Metabolic Programming: Effects of Early Nutrition on Growth, Metabolism and Body Composition

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Effects on Growth

Accelerated weight gain during infancy and early childhood is a strong predictor of childhood and adult obesity. Meta-analyses indicate that rapid weight gain in infancy explains 20–30% of the obesity risk in the adult population [1, 2]. Breastfeeding, in particular exclusive breastfeeding during the first 4–6 months of life and continuation of breastfeeding during the second half of infancy, seems to protect from obesity in child- and adulthood [3]. The WHO has published global growth standards [4] which are based on longitudinal data of predominantly breastfed (>6 months) children whose mothers were not malnourished (i.e. BMI 18–25). Weight from 4 months to 2 years is lower in the WHO standards than in international growth references, which are based on data from both formula- and breastfed children. The WHO growth standards are now used in most countries of the world. Longitudinal randomized clinical trials indicate that children who are fed infant and follow-up formulas with protein concentrations >2.25 g/100 kcal (high protein formulas) during the first year of life grow faster than indicated by the WHO standards [5–8]. How can we slow accelerated growth in formula-fed infants? The best way is to promote breastfeeding. If breastfeeding is not possible, a meta-analysis [5] now indicates that infants fed a formula with protein of 1.8 g/100 kcal (modified whey) during the first 4 months can grow according to the WHO standards – i.e. like breastfed infants. Two longitudinal randomized trials show that infants receiving low protein formulas with modified whey protein (1.6–1.8 g/100 kcal) between 3 and 12 months have lower weight for age and slower weight gain than infants fed high protein formulas [7, 8].
Effects on Biomarkers

Biomarkers which are indicators of growth, such as IGF-1, insulin, C-peptide and branched-chain amino acids, are higher in infants receiving high protein formulas than in breastfed infants or infants fed low protein formulas [7, 9]. The IGF axis regulates early growth and influences adipose tissue differentiation and early adipogenesis. The branched-chain amino acids leucine, isoleucine and valine are physiologic stimulators of insulin secretion. High protein intake of infants fed formula stimulates the IGF axis and insulin release, which is associated with a higher weight-for-length and BMI at the age of 2 years. Recently, it has been discussed that lower β-oxidation of fatty acids in infants who are fed high protein formulas might result in higher early weight gain and increased body fat deposition.

Effects on Body Composition

Estimation of fat mass (FM) and fat-free mass (FFM) allows more detailed insights into both quantitative and qualitative weight gain during or after feeding high or low protein formulas. A randomized controlled trial in infants who were fed high or low protein formulas from birth indicates that FM at 6 months (isotope dilution) correlates with BMI and weight gain velocity [10]. In infants of overweight and obese mothers who were fed high or low protein formulas, weight gain between 3 and 12 months and weight at 12 months were significantly higher in the group fed the high protein formula. Percent FM and FFM were similar at 12 months (dual energy X-ray absorptiometry) [7]. One randomized prospective study in an unselected US population has longitudinal data on infants fed high or low protein formulas. Children were followed until 60 months of age. Weight gain and composition of weight gain (FM and FFM in grams; Pea Pod) from 3 to 6 months were similar when the infants were exclusively fed the formulas. During follow-up, children who had the high protein formula gained significantly more fat from 6 to 36 months and from 6 to 60 months (dual energy X-ray absorptiometry) [8; unpubl. data].

Conclusions

Quantitative and qualitative growth indicators are among the most sensitive biomarkers to monitor long-term effects of early nutrition on child health. Several studies now indicate that the growth of children can be influenced by early nutrition. Breastfeeding and the use of low protein formulas in those infants who cannot be breastfed can help to prevent
accelerated growth during infancy and early childhood. In addition, fat gain until 5 years is lower in children who had been breastfed or fed a low protein formula. It is most important that the new low protein formulas are safe and adequate for the whole infant population. Based on new protein technologies, their essential and branched-chained amino acids are now closer to breast milk.

References