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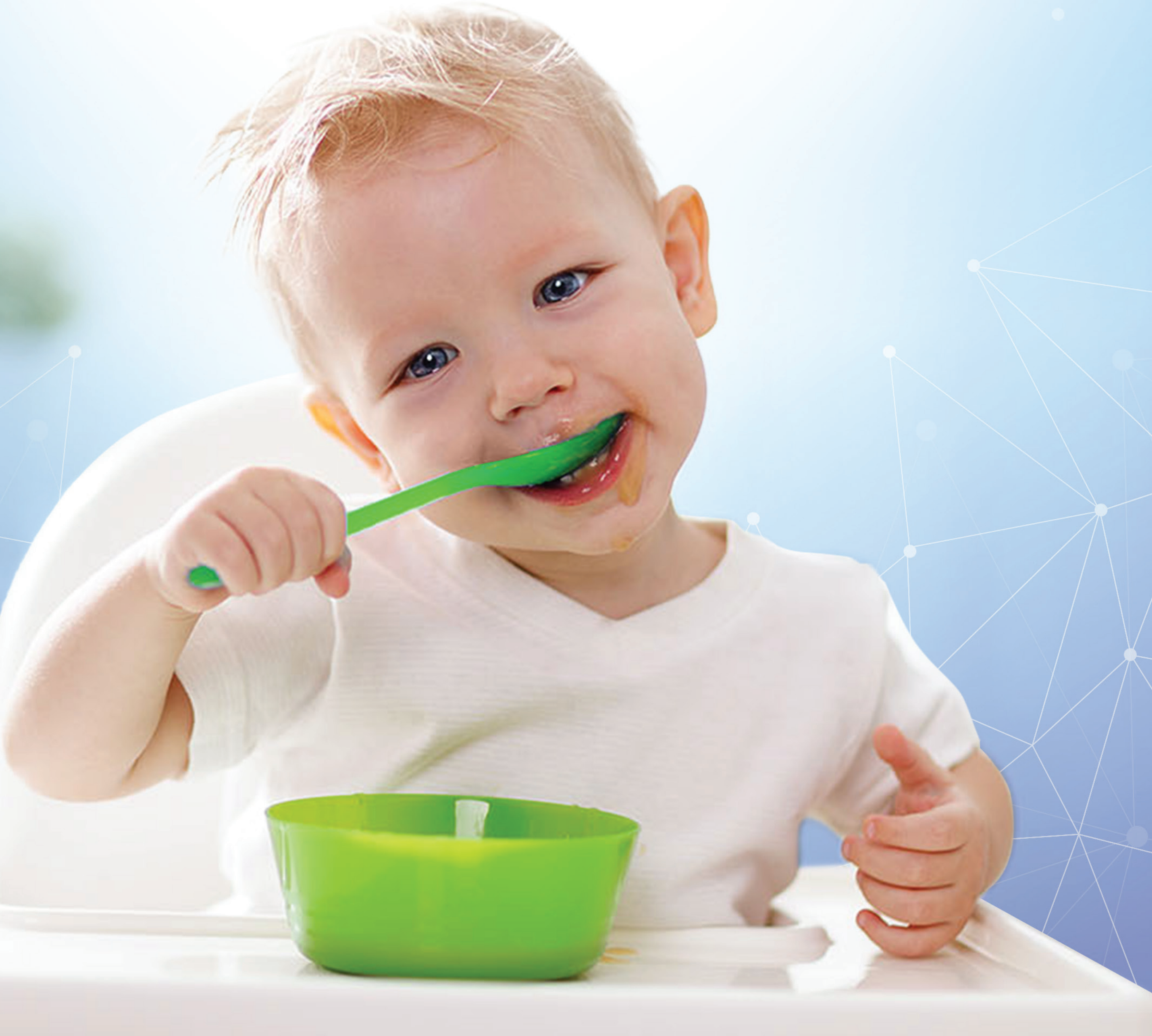
Toddler Foundations

Nurturing the Brain, Body and Behavior



Feeding our infants and toddlers: present and future consequences

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KEY MESSAGE

Complementary feeding (CF) is “the process starting when breast milk alone is no longer sufficient to meet the nutritional requirements of infants” so that “other foods and liquids are needed, along with breast milk” and should be introduced no later than 6 months of age.

The introduction of CF, with emphasis on the right timing can impact health outcomes such as prevention of allergy and obesity.

ABSTRACT

Complementary feeding (CF) is “the process starting when breast milk alone is no longer sufficient to meet the nutritional requirements of infants” so that “other foods and liquids are needed, along with breast milk”. A few years ago, it was shown, in Europe, that solids are introduced to 37% of formula fed infants and 17% to breastfed (BF) infants before 4 months of age. In the US, a report from 2022 states that Majority of US infants are introduced to CF before 6 months of age (51%), about 32% of infants receive CF before 4 months of age and this proportion is higher among formula-fed infants (42%) compared with those who are mixed-fed (32%) or fed human milk as the only source of milk (19%).

So why should we introduce CF and when? At around 6 months, the volume of human milk ingested by exclusively BF infants becomes insufficient to meet the requirements of calories, protein, iron, zinc and some fat-soluble vitamins (A & D). In a different lecture of this symposium, the important issues of texture, taste and acceptance are discussed.

When should we introduce CF? First, the gastrointestinal and renal function are sufficiently mature by around 4 months of age to enable term infants to process some CF and the infant should have attained the necessary motor skills to cope safely with CF.

In addition, the introduction of CF impact health outcomes such as prevention of allergy and obesity, and the timing may play a part on the impact of CF introduction.

In this presentation we chose to focus on prevention of allergy and use the peanut story as an example. In 2008, the prevalence of peanut allergy (PA) was determined in Israel and the UK among similar Jewish communities. Clinically validated questionnaire determined the prevalence of PA among Jewish schoolchildren (5171 in the UK and 5615 in Israel) and a second validated questionnaire assessed peanut consumption and weaning in Jewish infants (77 in the UK and 99 in Israel). In that study, the adjusted risk ratio for PA was 9.8 (95% CI, 3.1-30.5) higher in primary school children in the UK, while there was a significant

consumption of peanuts in Israeli infants compared to no intake in the UK. Following that study, a randomized prospective study was designed (The LEAP Study). It Randomly assigned 640 infants with severe eczema, egg allergy, or both to consume or avoid peanuts. The consumption group was recruited between 4-11 months of age. The consumption included at least 6 g of peanut protein per week, distributed in three or more meals per week, until they reached 60 months of age vs. avoidance.

In that study, in the intention to treat analysis, the prevalence of PA at 60 months of age was 13.7% in the avoidance group and 1.9% in the consumption group (P<0.001). Using data from 2 RCTs and one observational study, this group showed that the time of introduction is important, since the risk reduction is smaller for every month of delayed introduction until one year of age. Finally, a recent systematic review and meta-analysis (2023) concluded that based on high-certainty evidence from 4 trials (3796 participants) that introduction of peanut from 3 to 10 months of age was associated with reduced risk of PA (RR, 0.31; 95%CI, 0.19-0.51; I2 = 21%). In that systematic review, earlier introduction of multiple allergenic foods reduced the occurrence of any food allergy.

The recommendations of the European Society for Pediatric Gastroenterology, Hepatology and Nutrition (ESPGHAN) from a few years ago, are that allergenic foods may be introduced when CF is commenced any time after 4 months of age (17 weeks). Infants at high risk of PA (those with severe eczema, egg allergy or both should have peanut introduced (for example as smooth peanut butter) between 4 and 11 months; following evaluation by an appropriately trained professional. ESPGHAN also commented that during the CF period, >90% of the iron requirements of a BF infant must be met by CF and that cow's milk is a poor iron source. ESPGHAN cautions that cow's milk should not be used as the main drink before 12 months, although small volumes may be added to CF. However, it is important to note that in 2023, the WHO released its own recommendations for CF suggesting a worldwide recommendation for introduction of CF at 6 months of age and that cow's milk rather than formula can be used after

6 months. Though the stirred debate is beyond this presentation, it must be noted that some of the WHO recommendations are of very low certainty and the recommendations are universal while CF may need to be geographically tailored to allow timely exposure.

In conclusion, CF is an important building stone in our children's future health and proper and timely introduction of solids is an important pillar of health.

Early life texture experiences and the development of healthy eating behaviours

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KEY MESSAGE

Early life texture experiential learning is important in shaping both food preferences and dietary patterns and supporting the development of the child’s oral anatomy and physiology, and the healthy associated eating behaviours linked to normal growth and development.

ABSTRACT

Eating behaviors develop in early life and are further refined during childhood, shaping life-long food habits and dietary patterns. Newborns rely on innate reflexes such as sucking, swallowing, and rooting to meet their daily energy and nutrient requirements. During infancy and early childhood, children have high nutrient and energy requirements relative to their size, due to the energy cost of growth and development. Importantly, the eating skills and texture experiences acquired and refined in early life also have a direct influence on the development of oral anatomy and physiology. These early life feeding skills are acquired through experiences with food textures and help to stimulate oral anatomy development, the emergence of stable oral processing behaviors, and ultimately food preferences and weight status.

Infants transition at around 6-months of age from supine, dependent feeding with liquid foods, such as breast or bottle feeding to upright, independent feeding with semi-solid and solid foods. This rapid period of learning coincides with considerable anatomical and physiological changes, as the infant must learn to balance their head while the first teeth emerge, and they develop the muscle coordination needed to chew and orally process textured foods safely.

Chewing is a learned complex motor-task and is the result of the coordination of 26 muscle pairs and 5 cranial nerves, to grip/bite, masticate and safely swallow the food being consumed. Every food texture experience is an opportunity for the infant to learn the necessary skills to safely manipulate and swallow a bite of food, and each new texture challenge has to be ‘learned’, as different foods require unique oral processing skills to manipulate and swallow the food safely.

Despite the importance of early life texture exposure experiences, research has shown a relatively poor alignment between the age-appropriate recommendations made on food products and the consistency of the texture of weaning products. Parents often rely on age or cues from their toddler to assess their ‘readiness’

to transition to more complex textures, yet research has shown that neither age nor number of teeth can adequately explain differences in the ability to orally breakdown a test food. A child's developmental stage and experience across a diverse range of food textures is likely to be a better predictor of oral processing skill development.

Toddlers that have developed more advanced chewing skills tend to exhibit higher acceptance for a broader range of food textures than those with a more narrow texture exposure and less developed oral processing skills. These chewing skills shape the eating behaviors that become stable and carry forward into later childhood, such as a habitual fast or slow eating rate and associated differences in energy intake and weight status.

Research has shown that differences in habitual eating speed among school-age children are associated with energy intakes, weight status (BMI-z score) and adiposity levels. Understanding how early life texture learning drives the development of these oral processing skills is central to supporting the normal development of oral anatomy and the adoption of healthier eating patterns that support optimal growth and development.

Toddler nutrition and brain development

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KEY MESSAGE

Recent studies have identified critical periods in toddlerhood and preschool age where specific nutrient intakes significantly influence brain development. Specifically, three age windows between ages 1 and 5 were identified each showing specific pattern of nutrients supporting brain myelination, highlighting varying positive nutrient correlations across these periods. These findings underscore the importance of tailored nutritional strategies during early childhood to support optimal neurodevelopment.

ABSTRACT

Early life brain maturation is composed of complex cooccurrence of multiple processes paralleling functional development. Among these processes, we have demonstrated that myelination: i. can be non-invasively measured using MRI, ii. is associated with multiple brain functions (e.g. cognitive, learning and socio-emotional functions), iii. shows a rapid increase from birth to 2 years of age followed by a more stable increase until young adulthood and iv. can be modulated by nutrition in early life. Therefore, leveraging an on-going cohort in the US that is following infant from birth until school-age, we aimed to assess the nutritional impact on myelination from toddlerhood onwards.

Each participant underwent comprehensive assessments, including morphological and structural brain imaging—specifically water fraction myelination and diffusion tensor imaging including fractional anisotropy measures. Dietary intake was quantified through a 24-hour recall questionnaire (ASA-24h) and translated into nutrient intake. We used a sliding window approach to assess correlations between the intake of 88 nutrients and brain myelination across continuous age windows, allowing us to delineate three distinct nutrient-myelin association windows.

The first window, spanning 6 to 20 months, demonstrated 60% positive correlations, indicative of rapid myelin growth. The second window, from 20 to 30 months, revealed % positive correlations, correlating with the inflection point in the developmental trajectory, while the third window, covering 30 to 60 months, showed 37% positive correlations, aligning with a phase of continued but slower myelin maturation.

In the initial analyses we used myelination of the whole brain; to further refine our understanding of the nutrition impact on specific brain network maturation, we re-analysed the data by correlating the myelination of brain regions relevant to social-emotional, language, motor and vision functions. In this second round of analyses, we identified that certain nutrients seemed to be systematically associated with brain myelination, independently of the brain region, while others exhibited

associations that were specific to certain brain regions. These analyses evaluated the indirect effects of dietary intake on cognitive and learning performance through its influence on myelination and structural connectivity.

Our models consistently identified known key nutrients, such as iron and vitamin B, and new nutrients, such as polar lipids, that significantly contributed to cognitive and learning skills by enhancing myelin integrity and network efficiency across learning-related brain regions. These findings provide novel insights into the developmental windows during which nutrition most strongly influences brain maturation. This broad early life approach underscores the importance of targeted, brain-stage–appropriate nutritional interventions during periods of rapid myelination as well as during the period of slower myelination.

Overall, this work emphasizes that nutrition is a critical determinant of brain development across early life and childhood, shaping both the biological substrates of multiple brain functions, such as vision, language, social-emotional behaviors. These insights pave the way for developing nutritional strategies aimed at optimizing neurodevelopment and promoting lifelong cognitive health.