Infant growth and development.

Quality nutrition helps to enable healthy growth and development, and can help support the best possible start in life.

By Dr Sophie Gallier.
Breast is best

The World Health Organization (WHO) recommends exclusive breastfeeding from birth to 6 months of age for healthy growth, protection against infections, and brain development of the infant.

Continued breastfeeding along with complementary foods up to 2 years of age or beyond is further advised.

INFANT NUTRITION
Growth in infancy and early childhood

Growth rate is related to the nutritional status of the infant and has long-term health effects (Michaelsen, 2015). Breast milk is the best source of nutrition for infants. Breastfed infants grow faster, with more fat gain, than formula-fed infants in the first months after birth. Thereafter, growth rate slows down and breastfed infants gain more lean mass between 6 and 12 months of age and have a lower weight and length at 12 months of age (Michaelsen, 2015). In the first couple of months of life, growth rate is very rapid, with median monthly weight increment of 0.9-1.1 kg and height increment of 4 cm.

Deviations in growth, i.e. under-nutrition (growth restriction, stunting and wasting) or over-nutrition (overweight and obesity), may result in impaired neurodevelopment and a greater risk of non-communicable disease in later life. Indeed, a rapid growth in infancy, commonly observed in formula-fed babies who tend to have a higher intake of energy than breastfed infants, is often associated with higher adiposity, insulin release and risk of obesity in childhood and adolescence (Agostoni et al., 2001).

The WHO growth standards (WHO, 2006) were developed from the collection of growth data from 8500 predominantly-breastfed children from different ethnicities and cultural environments from around the world to provide a single international standard of physiological growth for 0-5 year-old boys and girls and promote breastfeeding as the best nutrition source for optimal growth. From this survey, it appeared that nutrition and socioeconomic factors have a greater influence than geography and ethnicity.
INFANT DEVELOPMENT
Brain growth and cognitive development

The development of the brain starts during pregnancy, highlighting the importance of maternal nutrition on foetal brain growth and neurodevelopmental processes such as neuron proliferation and myelination (Prado and Dewey, 2014). The infant brain grows rapidly and relies on a constant supply of energy and key nutrients (Table 1) to grow and function. The neural plate and the neural tube form 22 days after conception, followed by the creation of neurons and glial cells 7 weeks after conception. After birth, the child’s experience affects neural pathways and brain plasticity, the latter allowing the brain to adapt to new environment and recover from injuries during childhood and adolescence (Prado and Dewey, 2014).

<table>
<thead>
<tr>
<th>Nutrition and environment</th>
<th>Neuron proliferation</th>
<th>Axon and dendrite growth</th>
<th>Synapse formation, pruning and function</th>
<th>Myelination</th>
</tr>
</thead>
<tbody>
<tr>
<td>Undernutrition</td>
<td>Less brain cells and grey matter</td>
<td>Restricted dendritic growth</td>
<td>Fewer synapses</td>
<td>Reduced myelination</td>
</tr>
<tr>
<td>Fatty acids</td>
<td>Synthesis of membrane phospholipids and DHA accumulation</td>
<td>ARA and DHA play a role in synapse formation and neurotransmission</td>
<td>Structural components of myelin</td>
<td></td>
</tr>
<tr>
<td>Gangliosides and sialic acid</td>
<td>Present in high concentration in the nervous system cells and contribute to neuritogenesis</td>
<td>Enhanced axonal elongation and contribute to dendritogenesis</td>
<td>Regulation of synaptic transmission</td>
<td>Myelin stabilization</td>
</tr>
<tr>
<td>Phospholipids and choline</td>
<td>Transmembrane signalling during neurogenesis</td>
<td>Synthesis of the neurotransmitter acetylcholine</td>
<td>Increase myelination</td>
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<tr>
<td>Iron</td>
<td>Regulation of cell division in the central nervous system</td>
<td>Dendritic branching</td>
<td>Maturation of synapses and metabolism of neurotransmitters dopamine and norepinephrine</td>
<td>Myelin synthesis</td>
</tr>
<tr>
<td>Experience, learning and education</td>
<td>Greater brain weight and cortical thickness</td>
<td>Increased dendritic branching and spines</td>
<td>Increased synapse numbers per neuron</td>
<td>Increase myelination</td>
</tr>
</tbody>
</table>

Table 1: Evidence for the role of selected nutrients and experience in key neurodevelopmental processes. Adapted from Prado and Dewey (2014) and Mendez-Otero et al. (2013).
The nutritional composition of breast milk, the close contact between the mother and the child during breastfeeding and the positive attitude of a mother towards breastfeeding have a positive impact on the infant’s cognitive development (Agostoni et al., 2001). Visual, auditory and tactile stimulations contribute to the infant’s brain development (Prado and Dewey, 2014). Motor development (Table 2) occurs in synergy with cognitive and sensory development (Gerber et al., 2010).

Table 2: Some important gross motor milestones in the first 2 years of life. Adapted from Gerber et al. (2010)

<table>
<thead>
<tr>
<th>Age</th>
<th>What to expect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Birth</td>
<td>Movement is via involuntary reflexes</td>
</tr>
<tr>
<td>2 Months</td>
<td>Lifts chest when lying on tummy</td>
</tr>
<tr>
<td>4 Months</td>
<td>Props on wrists when lying on tummy</td>
</tr>
<tr>
<td>6 Months</td>
<td>Sits momentarily without support</td>
</tr>
<tr>
<td>8 Months</td>
<td>Gets into sitting positions; crawls on tummy</td>
</tr>
<tr>
<td>12 Months</td>
<td>Stands well; first independent steps</td>
</tr>
<tr>
<td>18 Months</td>
<td>Crawls down stairs; runs well</td>
</tr>
<tr>
<td>2 Years</td>
<td>Walks down stairs holding rail; kicks ball; throws ball overhead</td>
</tr>
</tbody>
</table>

The head circumference of a 2 year-old infant reaches 80% of its adult size (Michaelisen, 2015). This is linked with the rapid growth rate of the brain in the first years of life, starting from 25% of its adult weight at birth, doubling in size by 6 months of age and growing to about 80% of its adult size by 3 years of age (Figure 1; Debakan and Sadowsky, 1978). Breast milk lipids are an important fuel for the development of the brain (Agostoni et al., 2001). Breast milk lipids are present as fat globules with a triglyceride core stabilized by a specific milk fat globule membrane (MFGM). They provide critical building blocks for brain membranes: LC-PUFAs such as docosahexaenoic acid (DHA) and arachidonic acid (ARA) and MFGM complex lipids such as phospholipids and gangliosides (Koletzko, 2016). DHA also plays a role in the development of visual function (Koletzko, 2016).
MATURATION OF THE GUT AND ITS MICROFLORA

Organs develop at different rates during infancy, childhood and puberty. The infant gut is immature at birth. The intestinal wall acts as the first barrier for nutrients, pathogens and luminal components (Le Huërou-Luron et al., 2010). Therefore, rapid maturation of the gastrointestinal tract functions and the intestinal epithelial wall is critical for efficient absorption of nutrients, protection and development of the infant postnatally. Breast milk lipids and carbohydrates contribute greatly to the maturation of the infant gut. Infant formula feeding was reported to induce gut hypertrophy and faster maturation of the enzymatic hydrolytic functions (Le Huërou-Luron et al., 2010).

The newborn gut is considered sterile at birth (Campeotto et al., 2007). The colonization of the infant’s gut starts with maternal and environmental contacts and is greatly influenced by the type of feeding and the use of antibiotics in infancy. The establishment of the microflora is a successive and complex process in the first years of life (Le Huërou-Luron et al., 2010). It starts with the establishment of aerobic and facultative-anaerobic bacteria, which change the intestinal milieu by consuming oxygen allowing the proliferation of anaerobic bacteria such as Bifidobacteria, Clostridia and Bacteroides. Bifidobacteria rapidly become the predominant bacteria in the breastfed infant’s gut. The faecal microbiota of formula-fed infants is more diverse and more abundant in Clostridia and Bacteroides than in breastfed infants (Campeotto et al., 2007). The differences in faecal microbiota composition have an impact on the production of faecal short-chain fatty acids (SCFAs). The microbiota differences between breastfed and formula-fed infants seem to disappear after introduction of complementary foods (Campeotto et al., 2007).

Human milk oligosaccharides (HMOs), which are indigestible carbohydrates, and probiotics naturally present in human milk help shaping the infant’s gut microflora. The prebiotics, galacto-oligosaccharides and fructo-oligosaccharides, added to infant formulas stimulate the growth of Bifidobacteria and Lactobacilli while preventing pathogen growth (Campeotto et al., 2007). The gut microbiota has an impact on the infant’s intestinal physiology and immunity.

DEVELOPMENT OF THE IMMUNE SYSTEM

The gut microflora plays a metabolic role by fermenting non-absorbed nutrients in the small intestine. For example the metabolites from the fermentation of prebiotics result in the production of SCFAs, decreasing the pH of the gut, which prevents the growth of pathogens. Therefore a healthy microflora contributes to a protective gut barrier function and a healthy intestinal immune system (Campeotto et al., 2007).

Human milk proteins play a role in the development of the infant’s immune system in addition to hormones, growth factors, cytokines and enzymes (Le Huërou-Luron et al., 2010). Colostrum, particularly rich in immunoglobulins, acts as an immunity booster. Breastfeeding reduces the risk of infectious diarrhoea and necrotising enterocolitis (Le Huërou-Luron et al., 2010). Whey proteins, including α-lactalbumin and lactoferrin, have antibacterial activity. Lactoferrin, lysozyme, immunoglobulins and HMOs have a bifidogenic effect and play a key role in the development of the microflora of breastfed infants (Campeotto et al., 2007). Probiotics, mainly Bifidobacteria and Lactobacilli, are often added to infant formulas and foods, modulate positively the gut microflora and provide a range of protection from reduction of risk of infection, prevention of diarrhoea and reduction of prevalence of eczema (Campeotto et al., 2007; Wickens et al., 2008; Oswari et al., 2013). The presence of bacteria in breast milk is likely one contributor to the reduced risk of developing allergies observed in breastfed infants.
Conclusion

The growth and development of infants is influenced by both genetic and epigenetic factors. While each infant is born with a unique genetic potential, many other factors, such as environmental stimulations, education, and the type and the right amount of nutrients and food, play a role in how the infant develops intellectually, physically and physiologically.

REFERENCES


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