In Brief

Principles of Growth Assessment

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Note: This In Brief was written while Dr Beker was at Children's National Medical Center, Washington, DC. Dr Beker's In Brief is her own opinion and does not represent the United States Food and Drug Administration.

Author Disclosure
Drs Becker and Cheng did not disclose any financial relationships relevant to this In Brief.

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Growth in children is usually steady and predictable, and good references are available for assessment and comparison. Growth reflects changes in the mass of body tissues (muscle, fat, and bone), with differences in maturation and body composition between boys and girls. Growth is a key component of nutritional status and indicator of health and well-being for the individual and in populations, with every aspect of a child's health being affected by his or her nutritional status. Growth can be measured objectively by using various anthropometric measurements and is universally part of any pediatric care.

Typically, weight is measured by using scales, infantometer (length board), stadiometer (stature) for linear growth, calipers for skinfold measurements, and nonstretchable tape for head and arm or other circumferences. Recumbent length is referenced through age 3 years, stature from 2 to 20 years, and head circumference from birth to age 3 years.

Although infancy and adolescence are characterized by rapid growth, growth occurs in spurts, with rapid growth followed by slower growth. Stunting or faltering of linear growth reflects both a decrease in the number of spurts and the height of these spurts and can begin in utero.

Growth generally is divided into four periods: 1) infancy to 2 years of age, 2) preschool years (2 to 6 years), 3) middle childhood years (7 to 10 years), and 4) adolescence (11 to 20 years). These growth periods encompass changes in body composition as well as maturational milestones. During infancy, childhood, and adolescence, both cell number and cell size increase. Body composition changes significantly from infancy to adolescence in terms of absolute and relative changes in the amount of lipid, protein, water, and minerals. Skinfold measurements provide information on body composition that reflects nutritional stores, including lean body mass (muscle and water), lipid (energy stores), and bone (calcium and other minerals).

Selecting the correct growth chart for sex, age, and measurement device is essential to the assessment. Revised growth charts were published in May 2000 from the Centers for Disease Control and Prevention (CDC) and the National Center for Health Statistics (NCHS). They replace the 1977 NCHS charts and reflect large samples of healthy children living in the United States. These charts are available electronically (see Web site in references). The CDC-2000 infant charts are based on monthly (not quarterly) measurements, mixed races, and breast- and formula-fed infants. Growth measurements of an individual are compared with reference data for height/length, weight, and head circumference for age and sex, weight for height, and a new feature, body mass index (BMI). The BMI is calculated from the formula weight (kg)/height^2 (M) and is designed for clinical use for children ages 2 to 20 years. The objective of the BMI percentiles is to assist in screening for overweight and identification of underweight, making the BMI a screening tool to identify risk.

Growth charts do not reflect genetic potential or environmental factors and are inappropriate for preterm infants or children who have genetic disorders. Because no single measure defines an individual, children of unusual size (>95th percentile or <5th percentile) require further investigation to determine whether there is a growth problem. Additional care must be used when assessing smaller children because they appear to be more underweight than the 1977 charts indicate.

Anthropometric measurements are

inexpensive, noninvasive, and fast and reflect both short- and long-term nutrition status. The accuracy of measurements is an essential component of the assessment. Erroneous weight or linear measurements can place a child in an incorrect category, resulting in misinterpretation of growth parameters. Anthropometric measurements are objective, but growth characterization must be interpreted in the context of clinical assessment.

The average weight at birth is slightly higher (3.4 kg for girls; 3.8 kg for boys) on the revised CDC-2000 growth charts. Healthy neonates are expected to regain their birthweight within 8 to 10 days after birth; a weight loss of 5% is within the norm for formula-fed infants. A weight loss of 7% is not unusual for a breastfed infant, but if it occurs during the first 72 hours after birth, an evaluation and review of the mother-infant dyad is needed, and any impediments must be addressed immediately. A weight loss of 10% from birthweight is the maximum acceptable loss; additional loss is a potential emergency. Greater weight loss among breastfed infants has been associated with the use of additional water or forced fluids that impede the breastfeeding process. The average infant (at the 50th percentile on the new growth chart) doubles his or her birthweight at 5 months, triples the birthweight at 14 to 15 months (200% increase), and quadruples birthweight around 3 years of age. Body length increases by more than 50% in the first postnatal year and doubles by 3 to 4 years of age. Head circumference increases by almost 30% in the first postnatal year. Increased head circumference indirectly suggests brain growth and is of great importance during the first year after birth, with the head expected to increase an average of 10 cm in circumference. Faltering growth in head circumference may suggest problems of brain growth or severe extended malnutrition. Growth and developmental changes occur during this time and are related to nutritional status.

Measuring the length of an infant requires two people who have received training and can hold the child properly on the infantometer. The infantometer must be attached securely to a table and have a fixed headboard, moveable footboard, and rule or reader. The child's head should be held with the crown against the headboard so that the external auditory meatus and the lower margin of the eye are aligned perpendicularly. The other measurer gently stretches the infant's legs by holding both ankles with one hand while moving the footboard to meet the infant's heels flatly and perpendicularly. Before the final reading is made, the infant's knees are pressed gently against the board, and length is measured to the nearest 0.1 cm. This is not an easy measurement to obtain accurately because the infant often is objecting during the process.

Stature (standing height) is measured by using a stadiometer or similar apparatus. The child must be able to stand erect, with heels, buttocks, shoulders, and head all simultaneously touching the measuring board. The child's feet must be at a 90-degree angle, the axis of vision horizontal, and the head in a Frankfurt plane and parallel to the floor. Children should stare straight ahead and stand tall while keeping their heels on the floor. The headboard of the apparatus is slid down firmly on the crown and height recorded to the nearest 0.1 cm.

Weight can be measured on infant scales, beam balances scales, electronic scales, and readout scales. Regardless of the type, all scales require regular calibration to ensure accurate weight. Infants always should be weighed nude (no diaper); children should be weighed without their shoes and outer clothing. Weight should be recorded to the nearest 0.01 kg for infants and 0.1 kg for children.

Because head circumference reflects the particularly rapid brain growth of the first 3 years after birth, growth curves for head circumferences customarily are charted through age 3 years. Infants who have microcephalic or macrocephalic conditions require different monitoring of their head growth and the use of specialized charts.

Arm circumference and skinfold measurements can provide information on body composition that cannot be attained from weight and length/stature measurements. However, making such measurements requires training and proper technique to avoid significant intraobserver difference. Skinfold can be measured at the triceps, biceps, and at subscapular and suprailiac sites. The triceps skinfold is a good indicator of energy reserves, correlates well with total body fat stores, reflects short-term fluctuations, and can be compared with excellent reference data. Subscapular skinfold is less sensitive to short-term fluctuations but better reflects long-term energy stores. A combination of skinfold measurements can be used to estimate the percent body fat and lean body mass by using prediction equations. The mid-upper arm circumference reflects muscle, fat, and bone, providing a rapid index of malnutrition, especially if height and weight are unavailable, and is well referenced.

Comment: The new growth charts are easily downloaded from the previously noted Web site. Of note, growth charts that were downloaded from the site from October 16, 2000 to November 21, 2000 need to be replaced with the most recent chart because of some scaling errors. So, what's new about the new growth charts? First, the data are most representative of the population of children in the United States. Second, the age range of the charts extends beyond 18 years to 20 years of age. Third, the percentile values go beyond the 5th and 95th percentiles and include the 3rd and 97th percentiles. Finally, BMI charts are included. BMI values are correlated with total body fat, percentage body fat, and fat-free mass. High BMIs due to obesity in children have been associated with increased blood pressure, total cholesterol, low-density lipoprotein cholesterol, and triglycerides and low levels of high-density lipoprotein cholesterol. In adulthood, high BMIs have been related to increased morbidity and mortality. In adults, a BMI greater than 25 indicates overweight and greater than 30 indicates obesity. For children, cutoff values of concern are not well established, but recommendations for evaluation and interventions have been made at certain percentiles. BMI curves, however, allow monitoring of growth patterns that may indicate risk for over- or underweight at an early age.

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Clarifications: 2005 Revisited

When readers return their quiz answer sheets in January, many include comments about the journal in general, about specific articles, and especially about the answers to quiz questions. We read each comment carefully and print replies when warranted. As readers have become better acquainted with the online Rapid Response feature of the journal, the number of such year-end comments has diminished, but a few observations bear mention. Note that most of the errors in quiz answers already have been addressed online, in print, or in both.

In the March issue, quiz question #14 presents a patient who developed leukemia at the age of 15 years and finished chemotherapy at 10 years. The latter age should be 18 years.

In the May issue, in Case 3 of "Index of Suspicion," the decimal equivalent of 4% should be 0.04 and of 2% should be 0.02. In Case 1 of the October issue, the hemoglobin level should be 10.6 g/dL. In Case 1 of the December issue, the prothrombin and partial thromboplastin times should be expressed in seconds.

In connection with an article on malaria, a reader inquired about the availability of primaquine, which was a recommended drug for prophylaxis. We were stimulated by this question to search for a Web site that might contain current information about general drug availability. Readers can find such information at the Drug Shortages Resource Center of the American Society of Health-System Pharmacists (http://www.ashp.org/shortage/). If the desired information cannot be obtained there, a reasonable next step is to work with a local pharmacist to contact manufacturers directly to obtain the latest word on availability.

A Message to Our Readers

It has been called to our attention that the article entitled "Technical Tip: Subungual Hematoma" (*Pediatr Rev.* 2004;25:369) contains unattributed material from two other journals. (1)(2) Our journal's policy is clear. Even one sentence taken from another publication must be put into quotation marks, with the source acknowledged. The same philosophy extends to tables and figures, where the additional step of seeking permission from the publisher is taken. Journals published by the American Academy of Pediatrics follow guidelines developed by the International Committee of Medical Journal Editors (http://www.icmje.org/index.html#top). Because ours is a review journal and not a new science publication, we realize that authors gather information from a variety of published sources, but we recognize that choosing information to be incorporated into an original article is different from using material taken verbatim from other sources. We also acknowledge the difficulty for authors who have written extensively on a given subject to avoid the use of expressions they have penned in the past. At the same time, we ask that anything published in our journal that is not original be quoted and attributed. The editors have depended on the good faith of our authors to follow the rules and on our reviewers and readers to detect any inappropriate use of existing material. We are grateful to those who have called such rare incidents to our attention. With the increasing use of Internet research, we realize that we must become more proactive in this area. Consequently, we will be employing a professional plagiarism detection service to aid us in keeping the journal's content legitimate. We add our apology to that of the authors for this occurrence and pledge to continue to strive for the highest standards of medical journalism.

Lawrence F. Nazarian, MD
Editor-in-Chief

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