sensitive pathways are likely to be crucial in these processes. While epigenetic mechanisms provide a strong explanation of how nutritional exposures can affect the fetal gene expression and subsequent disease risk, other diet-induced tissue compositional changes may also contribute directly to altered immune and metabolic function – including diet-induced changes in the microbiome. A better understanding of nutritional programming of immune health, nutritional epigenetics and the biological processes sensitive to nutritional exposures in early life may lead to dietary strategies that provide more tolerogenic conditions during early immune programming, and reduce the burden of many inflammatory diseases – not just allergy.

**Suggested Reading**

