Evaluating the short child (part 1 of 2)

By David Wyatt, MD

Growth is a process that reflects the vigor of the organism. It is a faithful proxy for the health and nutritional status of the child. Accurate monitoring of a child’s growth is an essential part of well childcare and therefore should be a part of every well child visit. A robust growth record, properly interpreted, is reassuring. An abnormal growth pattern, recognized, may be an early warning of a clinically significant but as yet undiagnosed condition.

Developing a functional growth record requires proper equipment, good technique and consistent record keeping. A wall-mounted stadiometer or a supine length device, when used correctly, can provide the accuracy needed for proper growth assessment. Weight, height (or length) and BMI should be obtained and plotted at least once yearly on growth charts based upon the National Center for Health Statistics surveys (www.cdc.gov/growthcharts).

Once a child has been measured and plotted, data can be compared to national standards – the child’s peers. Height also should be interpreted in light of the genetic potential – the child’s parents. But most importantly, the height data should be evaluated as a pattern. We will consider each of these comparisons below.

Peers
Comparison to a national U.S. cohort permits a larger view of the child’s growth; that is, how current height corresponds to many other children of similar background. The database consists of a broad statistical sampling of U.S. children representing common medical and nutritional influences. The less a particular child fits the U.S. profile, the less useful the comparison to these standards. For the great majority of children, however, these standards will allow a meaningful “first look.”

The “normal range” is a statistical concept with many theoretical boundaries. Commonly used height-for-age charts show centile bands extending from the 5th to the 95th centile for the population. This implies that children outside of these centiles may be abnormal. Of course, 1 in 20 children will be below the 5th centile, and the great majority of these children will be healthy and “normal.” Newer growth charts add negative standard deviation lines below the 5th centile. These lines allow a more precise assessment of the shortest children. Any child more than three standard deviations below the mean will fall in the lowest 1 percent and is more likely to have an abnormal medical or nutritional condition. Children referred to pediatric endocrinologists for short stature have a mean height standard deviation of -2.6. Even within this population, however, most of the children are healthy.

A single height measurement, then, provides some estimate of the child’s health. Much more information can be added if the genetic potential of the child can be assessed.

Parents
Tall parents tend to have tall children, and short parents tend to have short children. Indeed, “tall marries tall and short marries short.” Nevertheless, the extremes of height within the population do not increase because of a phenomenon termed regression to the mean. That is, tall parents tend to have tall children who are somewhat shorter than the parents and short parents tend to have short children who are somewhat taller than the parents. Furthermore, within any family, there is a large biologic variability in height of the children. For these reasons, estimation of the true genetic target range for a set of parents, the range within which, as an example, 90 percent of children would be expected to fall, is complex. In general, a calculation of the mid-parental target height is based upon the parental heights and corrected for the sex of the child. Then a confidence interval describing the target range is calculated around that target height. This range must allow for the normal standard deviation of the population and the regression to the mean within a family. In the Endocrine Clinic at Children’s Hospital of Wisconsin, the calculations are as follows:

\[
\text{target height (cm) for males} = (\text{father’s height} + \text{mother’s height} + 13 \text{ cm})/2 \\
\text{target height (cm) for females} = (\text{father’s height} - 13 \text{ cm} + \text{mother’s height})/2 \\
\text{genetic target range} = \text{target height ± 9 cm}
\]

If a child’s height falls below the lower end of this target range, it is much more likely to represent abnormal growth, no matter the actual height centile. For example, a child who is at the 15 percent is well within the normal population range and compares well with his peers. But if he has tall parents and his genetic target range extends from the 30 to 90 percent, he does not compare well with his genetic potential. In this way,
assessing the genetic target range adds significantly to the evaluation. Comparing the child to his peers and to his genetic potential yields an increasingly accurate estimate of normalcy. The most revealing comparison, however, is the current height to the child’s own prior growth pattern.

**Pattern**

Except for the beginning (first two years) and end (adolescence), growth on an annual basis is remarkably steady. There are seasonal variations (faster growth in spring and summer), but from year to year, a child should stay close to the same isopleth (height centile line) between age 3 and adolescence. Acceleration above or deceleration below that channel often indicates abnormality. Note that acceleration can be as worrisome as a decline, since it may indicate precocious puberty, hyperthyroidism or other abnormal conditions that stimulate growth.

An abnormal fall (or rise) across height centiles cannot simply be quantified as “across two lines,” since the commonly used lines are not evenly spaced. For example, a two-line decline from the top centile (95th to 75th) represents a decline of 20 centiles; a fall between the next two lines (90th to 50th) represents 40 centiles; and a fall between the next two lines (75th to 25th) represents 50 centiles. Assuming accurate measurements, any decline of more than 20 centiles over a full year should raise concern. This applies even if the current height centile is well within the “normal” range.

In the first 2 years, about one in three healthy infants will show a 10 to 30-centile decline. This represents the normal shift from the intrauterine environment to the true genetic inheritance, and makes it much more difficult to detect abnormal growth patterns. In general, if an infant is healthy and well-nourished, a moderate decline may simply be monitored. After the first 2 or 3 years, however, all children should have “found their channel” and should show no further decline.

All children show a deceleration prior to the pubertal growth spurt. Those who mature later show a greater deceleration and will have a greater dip on their growth chart. The great majority of these children are normal and will reach a normal adult height once puberty begins. If they are in good general health and well-nourished, they may be reassured with a few simple screening tests (i.e., bone age X-ray, free T4 and TSH). Some may benefit from a brief course of androgens, but most do well with reassurance.

Having sufficient data to perform these three comparison – the child’s current height to his peers, his parents and his pattern – is often more valuable than any laboratory test. The comparison to the prior pattern of growth is the most important of the three and only can be done with a well-maintained growth record.

Part 2 of this article, which will examine various sample growth patterns, will appear in the Spring 2006 issue of *Pediatric Rounds*.
Evaluating the short child (part 2 of 2)

By David Wyatt, MD

Part 1 of this article, which can be found at www.chw.org/pediatricrounds in the Winter 2006 issue, reviews the fundamentals of monitoring and evaluating a child’s growth.

Careful monitoring of a child’s growth is an important part of well-child visits. Reviewing growth charts helps to illustrate the importance of keeping an accurate growth record. As you approach each chart, remember to compare the child’s stature to his peers, his parents and to his own pattern.

Each sample chart represents normative data for boys ages 2 to 20 years, with the height curves above the weight curves. Centile lines are shown, as are negative z score lines for height. These represent negative standard deviation scores and are used to compare very short children to their peers. At the far right of each height curve is a line representing the genetic target height range for the sample child. (Refer to part 1 for the calculations of these ranges.)

Familial short stature (FSS)

At age 10, this child’s height is below 99 percent of his peers, but is well within his genetic target range (range A). The parental heights are reassuring – assuming there is no medical abnormality in either parent that altered their heights. More importantly, this child’s growth pattern shows steady growth along an isopleth (here, the 1st centile). He is keeping up with his peers, growing at approximately the same rate. Thus, it is unlikely that this short child has a significant medical problem or endocrine deficiency. See Table 1.

If, however, this child had taller parents (genetic target range B), we would be much more concerned. The discrepancy between the child and his genetics would strongly indicate an underlying medical problem requiring evaluation. This case emphasizes that the comparison with the parents is as important as the comparison with the peers, and why the overall pattern is the most important data available.

FSS plus constitutional delay

By age 14, this child’s growth pattern has deviated from a previously steady isopleth at the 1st centile. His height centile is still within the genetic target range, but he is falling further behind his peers. At this age, a simple delayed puberty is the most common cause of such a dip. These adolescents account for the great majority of referrals to the Short Stature Clinic at Children’s Hospital of Wisconsin. The dip occurs as the child’s peers, who are in their peak adolescent growth rate, accelerate ahead of him. Of course, this dip also occurs in taller children with pubertal delay, but it is much less of a problem since the taller child has more “height margin” and is able to wait out the delay. For the child who has struggled at the shortest 1st centile, the further loss of relative height often becomes very worrisome. See Table 2a.

Some medical conditions can cause both pubertal delay and growth failure. For example, a severe chronic lung disease such as cystic fibrosis often is associated with chronic short stature aggravated by pubertal delay. Most such conditions are clinically obvious. Some, such as acquired hypothyroidism or celiac disease, are more subtle and may necessitate laboratory studies. Note there is a similar though less dramatic dip in weight centiles. Since the weight is better maintained than the height, it is unlikely to be a signal of the cause (for example, malnutrition) of the height centile decline.

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This growth chart depicts the typical “recovery” pattern of the child with FSS and constitutional delay. As puberty begins, he has a late acceleration with catch up growth to his previous centile. This occurs whether the child sees a pediatric endocrinologist or not. Many of these adolescents elect an optional low-dose testosterone therapy (three to six monthly depot injections) to give them a boost. Such therapy will not increase final height but is used for the psychological relief that comes with some catch-up growth and pubertal changes (such as pubic hair). See Table 2b.

Table 2b

Similar recovery growth can occur if a previous growth-impairing medical condition is resolved. Complete height recovery at this late age, however, may not be possible. Thus, it is important to diagnose such conditions as soon as possible. Maintenance of an accurate growth record can be of great help in the early detection of otherwise subtle conditions, such as hypothyroidism. Indeed, the estimated time from onset to diagnosis, based on bone age delay and growth records, for hypothyroidism is 5 to 6 years. An early appreciation of the growth deceleration could lead to an earlier diagnosis.

Growth failure

The growth chart for this 11-year-old child looks quite normal. His height is at the 25th centile, which is well within both the population norms and his genetic target range. His weight is somewhat excessive for his height (about 125 percent of ideal), but nothing else seems amiss. The child compares well with his peers and his parents. This is the problem with a single measurement. There is no growth pattern to view. See Table 3a.

Table 3a

This is the same child with more data. Now it is obvious there is significant growth failure – a decline in height from the 80th to the 25th centile over the last three years. This growth pattern is occurring too early to be explained as a pre-pubertal dip due to constitutional delay, and it requires a full medical evaluation. Such a pattern would not have been available without the maintenance of an accurate growth record; it exemplifies the importance of the growth record as a proxy for the health of the child. See Table 3b.

Table 3b

Malnourishment and growth failure

This is the same height data as in Table 3b. Note, however, that this child’s weight pattern is much different. In 3b, weight was maintained at a higher isopleth than the height, and weight centile loss followed height centile loss. Here, weight centile loss precedes height centile loss by several years. This pattern is typical of malnourishment. A child usually will show a deceleration in weight gain for some time before height gain is affected. Such a pattern should stimulate both a dietary and gastrointestinal evaluation. No endocrine deficiency would produce this height and weight pattern. See Table 4.
Worldwide, malnourishment is the most common cause of failure to achieve optimal genetic potential. Nations that have yet to achieve adequate childhood nutrition still show significant secular trends as their economies improve. Fully developed nations no longer show significant secular trends for height. In this way the growth of the children is a proxy for the economic health of the nation.

**Abnormal acceleration**

Any deviation from a steady channel of growth prior to puberty is an aberration deserving of medical attention. The growth pattern in Table 5 shows an abnormally early acceleration of height. The child is growing much more rapidly than his peers and is thus gaining height centiles relative to them. He has moved from the middle of his genetic target range to far above the upper end of that range. Such an abnormally timed acceleration is as worrisome as any deceleration and requires thorough evaluation. The most common cause of this pattern, precocious puberty, can diminish final height by rapid advancement of bone age and early growth cessation. See Table 5.

**Obesity driven growth**

Overweight is a major and worsening public health problem. Since almost one quarter of all children have excess weight, many children will show the growth pattern seen in this chart. Note the weight gain precedes and is much greater than the excess height gain. It is not known how excessive caloric intake stimulates linear growth. One mechanism might be an interaction of the increased insulin levels (due to insulin resistance) with the insulin-like growth factor (IGF-1) receptor. Certain clinical conditions associated with a deficient satiety center also can produce this degree of obesity driven growth. Examples include Prader-Willi syndrome and the hypothalamic hyperphagia seen after surgical removal of suprasellar craniopharyngiomas. Regardless of the fundamental etiology, this degree of obesity will lead to significant medical consequences, including diabetes, fatty infiltration of the liver, joint degeneration and cardiovascular disease. Since there currently is no known medical “cure” for obesity, prevention is the key approach. See Table 6.

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