

Infant growth and development

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



Ingredients by



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).



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

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 head circumference of a 2 year-old infant reaches 80% of its adult size (Michaelsen, 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).

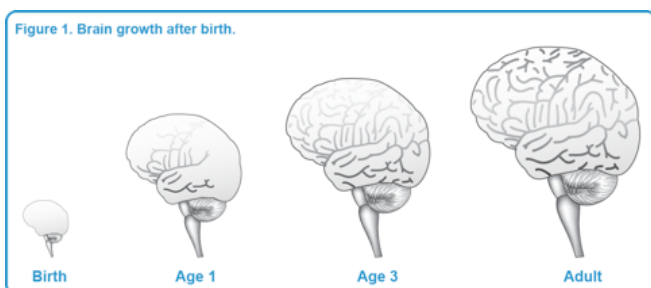


Figure 1: Brain growth after birth

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).

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

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



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 has 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.

Intestinal permeability is higher in formula-fed infants and has been associated with increased susceptibility to stress and inflammation in adulthood (Le Huërou-Luron et al., 2010). The higher intestinal permeability, and therefore increased exposure to antigens and bacterial translocation, and differences in postnatal development of gut barrier functions may have a dramatic impact on the education of the infant's immune system such as the acquisition of oral tolerance.



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

- Agostoni C. et al. 2001. Breastfeeding duration, milk fat composition and developmental indices at 1 years of life among breastfed infants. *Prostaglandins, Leukotrienes and Essential Fatty Acids*. 64: 105-109.
- Campeotto F. et al. 2007. Mise en place de la flore intestinale du nouveau-né. *Gastroenterol Clin biol*. 31: 533-542.
- Debakan AS and Sadowsky D. 1978. Changes in brain weights during the span of human life: relation of brain weights to body heights and body weights. *Ann Neurology*. 4: 345-346.
- Gerber R.J. Et al. 2010. Developmental milestones: motor development. *Pediatr Rev*. 31: 267-276.
- Koletzko B. 2016. Human milk lipids. *Ann Nutr Metab*. 69: 28-40.
- Le Huërou-Luron I, et al. 2010. Breast- v. formula-feeding: Impacts on the digestive tract and immediate and long-term health effects. *Nutrition Research Reviews*. 23: 23-36.
- Mendez-Otero R. et al. 2013. Chapter 9. Role of gangliosides in neurological development and the influence of dietary sources. In *Nutrition in Infancy. Nutrition and health*. Watson RR. et al. (eds). Springer Science+Business Media. New York. Vol. 2, pp 105-117.
- Michaelsen KF. 2015. Chapter 1.1. Child Growth. In *Pediatric Nutrition in Practice*. World Rev Nutr Diet. Koletzko B. et al. (eds). Basel, Karger. Vol 113, pp 1-5.
- Mintel Report Nutrition Insights: Infant Nutrition (ingredient focus) – December 2016.
- Oswari H. et al. 2013. Comparison of stool microbiota compositions, stool alpha1-antitrypsin and calprotectin concentrations, and diarrhoeal morbidity of Indonesian infants fed breast milk or probiotic/prebiotic-supplemented formula. *J Paediatr Child Health*. 49: 1032-9.
- Prado EL and Dewey KG. 2014. Nutrition and brain development in early life. *Nutrition Reviews*. 72: 267-284.
- Wickens K. et al. 2008. A differential effect of 2 probiotics in the prevention of eczema and atopy: A double-blind, randomized, placebo-controlled trial. *J Allergy Clin Immunol*. 122: 788-94.
- World Health Organization (WHO). 2006. WHO child growth standards: length/height-for-age, weight-for-age, weight-for-length, weight-for-height and body mass index-for-age: methods and development.

CONTACTS

Fonterra Co-operative Group
109 Fanshawe Street
Auckland 1010, New Zealand
+64 9 374 9000

Fonterra (Japan) Limited
20F 2-16-2 Konan Minato-ku
Tokyo 108-0075
+81 3 6737 1800

Fonterra (USA) Inc
9525 West Bryn Mawr Ave
Rosemont 60018, Illinois, USA
+1 847 928 1600

Fonterra Commercial Trading (Shanghai)
268 Middle Xizang Road
Shanghai 200001, China
+86 21 6133 5999

Fonterra (Europe) Coöperatie U.A.
Barbara Strozzi laan
Amsterdam 1083HN, Netherlands
+31 20 707 5300

Fonterra (SEA) Singapore
1 George Street
Singapore 049145
+65 6879 2977

Disclaimer: Fonterra supports the WHO code which states: Breast milk is the ideal source of nutrition for infants. Breast milk substitutes are recognised by the World Health Organisation as safe & nutritious alternatives to breast milk for infants whose mothers cannot or choose not to breastfeed. The content in this document is based on scientific evidence at the time of writing and intended for informative purposes only. NZMP, the NZMP droplet logo and SureStart™ are trademarks of Fonterra Co-operative Group Ltd.

Talk to the paediatric dairy ingredient experts

We're passionate about sharing our deep dairy expertise to help you grow your business. Talk to us today about your paediatric dairy ingredient needs.

To find out more or to purchase our ingredients please visit www.nzmp.com/surestart

