

Failure to Thrive: Malnutrition in the Pediatric Outpatient Setting

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HISTORY, BACKGROUND, AND DEFINITION OF TERMS

Pediatricians have described malnourished children with the words “failure to thrive” (FTT) since at least the nineteenth century.¹ There continues to be a notable lack of progress regarding a valid and reliable definition of the term.² One review of general pediatric and pediatric nutrition text-books failed to find a consensus definition, with various anthropometric and nonquantitative descriptive terms being employed.³ Olsen reviewed the pediatric literature and general text books and found many failed to provide specific criteria defining FTT. It was found, however, one or another anthropometrical indicator, with weight gain predominating, was used.⁴ Vinton and Dietz have rightly suggested that the term is a mere euphemism for undernutrition,⁵ though growth failure may result from medical conditions which involve other factors.⁶

The child termed “failed to thrive” in the office of a pediatrician in industrialized countries would more likely (and more accurately) be described in developing countries as malnourished or suffering from protein-energy malnutrition.⁷ The continued use of vague terminology such as failure to thrive limits the ability to scientifically study the nutritional status of a population as well attempts to determine the etiologies of poor growth and weight gain.

Nonetheless, if only owing to the strength of historical precedent, the term failure to thrive will continue to be used to describe infants and young children with malnutrition. It is recommended that quantitative criteria be employed. Commonly used criteria include: (1) a child whose weight (or weight for height) is more than 2 SD below the mean for sex and age and/or (2) a child whose weight curve has crossed downward more than 2 major percentile lines (defined as 5th, 10th, 25th, 50th, 75th, 90th, and 95th percentiles)⁸ on the Centers for Disease Control and Prevention (CDC) growth charts after having achieved a previously stable pattern.

Alternative wordings of the first criterion include “less than the 3rd percentile” or “a weight-for-age (or weight for height) z-score (or standard deviation score) less than -2.0 .”

z-scores are calculated by the following formula:

$$Z \text{ score} = \frac{\text{actual weight} - \text{median weight}}{\text{standard deviation}}$$

where standard deviation is the age- and sex-specific standard deviation of weight and median weight is the median value for age and sex. Expressing anthropometric measures in terms of z-scores is recommended by the World Health Organization (WHO), especially when describing groups of subjects.⁹ Z-scores allow more precision in describing anthropometric status than does the customary placement “near” or “below” a certain percentile curve. For example, the phrase “below the 3rd percentile” does not distinguish between a child just below this point (whose z-score may be -2.1) from one with severe growth faltering (whose z-score may be -3.5 or lower) (Figure 1). Similarly, 3% of normal children will weigh less than the 3rd percentile, but a z-score significantly lower than -2.0 clearly indicates a growth problem. There are CDC computer programs that calculate anthropometric data such as weight for height for age and weight for height; these are expressed as percentiles, z-scores, and percentage of the median without making recourse to plotting points by hand.¹⁰ Software for palm-based computers is also available.

The second criterion is a more functional definition of growth failure that takes into account that weight loss or even lack of normal growth during infancy and childhood is abnormal and patients

should not have attained low anthropometric scores before appropriate evaluation and treatment are instituted. What constitutes a “stable pattern” can be difficult to define. Edwards and colleagues addressed this issue by defining the true percentile as the maximum achieved between 4 and 8 weeks of age because weight at this point was found to correlate more strongly with weight at age 12 months than did birthweight.¹¹ They proposed a functional definition of failure to thrive as “a child whose weight deviates downwards across two or more major centiles from the maximum centile achieved at 4 to 8 weeks for a period of a month or more.”

Anthropometric assessment of nutritional status can also be categorized to help determine chronicity of nutritional deprivation. The simple use of a weight-for-age cut-off to define malnutrition is obviously nonspecific because patients included can be either well proportioned and just constitutionally small or truly of low weight. A classic distinction between acute malnutrition (“wasting” or low weight for height) and chronic malnutrition (“stunting” or low height for age) was proposed by Waterlow and has been widely adopted.¹² Table 1 recounts this classification scheme, in which percentage of the median is calculated by the following formula:

$$\% \text{ median} = \frac{\text{actual weight} \times 100}{\text{median}} \text{ weight}$$

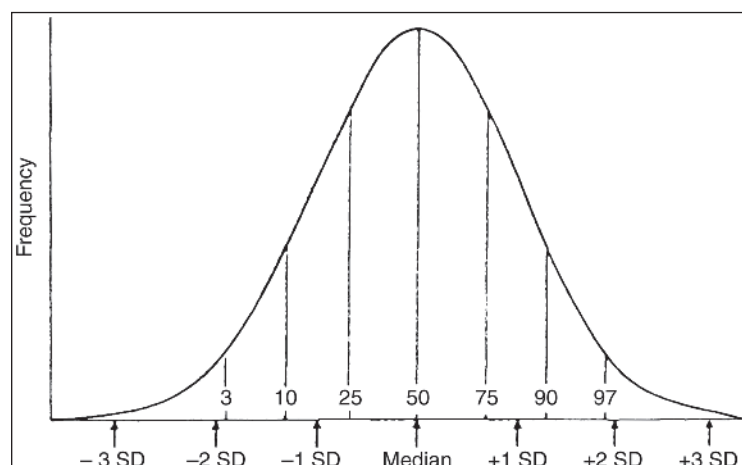


Figure 1 Comparison of percentiles vs. standard deviation or z-scores. Two SDs below (or above) the mean corresponds to the 3rd (or 97th) percentile. (Adapted from reference 17.)

Table 1 Waterlow Criteria for Categorizing Type and Chronicity of Malnutrition

Type of Malnutrition	Acute (Weight for Height) (% of Median)	Chronic (Height for Age) (% of Median)
Normal	>90	>95
Mild	80–90	90–95
Moderate	70–80	85–90
Severe	<70	<85

Abnormalities of weight for height are termed “wasting” and those of height for age are called “stunting.”
Adapted from reference 12.

where median weight is the median value for age and sex.

Caution should be exercised when a subject's height faltering is used to call attention to nutritional status. Genetic and constitutional causes of short stature need to be ruled out before implicating chronic malnutrition as the cause of poor height growth. Knowledge of the family growth history (parents and siblings) with interpretation of growth parameters in light of midparental height and familial growth patterns can be helpful in this regard. In addition, an individual may not track consistently along a percentile for any given index. Smith and colleagues have pointed out that the National Center for Health Statistics (NCHS) standard curves were mathematical averages based on

large numbers of children (ie, cross-sectional curves) and not growth lines along which individual children should be expected to grow (ie, longitudinal).¹³ This is also true for the currently recommended CDC growth curves. They demonstrated that infants manifest a growth rate at birth that is predominantly determined by maternal factors, with a shift to one that then is increasingly determined by genetic background. Thirty percent of healthy, full-term, white infants crossed one percentile line and 23% crossed two lines as they moved from birth to age 2 years. Children whose birth lengths were near the 10th percentile but whose subsequent lengths were closer to the 50th percentile tended to catch up at an average of 11.5 months; those born near the 90th percentile and moving down to the 50th percentile did so at an average age of 13 months (Figure 2). Karlberg and colleagues analyzed the length curves of healthy children in the first 3 years of life.¹⁴ Children were found to have nonlinear decelerations in their growth rates starting during infancy. During the second year of life, the variation in the growth rate was found to increase, with greater gains in linear growth during the spring/summer than fall/winter. During the third year, the growth pattern stabilized. Thus, fluctuations in length percentiles are a normal phenomenon in infant growth and, especially in the face of normal weight gain, should not prompt evaluation for nutritional disease. Horner and colleagues have demonstrated that a more significant decline in the linear growth

rate occurs in children with constitutional short stature.¹⁵ This fall in the growth rate generally first became apparent in the first 6 to 9 months of life and was greatest during the first 2 years. These children fell more than 2 SD below the mean for height by 3 years of age. Subsequently, their growth rate was the same as that of normal children but below and parallel to the 3rd percentile. Mei et al.⁸ studied the growth trends of over 10,000 children in the first 60 months of life using data from the California Child Health and Development Study. Though the data was collected between 1959 and 1967, and does not include Latinos, it does include children from a wide range of socioeconomic backgrounds. The frequency of crossing 2 major percentiles for the indices of height for age, weight for age, and weight for height was determined. Sex differences were not found. For children 0 to 6 months of age, 32% did so for height for age, 39% for weight for age, and 62% for weight for height. For children 6 to 24 months of age 13 to 15% did so for height for age, 6 to 15% for weight for age, 20 to 27% for weight for height. From the ages of 24 to 60 months, 2 to 10% did so for height for age, 1 to 5% for weight for age, and 6 to 15% for weight for height. Whether a child displayed catch-up or catch-down growth depended on initial measurements, with a tendency to regress towards the mean.

Alternative or supplemental anthropometric criteria for FTT have been proposed, including decreased weight velocity, low triceps skinfold (TSF) values, and midarm circumference (MAC). For example, data have been published on incremental gains in the length and weight of the infants enrolled in the Iowa and Fels studies.¹⁶ Measurement and interpretation of skinfold thickness and growth velocity have the disadvantage of requiring special equipment and/or graphically represented standards and may not add specificity or sensitivity to the screening criteria noted above. Depleted fat stores and slowed growth velocity are often concomitant findings in the patient with malnutrition, and their presence or absence can be noted on detailed clinical evaluation. However, for standard screening purposes in most US settings, the anthropometric measurements of weight, height, and age are usually sufficient.

Any diagnosis of malnutrition requires accurate measurements of weight, length, head circumference, and age. An infant's length should be measured supine on a length board until age 2 years, after which time they should be measured upright. Infants and children should be weighed with minimal clothing on scales accurate to at least 100 g. If possible, one person in the office should be designated as solely responsible for weighing and measuring patients. Detailed summaries of anthropometric techniques have been published elsewhere.¹⁷

Measurements should be plotted on appropriate graphs (see Appendix I). When plotting infants with a history of premature birth, their chronologic age should be corrected by gestational age until 24 months for weight, 40 months for length, and 18 months for head circumference.¹⁸

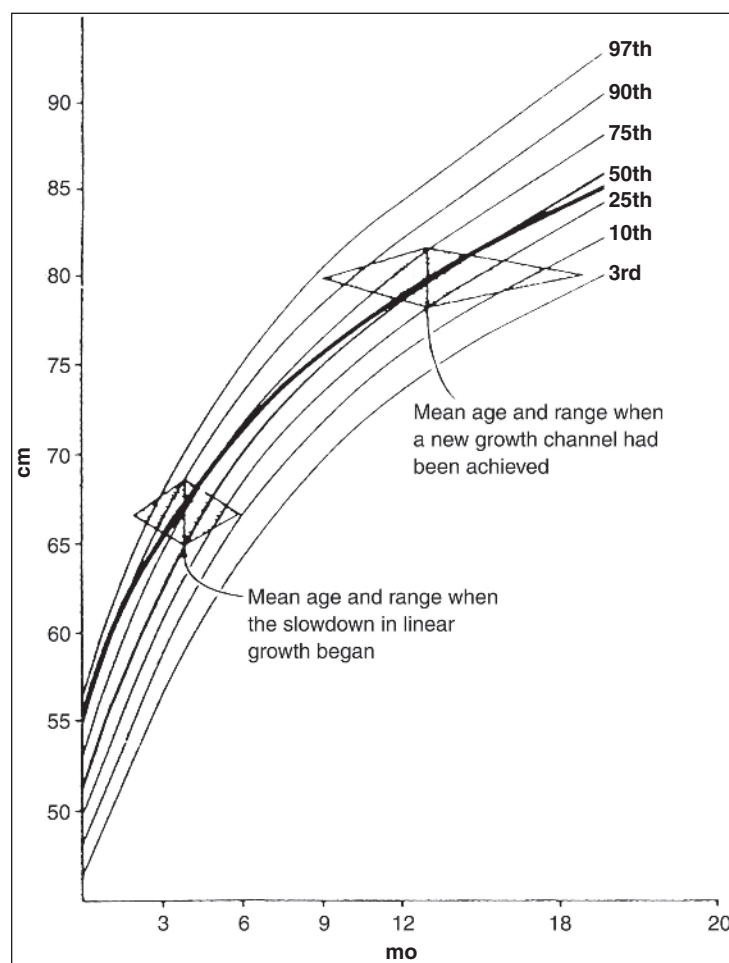


Figure 2 Mean linear growth curve of 16 healthy infants who crossed percentile lines during infancy. Whereas at birth they were at the 90th percentile, by age 2 years, they had reached the 40th percentile. This shift generally occurred between 3 and 13 months. (Adapted from reference 13.)

In 2000, the CDC developed new growth curves for infants from birth to 36 months and for children from 2 to 20 years of age.¹⁹ These curves are now recommended for use in the United States. The new growth charts were developed to rectify deficiencies of the 1977 NCHS curves.¹⁹ The CDC curves are more representative of a cross-section of the ethnicity of the children living in the United States. Data from breastfed infants are also included so that the mix of formula-fed and breastfed infants is more accurately represented. The distribution of birthweights now more closely matches the national distribution. Statistical methods have been employed to smooth the disjunction between length and height. Finally, curves for body mass index (BMI) are available for children from ages 2 to 20 years. On the NCHS charts, weight-for-stature charts were available but stopped at age 10 years for girls and 11 years for boys.

A somewhat misleading distinction in the medical literature is still written of concerning organic versus nonorganic failure to thrive (eg, Rosenn and colleagues²⁰). The former is malnutrition attributable to an underlying medical condition that has presumably limited the intake, absorption, or use of adequate calories. Nonorganic failure to thrive, in contrast, implies a primary social dysfunction of the family, mother-child dyad, or societal unit, the net result of which is inadequate nutritional intake. Berwick and colleagues reviewed the records of 122 children between the ages 1 and 25 months who were hospitalized for FTT.²¹ Thirty-three percent had no specific diagnosis, 32% were felt to have a social or environmental explanation, and 31% were given a specific medical diagnosis. Gahagan⁶ emphasizes that FTT is not a disease, but a symptom representing the final common pathway of medical, psychosocial, and environmental processes. Furthermore, rather than being classified as organic or nonorganic, it should be viewed as undernutrition resulting from an interaction of biological and environmental factors. The most common situation will be multifactorial or “mixed” FTT where both medical and nonmedical factors are identified resulting in a “layering of risk” which interact resulting in growth failure.^{6,22,23} This is not surprising and reflects the difficulty in any attempt to dichotomize between physiologic and social influences on health in general and nutrition specifically.

EPIDEMIOLOGY

Significant pediatric undernutrition in the United States is often cited to occur in 10% of low-income children.²⁴ The prevalence of underweight children can range from 1 to 10%, depending on the clinical setting.²⁵ Unfortunately, the definitions of undernutrition or FTT used to support such claims do not always employ well-established anthropometric criteria. Factors that can interfere with an accurate survey of FTT infants have been reviewed.²⁶

National surveys have been undertaken that provide information on the prevalence of inade-

quate growth.²⁵ The National Health and Nutrition Surveys [NHANES I (1971 to 1974), II (1976 to 1980), and III (1988 to 1991)] studied the prevalence of low height for age and weight for height among 2- to 5-year-olds. In the 1988 to 1991 survey, the prevalence was found to be 5.2% and 2.7%, respectively. The Pediatric Nutrition Surveillance System (PedNSS) measured the prevalence of inadequate growth in predominantly less than 5-year-old low-income children who participated in publicly funded nutrition and public health programs. In 1996, the prevalence for low height for age was 5.8% and low weight for height was 2.6% in 2- to 5-year-olds. Furthermore, the PedNSS reported in 1996 that infants from birth to 2 months experienced the highest prevalence for both indicators. In this group, 12% had low height for age and 4.1% low weight for height. Finally, blacks had the highest rates for both of these indicators. The prevalence of low weight for age amongst children 2 to 6 years has dropped over the past three decades from 5.5 to 4.1%, with the prevalence of low weight for height remaining relatively stable at 2.5%.⁶

In recent years, pediatric health care providers have encountered growing numbers of international adoptees and the children of new immigrants. Every year, 3 million children ages 0 to 19 years of age immigrate to the United States mainly from Asia, Western Europe, and North Africa.²⁷ Immigrant children have been found to be deficient for height for age and weight for age.²⁸ They may also have developmental delays, infectious diseases, a variety of health problems, and psychosocial stressors.^{27,28,30} Fifteen thousand foreign-born children are adopted by American citizens each year.²⁷ Since 1990, the majority were adopted from China and the countries of the former Soviet Union.²⁷ Nason and Narad report that poor growth is the most common and consistent problem observed upon arrival in this and other western nations of adoptees from foreign orphanages.²⁹ Among the children adopted from China, z-scores were < -2 SD in 39% for height, 18% for weight, and 24% for head circumference.³⁰ Developmental delays, both global and in specific areas, were common, as were parasite infestations, infections, and chronic medical conditions.³⁰ The degree of growth failure is proportional to the length of time spent in an orphanage.²⁹ Psychosocial growth failure has been postulated as a possible contributing factor.²⁹

MEDICAL RISK FACTORS FOR MALNUTRITION

There are many well-known medical and psychosocial risk factors for the development of FTT (Table 2), which can generally be viewed as relating to the infant or to the family. Almost all chronic medical conditions in a child can lead to poor weight gain by a variety of factors.³¹ These include decreased caloric intake (anorexia, food withholding, altered mental status), increased caloric requirements (fever, infections), and/or

Table 2 Risk Factors for the Development of Failure to Thrive

Infant characteristics

Any chronic medical condition resulting in

- Inadequate intake (eg, swallowing dysfunction, central nervous system depression, or any condition resulting in anorexia)
- Increased metabolic rate (eg, bronchopulmonary dysplasia, congenital heart disease, fevers)
- Maldigestion or malabsorption (eg, AIDS, cystic fibrosis, short gut, inflammatory bowel disease, celiac disease)
- Premature birth (especially intrauterine growth retardation)
- Developmental delay
- Congenital anomalies
- Intrauterine toxin exposure (eg, alcohol)
- Plumbism and/or anemia

Family characteristics

- Poverty
- Unusual health and nutrition beliefs
- Social isolation
- Disordered feeding techniques
- Substance abuse or other psychopathology (including Munchausen syndrome by proxy)
- Violence or abuse

inefficient use of ingested calories (maldigestion, malabsorption, and metabolic disorders). Nutritional recommendations for specific disease states are found elsewhere in this textbook.

An important medical risk factor for undernutrition in childhood is premature birth. Growth data are available for low birthweight preterm infants (see Appendix I).³²⁻³⁵ Growth curves for the use with hospitalized very-low birthweight growth curves have been developed.³⁶ Standard growth curves should be used once the infant has achieved a gestational age of 40 weeks. As noted above, correction for prematurity should be done when plotting an infant's anthropometric measurements on the CDC growth curves to correctly assess growth. Even with correction for gestational age, however, Casey and colleagues have shown that patients who were both low birthweight and premature have smaller mean lengths, weights, and head circumferences than their term counterparts in the first 3 years of life.^{33,34} The lower the birthweight, the greater the depression of the mean.

The infant who is small for gestational age is a special case because prenatal factors may have already exerted a deleterious effect on somatic growth. The reasons for in utero growth failure may include genetic abnormalities (chromosomal aberrations, syndromes), environmental influences (maternal smoking, malnutrition, exposure to drugs or other toxins), and infection. Infants with symmetric growth retardation (where weight, height, and head circumference are equivalently depressed) are less likely to respond to nutritional supplementation with catch-up growth. Conversely, asymmetrically growth-retarded infants where weight is disproportionately low have more truly suffered in utero malnutrition and can therefore be expected to

achieve better growth after birth.³⁷ Strauss and Dietz have observed that infants who are labeled intrauterine growth retarded (IUGR) often have mothers and non-IUGR siblings who are smaller and lighter and come from families in which there is an increased prevalence of IUGR infants.³⁸ They concluded that some of these infants may be genetically small, which may limit their catch-up growth.

A prospective case-control study of premature infants has identified some risk factors for poor weight gain after hospital discharge.³⁹ Among 914 infants with birth weights $\leq 2,500$ g, 19.7% were diagnosed with FTT at some point in the first 3 years of life. Multivariate analysis revealed that among infants with growth failure, significantly more had birthweights less than 1,500 g, were small for gestational age, had an abnormal neurological examination at 40 weeks gestational age, or had a mother whose height was less than 159 cm. This study found that infants born to mothers who were college graduates or who were living with the infant's father were at higher risk of FTT. Family income, prenatal care, and maternal race were not found to be significant factors. Dusick et al.⁴⁰ report that amongst very low birthweight (VLBW) infants, the presence and degree of intrauterine growth restriction predicts a higher incidence of growth failure (as defined as < 10 th %) both early on and at 18 to 22 months for length, height, and head circumference. They also found that other significant predictive factors for increased risk of growth delay in these children are white race and Grade III/VI intracranial hemorrhage/periventricular leukomalacia. Furthermore, they determined that significant postdischarge risk factors for poor growth at 18 months include abnormal swallow and abnormal neurological examination. They did not find, however, that the mother's educational level was associated with poor growth.

The child with neurological disease, especially cerebral palsy, is at risk for abnormalities of growth and nutritional status.⁴¹⁻⁴⁴ Many children with developmental delay are short for their age, and although stunting owing to chronic malnutrition is a possible cause, genetic programming caused by an underlying condition or altered neuroendocrine axis may also be an etiology. In addition, children with developmental delay may suffer from swallowing dysfunction, gastroesophageal reflux, constipation, and other gastrointestinal diseases that, in addition to their underlying neurological dysfunction, may alter their caloric intake. Children with hypertonia and movement disorders can have excessive energy expenditure, which may be an additional factor contributing to poor growth. Conversely, children with cerebral palsy often have limited physical activity and therefore lower energy requirements than similarly aged children, thereby placing them at risk for obesity.

Anthropometric evaluation of children with spastic cerebral palsy can be difficult because of contractures or scoliosis. Furthermore, interpretation of growth needs to be done in light of the

growth potential of any known underlying medical condition or syndrome. Due to the difficulty of correctly measuring and interpreting the linear growth of these children, emphasis should instead be placed on obtaining alternative measures of growth and nutritional status. Weight for height can be used, but in cerebral palsy patients may underestimate their degree of malnutrition.⁴¹ Stallings and Spender and their colleagues have found that linear growth in children with quadriplegic, hemiplegic, and diplegic cerebral palsy can be assessed by measurement of upper arm and lower leg lengths.^{42,45} Growth curves are available for these parameters.⁴⁵ In children with quadriplegic cerebral palsy, upper arm length and lower leg length were found to correlate with TSF and MAC.⁴² Samson-Fang and Stevenson have recommended the use of TSF for the nutritional screening of children with cerebral palsy.⁴¹ A TSF less than the 10th percentile indicates the need to more fully assess a child's nutritional status, growth, and overall health.

Table 3⁴⁶ lists suggested energy requirements in developmentally delayed children based on calorie per centimeter of height. Experience has shown that estimating needs by Recommended Dietary Allowance (RDA) and weight for these children often leads to excessive energy intake.

Children born with congenital anomalies are also at nutritional risk. For example, infants born with cleft lip and/or palate may have significant oral-motor dysfunction requiring special nipples and feeding instructions. Some of these infants may require feedings by nasogastric tube or gastrostomy. Montagnoli et al.⁴⁷ determined the incidence of growth impairment as defined by height or weight less than the 10% in 881 Brazilian children with cleft lip and/or palate. They report that in the first 2 years of life, amongst children with isolated cleft lip,

about 20% demonstrated impairment for weight and height. For children with cleft lip and palate or isolated cleft palate, the incidence of growth impairment was similar, occurring in roughly one-third for both weight and height. It is important to remember that the presence of cleft lip and/or palate or other congenital anomalies may be a manifestation of an underlying syndrome or association of which intrauterine growth retardation, poor growth, or short stature is a component. If available, syndrome-specific growth curves should be used. Weight for height, BMI, or TSF and MAC may also be helpful in these children as well.

Lead intoxication is a medical risk for poor growth.⁴⁸ High blood lead levels probably correlate with poor nutrition based on the fact that a high-fat, low-iron diet promotes lead absorption from the intestine. What is less clear is to what extent the anorexia and other behavioral problems seen with iron deficiency and/or lead poisoning are contributing factors to malnutrition.

PSYCHOSOCIAL RISK FACTORS

Factors that predispose to poor growth in the United States may be social or behavioral in origin. Poverty is a significant and has been stated to be the greatest single risk factor for FTT.^{49,50} Frank and Zeisel report that 13% of their patients are homeless and noted that inadequate medical care can exacerbate the tendency of acute illnesses to lead to poor growth.²⁴ The degree to which Federal food aid to poor families in the United States helps improve the nutritional status of this population is controversial,⁵¹ though it is reported that food stamps have been shown to increase the intake of nutrients in children of impoverished families.⁵² Food insecurity has been cited as a factor as well.⁶ Families experience food insecurity when the availability of food is limited or uncertain, often associated with intermittent hunger.⁶ In 1999, 10.9% of families reported food insecurity.⁵² For those living below the poverty line, food insecurity was reported by 46%.⁵² Casey et al.⁵² report that welfare reform has led to the reduction in food stamp benefits, increased food insecurity, as well as an association with positive maternal depression screens. Depression can also have deleterious effects on child growth as described below.

Feeding-related behavioral disorders are not uncommon in children with poor growth.⁵³⁻⁵⁸ and may extend beyond mealtimes.⁵⁷ These children are perceived as having more difficult temperamental characteristics and are rated by their parents as being more negative, irregular, dependent, and unstoppable.⁵⁵ There may be a temperamental mismatch between the child and mother.⁵⁴ Chatoor and colleagues developed diagnostic criteria for infantile anorexia.^{55,56} The diagnostic criteria of this disorder include: (1) refusal to consume adequate amounts of food for at least 1 month, (2) onset of food refusal

Table 3 Estimated Energy Needs for Developmentally Delayed Children

	Daily Caloric Condition Recommendation
Ambulatory, ages 5-12 yr	13.9 kcal/cm height
Nonambulatory, ages 5-12 yr	11.1 kcal/cm height
Cerebral palsy with decreased levels of activity	10 kcal/cm height
Cerebral palsy with increased levels of activity	15 kcal/cm height
Athetoid cerebral palsy, adolescence	Up to 6,000 kcal
Down syndrome, boys ages 5-12 yr	16.1 kcal/cm height
Down syndrome, girls ages 5-12 yr	14.3 kcal/cm height
Myelomeningocele	Approximately RDA for age may need as little as 7 cal/cm height

Adapted from reference 46.
RDA = recommended dietary allowance.

before 3 years of age, most often during the transition from spoon to self-feeding between 9 to 12 months of age, (3) child does not effectively communicate hunger signals, lacks interest in food but shows interest in exploration and/or interaction with caregiver, (4) demonstrates significant growth deficiency, (5) food refusal did not follow a traumatic event, and (6) food refusal is not due to an underlying medical condition or illness. Some behaviors may have a medical basis or have had roots in prior medical problems experienced by the child leading to food aversion^{53,54,59} or the perception that the child is vulnerable or fragile.⁵⁷

Maternal developmental delay, learning disorders, anxiety, psychiatric disease, substance abuse, and difficulties with maternal attachment all may impact the feeding and nurturing of a child as well.^{54,55,58} Indeed, an extensive literature has arisen around the transactional model of FTT,¹⁸ which emphasizes the interrelationships between medical, behavioral, and developmental characteristics of the infant on the one hand and the familial, psychosocial, and economic environment of the child's caretakers on the other. Such a multifactorial approach to the problem of poor growth has direct implications for treatment modalities, as discussed below.

Depression is common in women of all ages, especially young women who are mothers of young children.⁵² Puerperal mood disorders are common as well.⁶¹ Postpartum blues, characterized by mood swings, tearfulness, generalized anxiety, and irritability affects 85% of women in the first 5 to 7 postpartum days.⁶¹ If resolved by 10 days postpartum, treatment or referral is not

indicated.⁶² Postnatal depression affects 5 to 25% of women of childbearing age.⁶¹ Maternal depression is known to affect the mother-child interaction in many ways.^{52,62} It has been associated with an increased probability of behavioral problems and a significant negative impact on development.⁵² There is a growing body of literature describing the association of maternal depression and poor growth. O'Brien et al.⁶² identified children less than 2 years of age with faltering growth and screened their mothers for depression with a standardized tool. On this basis, they found that the mothers of children with faltering growth were at increased risk of postnatal depression and anxiety.

Other psychosocial risk factors for FTT include the health and nutrition beliefs and concerns of the family, including a fear of obesity or cardiovascular disease.⁶³ Such concerns can lead to suboptimal caloric intake or a diet low in fat, resulting in poor growth. Also in this category are infants who are exclusively breastfed for longer than is recommended. Breast milk as the sole source of nutrition is inadequate for optimal growth after 6 to 8 months.⁶⁴ It should be noted that although growth failure in the neonatal period owing to breast milk insufficiency can be serious, FTT in the older breastfed infant is more likely attributable to underlying medical problems.^{65,66} There have also been reports of severe malnutrition caused by the inappropriate use of health food beverages. Carvalho and colleagues reported two cases of children who developed severe nutritional deficiencies caused by the consumption of health food beverages.⁶⁷ One received a soy-based beverage and was placed on a strict vegan diet in accordance with the dietary practices of the parents. Another was reported who received a rice beverage because of perceived milk intolerance. Concern about food allergies is widespread, with one quarter of American households altering their dietary intake based on the perception that one or more household members suffer from food allergies.^{68,69} These concerns can lead to the unnecessary restriction of a child's diet.⁶⁹

Parenting skills (especially feeding skills), life stresses, and social isolation are also factors that can contribute to growth failure. Most studies examining the role of stress and other social factors in pediatric malnutrition have been retrospective and therefore unable to say whether stress preceded or was caused by the infant's nutritional status. Altemeier and colleagues performed a prospective, case-control study among mothers at risk for having children with poor growth by performing prenatal interviews and monitoring subsequent growth.⁷⁰ They found that a combined measure of life stress of the parents correlated significantly with subsequent FTT, as did maternal characteristics such as frequent separations, arguments, and reconciliations with the child's father. Self-reported drug and alcohol use, self-image, and attitude toward pregnancy were not correlated with infant growth. Of note, mothers whose children grew poorly reported unhappy

childhoods and being subjected to physical abuse more often than did mothers whose children grew normally. In one series, 66% of mothers of infants with growth failure reported having been abused as children themselves compared with 26% of controls from a similar socioeconomic group.⁷¹

The children of immigrants and international adoptees may experience unique stressors, including those related to relocating to a new country, language barriers, having spent extended periods in orphanages, or having witnessed war and other atrocities.^{27,28,30}

Unfortunately, the theme of abuse and violence runs throughout much of the lives of children who grow poorly. Frank childhood neglect (or the maternal deprivation syndrome) was first hypothesized to be the etiology of many cases of growth failure, as implied by past uses of the term failure to thrive.⁷² Food withholding has also been reported to occur in some cases of growth failure.⁷³ A case series of children diagnosed with Munchausen syndrome by proxy indicated that 29% had been diagnosed with FTT, and 17% of their siblings had had either nonaccidental injury, neglect, inappropriate medication administration, or FTT.⁷⁴ Kellogg and Lukefahr reviewed 12 cases of criminal starvation of infants and children.⁷⁵ The median age of the children was 2.7 years, with a range of about 2 months to 13.5 years. Though rare, the consequences to the children were dire, with most suffering from severe wasting and stunting, half with past or present evidence of physical or sexual abuse, and half dying shortly after presentation to medical care or law enforcement. These reports all underscore the fact that infants and children with growth failure may represent a flag for serious social and psychological problems in the family. Block et al. list the risk factors which should alert care providers of the possibility that FTT is the result of neglect⁵⁰

APPROACH TO THE PATIENT WITH FTT

Evaluation of a child with growth failure should begin (and often end) with a thorough history and physical examination because the diagnostic benefits of additional laboratory tests are minimal.^{21,76} The identification of psychosocial issues that may be confronting the family or care givers should be done concurrently. Because many children with poor growth suffer from behavioral and developmental problems as well as social and economic disadvantages, a multidisciplinary approach has been advocated as an effective method of diagnosis and therapy.⁷⁷⁻⁷⁹ The use of home visits in conjunction with a multidisciplinary growth and nutrition clinic may provide further benefit.⁸⁰ Evaluation by a social worker, behavioral specialist, and/or psychologist supplement the medical and nutritional evaluation. Translators are often necessary to permit adequate communication with immigrant or non-English-speaking families.

Table 4 Recognition of FTT Secondary to Neglect or Abuse

<p>The risk factors that should alert the pediatrician to the possibility of neglect as the cause of FTT include:</p> <ul style="list-style-type: none"> -Parental depression, stress, marital strife, divorce -Parental history of abuse as a child -Mental retardation and psychological abnormalities in the parent(s) -Young and single mothers without social supports -Domestic violence -Alcohol or other substance abuse -Previous child abuse in the family -Social isolation and/or poverty -Parents with inadequate adaptive and social skills -Parents who are overly focused on career and/or activities away from home -Failure to adhere to medical regimens -Lack of knowledge of normal growth and development -Infant with low birth or prolonged hospitalization <p>Moreover, concerns of abuse or neglect should be raised during the course of intervention and monitored if the following become evident:</p> <ul style="list-style-type: none"> -Intentional withholding of food -Strong beliefs in health and/or nutrition regimens that jeopardize a child's well-being; and or -Family that is resistant to recommended interventions despite multidisciplinary team approach

Adapted from reference 50.

Table 5 Historical Evaluation of Infants and Children with Growth Failure

Prenatal
<ul style="list-style-type: none"> • General obstetric history • Recurrent miscarriages • Was the pregnancy planned? • Use of medications, drugs, or cigarettes
Labor, delivery, and neonatal events
<ul style="list-style-type: none"> • Neonatal asphyxia or Apgar scores • Prematurity • Small for gestational age • Birthweight and length • Congenital malformations or infections • Maternal bonding at birth • Length of hospitalization • Breastfeeding support • Feeding difficulties as neonate
Medical history of child
<ul style="list-style-type: none"> • Regular physician • Immunizations • Development • Medical or surgical illnesses • Frequent infections
Growth history
<ul style="list-style-type: none"> • Plot previous growth points
Nutrition history
<ul style="list-style-type: none"> • Feeding behavior and environment • Perceived sensitivities or allergies to foods • Quantitative assessment of intake (3-d diet record, 24-h food recall)
Family history
<ul style="list-style-type: none"> • Maternal and paternal height and weight • Growth of other siblings • Gastrointestinal and other systemic diseases
Social history
<ul style="list-style-type: none"> • Age and occupation of parents • Who feeds the child? • Life stresses (loss of job, divorce, death in family) • Social and economic supports (WIC, AFDC) • Perception of growth failure as a problem • History of violence or abuse by or of caretaker
Review of systems/clues to organic disease
<ul style="list-style-type: none"> • Anorexia • Change in mental status • Dysphagia • Stooling pattern and consistency • Vomiting or gastroesophageal reflux • Recurrent fevers • Dysuria, urinary frequency • Activity level, ability to keep up with peers

AFDC = aid to families and dependent children; WIC = special supplemental nutrition program for women, infants and children.

In the medical assessment, important historical points to consider (Table 5) include maternal history (especially use of drugs, possible congenital infections, maternal nutrition, and health during pregnancy), labor, delivery, and neonatal events. Altmeier and colleagues showed that although postpartum complications of the mother did not predict subsequent FTT, unresolved health questions at nursery discharge (eg, bilirubin levels) and difficulty feeding in the neonatal period were associated with later growth problems.⁷⁰

A thorough history and review of systems is crucial, as almost any medical condition may

present with poor growth. This should include intercurrent illnesses, medication use, and immunization history. Acute infections can embarrass nutritional status by the increased metabolic demands of fever and stress response, as well as by reducing caloric intake through anorexia. At the same time, a history of recurrent or unusual infections should increase the clinician's suspicion for the presence of an immunodeficiency, including acquired immune deficiency syndrome (AIDS). A developmental history should be obtained. Any suggestion of oromotor or feeding difficulties should also be sought. Assessment by an interdisciplinary feeding team may be helpful and effective.⁵⁹

The growth history should be reviewed by careful plotting of past growth points on the CDC or syndrome-specific curves. The growth pattern over time can either provide important clues to an underlying medical condition, or in fact lead to a diagnosis of health. The growth curve should be interpreted in the context of the family's growth history and pattern. Specific growth curves are available for a number of syndromes. These should be used once the diagnosis has been established (see Appendix I).⁸¹⁻⁸³ The quality of data for ethnic-specific growth curves may be suspect and their use is probably not advisable.

Dietary history should include an assessment of the foods taken, quantities, schedule of feedings and fluid intake, setting of meals, who provides the meals, if self-feeding is permitted when appropriate, force feeding, meal duration, indication of oromotor difficulties (eg., choking, gagging, pouching), oral-aversive behaviors, adverse reactions to foods, overnight feedings, formula preparation, frequency of breastfeeding, adequacy of breast milk supply, dietary restrictions, juice and soda intake, feeding history, and the organization of the household at mealtimes. Culturally-based food preferences and feeding practices should also be ascertained. Intake can be determined based upon a 24-hour food recall. A more accurate assessment is a diary of food consumed over 3 to 5 days, though some families may find this challenging to do.⁸⁴ Calculation of intake with respect to the US RDAs for age can then be performed and the need for dietary supplementation of micro- and/or macronutrients determined.

Excessive fruit juice consumption, especially in toddlers, can lead to poor nutrition. Besides the role some juices can play in the etiology of chronic diarrhea, they may displace more calorically dense and nutritionally balanced foods from the diet.^{85,86} Reduction of juice intake has been shown to be associated with improved weight gain in a series of eight children who were referred for evaluation of growth failure.⁸⁷

Family history should include the growth parameters and patterns of siblings and parents. The average of maternal and paternal heights can be calculated to derive a midparental height using the following formula:

$$\frac{\text{maternal} + \text{paternal heights}}{2} + 5 \text{ cm if a boy} \\ - 5 \text{ cm if a girl}$$

Comparison with published values can then be done to predict adult stature.⁸⁸ The family history should be complete, searching for any family history suggestive of genetic or constitutional short stature, endocrinopathy, syndromes, or any disorder of a major organ system, psychiatric disorders, and eating disorders.

A social history that documents the caretaker's economic status is crucial to help guide diagnostic and therapeutic efforts. Elicitation of the social risk factors outlined above should be performed, as well as the parent's perception of the child's nutritional status. The family's ability to afford, store, and prepare food should also be determined.

A home visit performed by an appropriately trained professional may be helpful. The child and family can be evaluated in a more natural setting, aiding the assessment of the child's environment and mealtimes and allowing for the modeling of behaviors. These visits can even be extended to the child's other significant caregivers (eg, other family members, day care, or preschool). Another method that may be helpful is to ask the child's primary caretaker to videotape the child eating a meal. This tape can then be reviewed with the family, with specific advice and praise offered based upon the observed child and caretaker feeding behaviors recorded.

Screening for organic disease should also include a thorough review of systems. Questions regarding gastrointestinal function (dysphagia, vomiting, abdominal pain, bloating, diarrhea, etc.) are especially important. The presence of fevers or other metabolic stresses should be assessed.

The physical examination of a child with poor growth must be comprehensive, as any physical findings may implicate organic and/or socioeconomic causes of growth failure, as well as potentially providing reassurance regarding the child's growth and health status. The importance of accurate anthropometric measurements has already been stressed. The pattern of growth failure itself is often indicative of whether medical, genetic, or environmental factors are to blame. Genetically small children often maintain normal weight for height, have proportionately low weights, lengths, and head circumferences, and can grow parallel to but lower than the 5th percentile curve. Alternatively, children with caloric deprivation or malabsorption fall off their weight curves first, followed by length, then by head circumference. They will therefore acutely show a deficit of weight for length and then more chronically a deficit of height for age. Figure 3⁸⁹ illustrates characteristic linear growth curves for children with intrinsic shortness, constitutional growth delay, and attenuated growth (as might be seen with caloric deprivation or gastrointestinal disease).

A critical aspect of the physical examination is an assessment of caregiver-child interaction, such as physical proximity, verbalization toward each other, and eye contact. The affect of the care provider should also be assessed. Evidence of child neglect should be sought by paying attention to

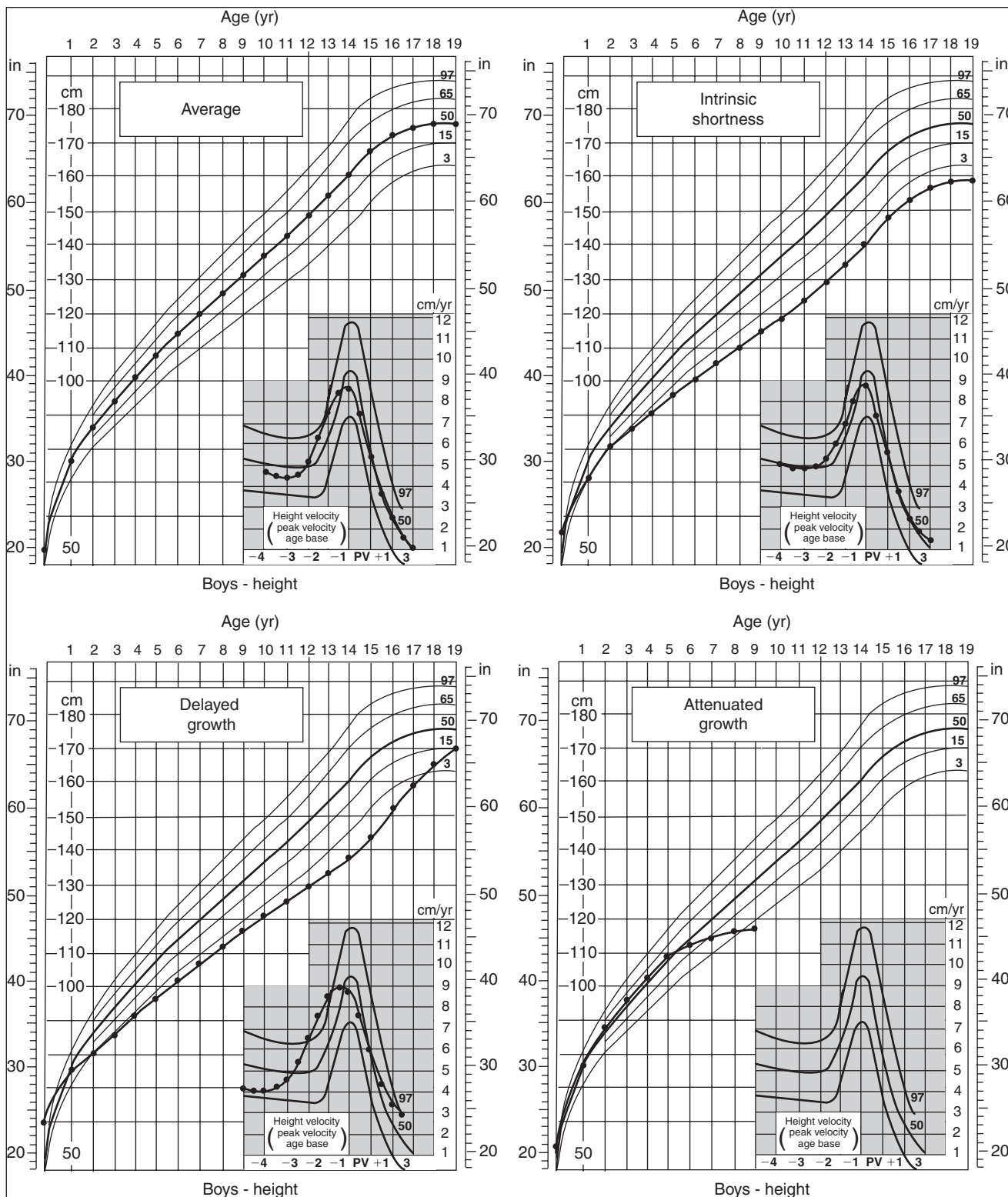


Figure 3 Linear growth curves (and height velocity curves, *insets*) of four different patterns of growth: average, intrinsic shortness, delayed growth, and attenuated growth. The last pattern is more characteristic of malnutrition. (Adapted from reference 89.)

general hygiene, oral health, and evidence of physical abuse. The possibility of organic disease can be evaluated by examination of all major organ systems. Table 6⁹⁰ gives a summary of possible findings on physical examination in children with growth failure, which should prompt further evaluation for underlying medical problems.

Unfortunately, the extensive differential diagnosis that can be engendered by the consideration of a child with poor growth (which Tunnessen compared to the index of any pediatric textbook⁹¹) can lead to excessive diagnostic testing. Sills'

landmark study in 1978 succinctly showed the lack of utility of many laboratory tests in children with poor growth.⁷⁶ In 185 children less than 3-years-old admitted for evaluation of FTT, only 36 of 2,607 laboratory tests performed (1.4%) were helpful in making a diagnosis, and all of these 36 positive results were suspected on clinical grounds. Berwick and colleagues also demonstrated the importance of a thorough history and examination over extensive testing.²¹ Therefore, a thorough history, family history, social history, review of the growth pattern as revealed by the curves, and

physical examination are the most effective screening tools for the presence of organic disease.

Laboratory testing should be minimized. Some basic screening tests may include complete blood count, blood urea nitrogen, albumin, erythrocyte sedimentation rate, lead concentration, and urinalysis. Screening for celiac disease should also be considered. An increased incidence of this disorder has been noted,^{92,93} with a significant number not presenting with the classic triad of chronic diarrhea, abdominal distension, and FTT, but sub-optimal growth. The diagnostic yield of screening

Table 6 Physical Examination of Infants and Children with Growth Failure

	Abnormality	Considerations
Vital signs	Adrenal or thyroid insufficiency	
	Hypertension	Renal disease
	Tachypnea/tachycardia	Increased metabolic demands
Skin	Pallor	Anemia
	Poor hygiene	Neglect
	Eccyhmoses	Abuse
	Candidiasis	Immunodeficiency
	Eczema	Allergic disease
	Erythema nodosum	Ulcerative colitis, vasculitis
HEENT	Hair loss	Stress
	Chronic otitis media	Immunodeficiency, structural orofacial defect
	Cataracts	Congenital infections, galactosemia
	Papilledema	Increased intracranial pressure
	Uveitis	Vasculitis
	Aphthous stomatitis	Crohn's disease
	Delayed tooth eruption	Delayed bone age
	Milk bottle caries	Neglect
	Thyroid enlargement	Thyroid enlargement
	Wheezes	Cystic fibrosis, asthma
Chest		
Cardiovascular	Murmur	Congenital malformations
Abdomen	Distention, hyperactive bowel sounds	Malabsorption
	Hepatosplenomegaly	Liver disease, glycogen storage, tumor
Genitourinary	Anomalies	Associated endocrinopathies
	Diaper rashes	Diarrhea, neglect
Rectum	Fistulae	Crohn's disease
	Empty ampulla	Hirschprung's disease
Extremities	Edema	Hypoalbuminemia
	Loss of muscle mass	Chronic malnutrition
	Clubbing	Chronic lung disease
Nervous system	Abnormal deep tendon reflexes	Cerebral palsy
	Developmental delay	Altered caloric intake or requirements
	Cranial nerve palsy	Dysphagia
Behavior	Uncooperative	Difficult to feed temperament

Adapted from reference 90.
HEENT = head, eyes, ears, nose, and throat.

tests of immigrant children and international adoptees with undernutrition is higher.^{27-30,94,95} Current recommendations for the healthcare and screening of immigrant children and international adoptees are covered elsewhere.^{27,28}

Admission to the hospital for evaluation and observation of growth under supervision may be indicated.⁹⁶ Admission should especially be considered for those children with dehydration, severe malnutrition, serious medical illness which would benefit from inpatient treatment or evaluation, significant impairment of the care provider (mental illness, drug use), or if there is concern about abuse or the safety of the child's environment. It is hoped that the combination of the provision of adequate calories and extraction from an unfavorable environment may lead to a rapid weight gain in patients with FTT and children with medical reasons for their poor nutritional status will be correctly identified. Unfortunately, once a child is hospitalized, the tendency to perform diagnostic tests often increases, which may, in turn, interfere with feeding the child (multiple consultants, tests requiring nil by mouth status, etc.). Berwick and colleagues pointed out that weight gain or loss in the hospital did not

distinguish between organic and psychosocial causes of poor growth, and it is unclear whether children with poor growth owing to social or environmental reasons will actually grow better when admitted than those with organic disease.²¹

TREATMENT OF GROWTH FAILURE

The treatment of undernutrition in children is determined by the identified contributing factors, be they biologic, psychiatric, or socioeconomic. Rarely, simple dietary advice regarding correct formula preparation may be all that is needed to ensure adequate caloric intake. Much more likely is the need for a long-term treatment and a follow-up plan, involving nutritional advice, behavioral modification, and social work intervention. As noted above, the multidisciplinary team approach to management has advantages and may even result in better nutritional outcomes for patients.^{76,78-80}

If a heretofore unsuspected medical illness is diagnosed, treatment of the underlying problem should proceed. However, nutritional aspects of the medical illness should not be ignored, given

the well-recognized propensity of poorly nourished individuals to suffer more complications and higher mortality rates with many disease processes.⁹⁷ The relationships between nutritional status and specific disease states are explored in Part IV of this text.

If medical and nutritional assessments indicate that inadequacy of caloric intake is the etiology of the poor growth, primary nutritional therapy should be the treatment of choice. The pace and aggressiveness of nutritional repletion should be dictated by the degree of malnutrition, with mild cases most suitable for outpatient management.⁹⁸

It has been recommended that to achieve adequate catch-up growth, calories be increased in proportion to the weight deficit. A general guideline for caloric requirements for infants with poor growth is

$$\text{kcal per kg required} = \frac{\text{RDA for age (kcal/kg)} \times \text{ideal weight for age}}{\text{actual weight}}$$

where ideal weight for height is the median weight for the patient's height (as read from the NCHS weight for height curves).

For example, a 3-month-old boy with a weight of 3.6 kg and length of 57 cm has the following anthropometric measures: weight-for-age z-score, -2.50; height-for-age z-score, -1.55; and weight-for-height z-score, -2.11. In addition, assessment via the Waterlow classification shows that he is suffering from moderate acute malnutrition (weight for height = 74% of the median) and mild chronic malnutrition (height for age = 93% of the median). Because his RDA for calories is 108 kcal/kg/d and his ideal weight for length is 4.8 kg, his estimated caloric requirement for catch-up growth is $(108 \times 4.8)/3.6 = 144$ cal/kg/d. Similarly, because his RDA for protein is 2.2 g/kg/d, his protein requirement for catch-up growth is closer to $(2.2 \times 4.8)/3.6 = 2.9$ g/kg/d.

In mild malnutrition, therapy should center on ways to increase oral caloric intake in an outpatient setting. Commonly, dietary supplementation with high-calorie foods, food additives, and age-appropriate high-calorie drinks are recommended to increase macronutrient intake. Infants may respond well to increasing the caloric density of their formula. For toddlers and children, the use of oils, sour cream, heavy cream, butter, peanut butter, and cheese as dietary additives is helpful. It may be necessary to work within the framework of the traditional food preferences and feeding practices of immigrant families and adoptees. For micronutrients, routine supplementation with a zinc- and iron-containing multivitamin is probably prudent, with the need for further iron therapy determined by laboratory evidence of deficiency.

Commenting upon children with LBW and the growth faltering of infants after weaning in developing nations, Weaver raises the issue of the "catch-up growth dilemma".⁹⁹ Referring to both animal and human studies, the author points out that accelerated growth early in life does appear to provide the benefits of improved survival, nutritional status, and infection resistance.

Table 7 Classification of Feeding Disorders in Infants and Children with Growth Failure

Disorder Type	Age of Onset	Associated Medical Conditions	Features of Infants	Features of Caretakers	Treatment
Homeostasis	0–2 mo	Limited experience with oral feeds (eg, respiratory occupational therapy distress) and swallow	Excitable; irritable; passive	Anxious; depressed; over- or under-feeds; stimulates infants resuck	Pacifier during nastogastric
Attachment	2–6 mo	Sad; hypervigilant; or separation from mother; developmental delay (eg, diabetes, celiac)	Detached; depressed; arches or resists when picked up	Emotional nurturance; holds infant loosely	Developmental stimulation; education of caretaker regarding needs of infant
Individualization or separation	6 mo–3 yr	(eg, diabetes, celiac)	Refuses food; defiant; plays with food	Frustrated does not allow infant to self-feed	Regularly scheduled separate mealtimes; encourage self-feeding

Adapted from reference 101.

However, there may also be a high price to be paid later in life with obesity, insulin resistance, bone demineralization, and cardiovascular disease. It is urged that this dilemma be considered when approaching feeding recommendations.

Possible indications for hospitalization for evaluation and treatment are as above. A common error among hospitalized patients with growth failure is to underestimate their caloric requirements for growth because these can be quite high. Children recovering from severe malnutrition may gain weight safely on caloric intakes as high as 170 kcal/kg/d and protein intakes of 4 to 5 g/kg/d.¹⁰⁰ It should be noted that such extremes in caloric requirements are unusual in the average patient admitted for growth failure in the United States. It is also important to note that any calculations used to judge caloric requirements are merely estimates and that the sufficiency of any diet is proven by the occurrence of subsequent weight and, eventually, height gain. These parameters should be measured and charted graphically to allow assessment of the dietary intervention.

In addition to nutritional therapy, evaluation of family dynamics and economic situation (eg, eligibility for state and federal assistance) should be performed. As mentioned above, visits to the home or other settings where the child receives care by a nurse or other appropriate personnel can also be enlightening in this regard. Regular outpatient and/or home visits should occur to document adequate weight gain and compliance with dietary management and to address any ongoing behavioral issues.

Behavioral modification should center on improving feeding techniques, removing conflict or struggles from mealtimes, reducing between-meal snacking or “grazing,” and eliminating television and other distractions during mealtimes. Caregivers are encouraged to establish

an eating routine with specific times, as well as a consistent setting and place for meals. It is also recommended that the duration of meals be limited to 30 minutes. Table 7¹⁰¹ recounts a helpful schema in which three developmental stages of feeding disorders are described, with typical features of effected infants and caretakers. As noted, the approach to therapy will largely be determined by the type of feeding disorder and age of the patient.

PROGNOSIS

The ultimate growth potential of a child with growth failure is determined by a variety of factors, including genetic potential, the timing of malnutrition (intrauterine vs neonatal vs later infancy), and the severity of malnutrition (weight alone affected vs weight, height, and head circumference). The presence of underlying medical problems and their ability to be successfully managed are also important variables. Some premature infants fail to catch up normally. For instance, Kitchen and colleagues showed that in a cohort of children whose birthweights had been less than 1,500 g and who had weights or heights less than the 10th percentile at age 2 years, half were still less than the 10th percentile at age 8 years.¹⁰² Casey and colleagues have reported that low-birthweight premature infants demonstrated little catch-up growth in the first 3 years of life.^{33,34} Subsequent studies have demonstrated that these children may demonstrate catch-up growth through childhood and even into adolescence, ultimately achieving predicted genetic height.^{103,104} One study compared adolescents born with an extremely low birthweight (ELBW, < 1,000 g) without significant neurodevelopmental disability with a matched group who had a normal birthweight.¹⁰⁵ It was found that those

who were ELBW attained growth parameters within 2 SD of the mean, although they had smaller heights, weights, and head circumferences than their normal birthweight peers. The effect was most marked for those who were ELBW and small for gestational age. There were no significant differences in sexual maturation.

Long-term data on the growth of full-term children with a history of growth failure have been limited. In one cohort of 40 children who had been admitted for malnutrition, 17 (42.5%) had weights or heights below the 3rd percentile on follow-up after a mean of 3.4 years.¹⁰⁶ In another series of 30 children diagnosed before age 2 years, mean weights were 15% lower and mean heights were 5% lower than a control group in years 3 through 6 of life.¹⁰⁷ The interpretation of these types of studies is made difficult by biases introduced by patient selection and follow-up rate because patients requiring admission obviously represent a more severely affected spectrum of disease. Thus, not all children referred for growth failure are expected to suffer long-term growth problems.

International adoptees from orphanages often demonstrate significant postadoption catch-up growth.²⁹ Age and height at the time of adoption are negative predictors of growth, BMI is a positive predictor.²⁹ It is recommended that adoptive parents should be counseled to allow 3 to 6 months for evidence of improved growth velocity before further intervention is undertaken in the absence of a potential medical issue.²⁹

The long-term growth pattern of international adoptees is still unknown.²⁹ However, there are an increasing number of reports of precocious puberty, especially in girls, in those who have experienced rapid catch-up growth with the depression of ultimate adult height.²⁹ The “catch-up growth dilemma” and the later consequences of rapid catch-up growth have been previously discussed.

A major concern remains the impact of poor growth and nutrition upon cognitive, behavioral, and social development. As alluded to above and as further developed elsewhere in this textbook, the human neurologic system continues to develop and grow postnatally, making nutritional and environmental influences early in life crucial in any effort to achieve genetic potential. The effects of early iron-deficiency anemia upon development are well known.⁶ It would be reasonable to assume that deficiencies of nutrients, micronutrients, and calories could be deleterious to the growing and developing brain as well. There are reports of a significant association between the severity of growth deficiency and IQ, with some maintaining that up to 55% of infants with FTT demonstrated developmental delay, and that those with a history of FTT may continue to demonstrate learning difficulties and developmental delay 5 years after initial presentation.¹⁰⁸

To help clarify the role of malnutrition per se in the genesis of developmental and intellectual delay, a classic study assessed the intellectual,

motor, and social functioning of 41 patients who had suffered malnutrition in infancy.¹⁰⁹ Many of these patients had a history of cystic fibrosis, none had socioeconomic deprivation. Although controls scored higher than their previously malnourished siblings on intelligence testing at 2 to 5 years, this difference was not seen at later ages. Tests of motor development and social maturity were also similar between the two groups. Subsequent studies have supported the concept that appropriate psychosocial stimulation is important for cognitive development both early and later in the child's life.^{110,111} How the generally milder degree of malnutrition seen in US children with growth failure impacts on subsequent cognitive, behavior, and emotional development is less clear. Corbett and Drewett¹¹² reviewed studies of the cognitive development of children with FTT and noted a decline in IQ of 4.2 points. They were unable to attribute this difference purely to poor nutrition versus other confounding factors such as environment or birthweight, nor were they able to demonstrate that the typical interventions were effective in reversing or preventing the difference in IQ. Chatoor et al.¹⁰⁸ studied 88 toddlers up to 33-month-old who were classified as healthy eaters, picky eaters, or having infantile anorexia. It was found that the last two groups had lower developmental scores than the healthy eater group, though still within the normal range. The correlation with body weight and developmental scores for the infantile anorexia group approached statistical significance. It was also found that more problematic and conflictive mother-toddler feeding and play interactions were associated with lower developmental scores as well.

PREVENTION

Because, in the United States, most causes of poor growth stem from or are complicated by social and economic adversity, amelioration of these conditions is the ultimate path to improved nutritional status of children. In the meantime, clinicians caring for these children should have an increased awareness of the medical and psychosocial factors that may predispose to growth failure, should classify such patients along the anthropometric guidelines mentioned above, and should recognize the benefits of multidisciplinary approach to difficult management situations.

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