FAST FACTS

Indispensable Guides to Clinical Practice

Infant Nutrition

by Alan Lucas and Stanley Zlotkin

HEALTH PRESS

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Glossary of abbreviations

AA: arachidonic acid

AI: adequate intake

BMI: body mass index

BMR: basal metabolic rate

COMA: UK Committee on Medical Aspects

DHA: docosahexaenoic acid

GERD: gastroesophageal reflux disease

IDDM: insulin-dependent diabetes mellitus

LCPUFA: long-chain polyunsaturated fatty acid

NCHS: US National Center for Health Statistics

OES: oral electrolyte solution

ORT: oral rehydration therapy

PCB: polychlorinated biphenyl

PCDD: polychlorinated dibenzo-*p*-dioxin

PCDF: polychlorinated dibenzo-furan

RAE: retinol activity equivalent

RAST: radioallergosorbent test

RDA: recommended dietary allowance

SIDS: sudden infant death syndrome

WHO: World Health Organization

Introduction

Nutrition is the oldest branch of pediatrics and fundamental to it. Intensive research spans 200 years (Figure 1). Yet, paradoxically, nutrition has never developed as a formal specialty. Although virtually every parent seeks nutritional advice, and many hospitalized infants and children pose serious nutritional management problems, training of health professionals is minimal. This is likely to change in the light of recent advances in three areas that underpin a new understanding of the importance of early nutrition, namely:

- impact on long-term health and development
- effect on disease course
- health and safety aspects of early nutrition.

Figure 1 Nutrition has a long history. By the beginning of the last century, there was already a broad understanding of nutritional biochemistry and physiology, and of nutrient requirements. Funk coined the term 'vitamines' in 1911, and there has been long-standing interest in the treatment and prevention of specific nutrient deficiencies, such as rickets, depicted here.

The concept that internal or environmental stimuli, operating during critical periods of early development, can have lifelong effects on the organism has been termed 'programming'. Numerous animal studies support the idea that early nutrition can operate in this way. Brief early dietary manipulations have been shown to affect, into adulthood, brain development and propensity to disease, including diabetes, obesity, atherosclerosis and hypertension. Increasing evidence for these effects in humans has vastly raised the public health and clinical profile of pediatric nutrition.

Nutritional care may influence disease prognosis, clinical course, hospital stay, need for expensive treatments and requirement for healthcare resources in an increasing number of clinical circumstances, such as prematurity, gut disease, kidney disease and surgery. In sick infants, simple nutritional choices can influence the development of life-threatening disease processes, such as sepsis or necrotizing enterocolitis. Food given to infants can also have significant safety implications, some of which are discussed in this book.

Because early nutrition is important for the health and development of infants, it is critical that a broad range of health professionals involved in pediatrics gain insight into this emerging field. *Fast Facts – Infant Nutrition* provides practical, evidence-based guidance.

1 Physiology

Significant postnatal adaptations are required to equip the infant for the major changes in nutrition and mode of feeding that occur after birth. These adaptions are:

- **mechanical –** neuromotor development permits coordinated sucking, swallowing and, later, mastication of foods
- **physiological –** notably changes in motor, digestive and absorptive functions of the gut and in other organs (liver, pancreas, kidneys) that equip the infant for postnatal feeding
- **biochemical –** changes in enzyme activity and biochemical pathways; for example the need to synthesize glucose endogenously (gluconeogenesis) after the transplacental supply of glucose from the mother suddenly ceases at birth
- **protective –** particularly developments in immune function and the mucosal barrier of the gut that occur as food-related exposure to potentially pathogenic organisms and antigens occurs postnatally.

Some of these postnatal adaptations are immediate (for instance gluconeogenesis); others develop gradually as the infant progresses from milk feeds towards a more adult diet; and some responses to early nutrition, which may be 'adaptive', are not manifest until later in life (the concept of 'programming'; see the chapter on Future trends).

In this chapter, selected physiological aspects relevant to practice are discussed.

Transition from fetal life

In utero, the fetus is mainly fed 'intravenously' via the placenta. However, at full term, the fetus also swallows approximately 500 mL of amniotic fluid daily, which provides approximately 25% of its protein requirement and a similar fluid intake to that of a breastfed baby. This 'enteral' feeding prenatally may help prepare the gut for feeding after birth. Postnatal feeding triggers further adaptive changes in the structure and function of the gut, and in metabolism, which equip the baby for milk feeding. If an infant, such as a sick intravenously fed baby, is deprived of enteral feeding after birth, the stimulus of food in the gut is removed and atrophic changes may occur in the intestine that impair its function and defense mechanisms. For this reason, 'minimal enteral feeding' is often used in sick babies who cannot be fully enterally fed, to maintain a stimulus for gut development.

Evolution of feeding skills

Some reflexes, notably those involving the cranial nerves, show a predictable pattern of maturation and extinction during early infancy and are necessary for normal early feeding patterns (Table 1.1). At 6 months, a baby has increasing control over its lips and tongue, and chewing movements begin. In addition, control of the neck and back muscles enables the infant to sit erect with support. Around 7–8 months, fine motor ability

TABLE 1.1

Infantile oral motor reflexes present from birth

Reflex	Description	Age at extinction
Rooting	Stroking around mouth elicits movement of head towards source of stimulus and latching onto nipple	3–4 months
Suck/swallow	Stroking anterior third of tongue or center of lips elicits suck/swallow movements	6 months (evolution to mature sucking)
Biting	Stroking gum elicits rhythmic vertical biting motion of the jaw	6 months
Gag	Stimulus to the posterior three-quarters of the tongue and pharyngeal wall elicits constriction and elevation of the pharynx	Sensitivity shifts back to one-quarter of the tongue and the pharyngeal wall by adulthood
Extrusion	Food placed on the back of the tongue using a spoon is transferred to the front and expelled from the mouth	3–4 months

3 Growth

Growth is a critical biological attribute that distinguishes the pediatric population. It is the traditional test of overall nutritional status and is deranged in many conditions. Proper assessment of growth can have major biological, clinical, public health and social value, but health professionals are frequently inadequately trained in the collection, processing and interpretation of growth data.

Measurement of growth

The standard body measurements used in practice are weight, length and head circumference (Table 3.1 and Figure 3.1). In healthy infants, body weight is a 'summary' of many aspects of growth and, given appropriate equipment, it is the simplest and most accurate measurement. More sophisticated scales reduce infant movement artefacts by damping or automatically averaging several weights. Length measurement is more difficult and requires training; inaccurate measurements have little value.

Measurement of length and weight allows indices of weight for length, such as body mass index (BMI), to be calculated. Other body measurements, such as mid-arm and other circumferences and skin-fold thicknesses, are generally not clinically useful in infancy.

Growth charts

Growth is most commonly assessed using growth charts that are based on sizes of babies measured at different ages, though not necessarily the same babies at each age. At each time point, a family of centiles is derived for weight, length and head circumference. Thus the 25th, 50th and 75th centiles define the value, say for body weight, below which 25%, 50% and 75% of the population lie, respectively. With secular changes in infant feeding practices, the growth of babies has changed over time, and modern babies no longer grow according to charts devised 30–40 years ago. In many countries growth charts are being updated. The most modern charts used routinely in the UK, and

TABLE 3.1

Taking growth measurements

Weight

- An infant or toddler should always be weighed naked on a self-zeroing or regularly calibrated scale

Head circumference

- Head circumference should be measured midway between the eyebrows and the hairline at the front of the head and the occipital prominence at the back (Figure 3.1). Appropriate thin plastic, metal or disposable paper tape should be used; sewing tape is not recommended for this purpose

Supine length

- Infants (and children up to approximately 18 months) should be measured in the supine position (on their back) by two people with equipment comprising both a headboard and moveable footboard (Figure 3.1). While one person holds the head against the headboard, with the head facing upwards in the Frankfort plane (an imaginary line from the center of the ear hole to the lower border of the eye socket), a second person measures the length by bringing the footboard up to the heels. Downward pressure is applied to the child's knees to ensure that the legs are flat (this does not carry any risk of hip dislocation)

illustrated here, are derived from the growth of modern infants. These charts are based on nine centiles (0.4th, 2nd, 9th, 25th, 50th, 75th, 90th, 98th and 99.6th), with each centile position mathematically 'smoothed' across the age range to produce a tidy chart (Figure 3.2).

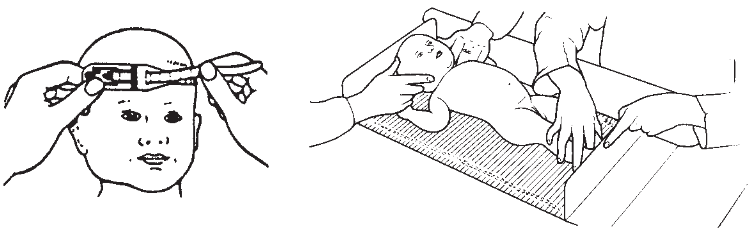

Figure 3.1 Measurement of head circumference and length. Reproduced by permission of the Child Growth Foundation, London, UK.