Normal Growth and Development

GROWTH ASSESSMENT

Growth Parameters
In pediatric medicine, growth is an important indicator of a patient's nutritional status and general health. Routine assessment of growth parameters includes:
- weight in all patients
- length in infants at birth to age 3 years
- head circumference in infants at birth to age 3 years
- height in children ≥2 years
- body mass index (BMI) in children ≥2 years

BMI is calculated by:
- dividing the patient's weight in kilograms by the patient's height in meters squared: \( \text{BMI} = \frac{\text{weight (kg)}}{\text{height (m)}^2} \)
- or dividing the patient's weight in pounds by the patient's height in inches squared, then multiplying the result by 703: \( \text{BMI} = \frac{\text{weight (lb)}}{\text{height (in)}^2} \times 703 \)

Children at risk for abnormal growth patterns include those <5th percentile or >95th percentile, respectively, for weight and/or height. Patients who have BMIs between the 85th and 95th percentiles are considered at risk of overweight, and those ≥95th percentile are considered overweight. These cutoffs may be modified as BMI gains in standard usage. The real value of growth assessment becomes evident over time; the different parameters form "growth curves" that can reveal sudden and/or unexpected changes in growth velocity, although the patient's actual measurements may still be in the normal range. Children who "fall off" their expected growth curves, especially when measurements cross two percentile lines, warrant further investigation into the cause of their decelerated growth.

Several important rules of thumb regarding growth in children are listed below.
- The average newborn weight in the United States is 3.5 kg (7 lb, 11 oz).
- Newborns lose weight in the first several days after birth; weight loss that exceeds 10% of birthweight is considered abnormal and requires immediate intervention.
- Newborns should regain their birthweight by days of life 10 to 14.
- Breast-fed infants on average lose a greater percentage of their birthweight than formula-fed infants and thus, generally take longer to regain their birthweight.
- Healthy infants double their birthweight at age 4 to 5 months and triple their birthweight by age 12 to 14 months.
- The average newborn length in the United States is 50 cm (almost 20 in).
- Between the ages of 3 and 4 years, a healthy child's stature should reach double that child's birth length.
- The average newborn head circumference in the United States is 36 cm (about 14 in).
- Head circumference is expected to increase by almost 30% during the first year of life (average 47 cm, about 18.5 in).

Abnormalities in Head Circumference
At birth, normal head circumference ranges from about 32.5 to 38 cm (12.8 to 15 in). Head circumference provides an indirect assessment of brain growth.

Microcephaly is defined as a head circumference greater than two standard deviations below the mean. Most cases are due to small brain size. Microcephaly is associated with an increased incidence of mental retardation. Microcephaly may be primary (genetic) or secondary (acquired).
- Primary microcephaly is present at birth and is typically familial or associated with specific genetic abnormalities such as Down syndrome.
- Secondary microcephaly results from an insult to the brain in utero or during the first 2 years of life. Examples include congenital infections, in utero drug or alcohol exposure, maternal hypertension during pregnancy, meningitis, failure to thrive, and hypoxic encephalopathy. When the cause is a prenatal event, the earlier in development the event occurs, the smaller the head will be. The infant with a normal head circumference at birth and subsequent development of microcephaly has acquired microcephaly by definition. Examination of the head circumference growth chart and a careful history and physical examination usually suggest the diagnosis.

Macrocephaly is defined as a head circumference greater than two standard deviations above the mean (alternatively, >97th percentile). Familial (inherited) macrocephaly is typically associated with normal intelligence. These infants are...
born with large heads, and their head circumference growth curves track along a consistent percentile. There is no associated cerebral pathology. The development of macrocephaly after birth may result from neurocutaneous disorders, metabolic storage disease, bleeding, or hydrocephalus. Hydrocephalus is an abnormal accumulation of cerebrospinal fluid within the ventricles through impaired absorption or increased production. In the infant,

### TABLE 1-1
NORMAL DEVELOPMENTAL MILESTONES

<table>
<thead>
<tr>
<th>Age</th>
<th>Gross Motor</th>
<th>Fine (Visual) Motor</th>
<th>Language</th>
<th>Social/Adaptive</th>
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</thead>
<tbody>
<tr>
<td>Birth to 1 mo</td>
<td>Raises head slightly in prone position</td>
<td>Follows with eyes to midline only; hands tightly fisted</td>
<td>Alerts/startles to sound</td>
<td>Fixes on face (at birth)</td>
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<tr>
<td>2 mo</td>
<td>Raises chest and head off bed in prone position</td>
<td>Regards object and follows through 180° arc; briefly retains rattle</td>
<td>Coos and vocalizes reciprocally</td>
<td>Social smile; recognizes parent</td>
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<tr>
<td>4 mo</td>
<td>Lifts onto extended elbows in prone position; steady head control with no head lag; rolls over front to back</td>
<td>Reaches for objects with both hands together; bats at objects; grabs and retains objects</td>
<td>Orient to voice; laughs and squeals</td>
<td>Initiates social interaction</td>
</tr>
<tr>
<td>6 mo</td>
<td>Sits but may need support; rolls in both directions</td>
<td>Reaches with one hand; transfers objects hand-to-hand</td>
<td>Babble</td>
<td>Recognizes object or person as unfamiliar</td>
</tr>
<tr>
<td>9 mo</td>
<td>Sits without support; crawls; pulls to stand</td>
<td>Uses pincer grasp; finger-feeds</td>
<td>Imitates speech sounds (nonspecific &quot;mama,&quot; &quot;dada&quot;); understands &quot;no&quot;</td>
<td>Plays gesture games (&quot;pat-a-cake&quot;); understands own name; object permanence; stranger anxiety</td>
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<tr>
<td>12 mo</td>
<td>Cruises; stands alone; takes a few independent steps</td>
<td>Can voluntarily release items</td>
<td>Discriminative use of &quot;mama,&quot; &quot;dada,&quot; plus one to four other words; follows command with gesture</td>
<td>Imitates; comes when called; cooperates with dressing</td>
</tr>
<tr>
<td>15 mo</td>
<td>Walks well independently</td>
<td>Builds a two-block tower; throws ball underhand</td>
<td>Four to six words in addition to above; uses jargon; responds to one-step verbal command</td>
<td>Begins to use cup; indicates wants or needs</td>
</tr>
<tr>
<td>18 mo</td>
<td>Runs; walks up stairs with hand held; stoops and recovers</td>
<td>Builds a three-block tower; uses spoon; spontaneous scribbling</td>
<td>Uses ten to 25 words; points to body parts when asked; uses words to communicate needs or wants</td>
<td>Uses words to communicate wants or needs; plays near (but not with) other children</td>
</tr>
<tr>
<td>24 mo</td>
<td>Walks unassisted up and down stairs; kicks ball; throws ball overhand; jumps with two feet off the floor</td>
<td>Builds four- to six-block tower; uses fork and spoon; copies a straight line</td>
<td>Uses 50+ words, two- and three-word phrases; uses &quot;I&quot; and &quot;me;&quot; 50% of speech intelligible to stranger</td>
<td>Removes simple clothing; parallel play</td>
</tr>
<tr>
<td>36 mo</td>
<td>Pedals tricycle; broad jumps</td>
<td>Copies a circle</td>
<td>Uses five- to eight-word sentences; 75% of speech intelligible to stranger</td>
<td>Knows age and gender; engages in group play; shares</td>
</tr>
<tr>
<td>4 y</td>
<td>Balances on one foot</td>
<td>Copies a cross; catches ball</td>
<td>Tells a story; 100% of speech intelligible to stranger</td>
<td>Dresses self; puts on shoes; washes and dries hands; imaginative play</td>
</tr>
<tr>
<td>5 y</td>
<td>Skips with alternating feet</td>
<td>Draws a person with six body parts</td>
<td>Asks what words mean</td>
<td>Names four colors; plays cooperative games; understands &quot;rules&quot; and abides by them</td>
</tr>
<tr>
<td>6 y</td>
<td>Rides a bicycle</td>
<td>Writes name</td>
<td>Identifies written letters and numbers</td>
<td>Knows right from left; knows all color names</td>
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</tbody>
</table>
hydrocephalus may present with rapidly increasing head circumference measurements that form a curve that crosses percentile lines. Other signs include a large, bulging anterior fontanelle and dilated scalp veins. Cranial ultrasonography confirms the diagnosis. Macrocephaly with hydrocephalus is more likely to be associated with subsequent cognitive impairment. Chapter 18 contains a more detailed discussion of hydrocephalus.

NORMAL DEVELOPMENT AND DEVELOPMENTAL DELAY

Although the timetable varies somewhat from child to child, the sequence of pediatric neurodevelopment is orderly and predictable. Development generally proceeds:

- in the cephalic-to-caudal direction (head to toe)
- in the proximal-to-distal direction (center to extremities)
- from involuntary reflexes to voluntary, purposeful action
- from dependence on caregivers to relative independence

For organizational purposes, developmental milestones are typically categorized into gross motor, fine (or visual) motor, language, and social/adaptive domains (Table 1-1). Children should be screened for achievement of skills in each of these areas at every health maintenance visit by parental report or through direct assessment. The earlier a delay in development is diagnosed, the sooner intervention and support can be provided to the child and family. Findings suggestive of developmental delay are noted in Table 1-2. Of note, conditions such as prematurity, vision impairment, and hearing loss affect the timing of development and disorders of cognition, speech and language, and motor function at a level at least two standard deviations below the child’s expected achievement for age in two or more of the developmental categories listed above. Global delay is associated with mental retardation.

Abnormal development may consist of global delay, isolated delay, or atypical development.

- **Global developmental delay** is diagnosed when a child is functioning at a level at least two standard deviations below the child’s expected achievement for age in two or more of the developmental categories listed above. Global delay is associated with mental retardation.
- **Isolated developmental delay** exists when a child is functioning at or below the level described above in only one domain of development. Delay in a single area may adversely affect other developmental streams or may interfere with testing to assess the child’s global development.
- **Atypical development** refers to any of the following: (a) divergence from the normal sequence of development such as skipping skills or developing certain skills very early (splinter skills), (b) discrepancies among the areas of development, (c) loss of skills previously achieved, and (d) the presence of atypical behaviors (e.g., echolalia).

### Table 1-2: Features Suggestive of Abnormal Development or Delay

<table>
<thead>
<tr>
<th>Category</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>General</strong></td>
<td>Skipping skills</td>
</tr>
<tr>
<td></td>
<td>Atypical behaviors (e.g., perseveration)</td>
</tr>
<tr>
<td><strong>Motor</strong></td>
<td>Abnormally sustained primitive reflex posturing at birth or thereafter</td>
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<tr>
<td></td>
<td>Rolling over at 1 to 2 mo (increased tone)</td>
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<tr>
<td></td>
<td>Tight or persistent fisting at age 3 mo (increased tone)</td>
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<tr>
<td></td>
<td>No visual tracking by 4 mo of age (visual impairment)</td>
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<tr>
<td></td>
<td>Poor head control at 6 mo (hypotonia)</td>
</tr>
<tr>
<td></td>
<td>Inability to sit by 9 mo of age (hypotonia or weakness)</td>
</tr>
<tr>
<td></td>
<td>Persistence of primitive reflexes beyond 9 mo (neurologic dysfunction)</td>
</tr>
<tr>
<td></td>
<td>Hand dominance before 18 mo (contralateral weakness)</td>
</tr>
<tr>
<td><strong>Language</strong></td>
<td>No alert to sound at birth or thereafter (hearing impairment)</td>
</tr>
<tr>
<td></td>
<td>No babbling with consonants by 9 mo (hearing impairment)</td>
</tr>
<tr>
<td></td>
<td>Repetitive, noncommunicative speech (autism)</td>
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<tr>
<td></td>
<td>No use of single words by 24 mo of age (motor dysfunction, speech disorder)</td>
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<tr>
<td></td>
<td>Failure to speak in three-word sentences by 36 mo of age</td>
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<tr>
<td></td>
<td>Unintelligible speech in a child older than 36 mo of age (articulation disorder)</td>
</tr>
<tr>
<td><strong>Social/Adaptive</strong></td>
<td>No fixation of visual attention by 2 mo of age</td>
</tr>
<tr>
<td></td>
<td>No social smile by 4 mo (visual impairment or attachment issues)</td>
</tr>
<tr>
<td></td>
<td>No stranger anxiety 9 to 12 mo (attachment issues)</td>
</tr>
<tr>
<td></td>
<td>Inadequate initiation of social interaction (autism)</td>
</tr>
</tbody>
</table>

Language development is the best indicator of future intellectual potential. Delays in language development are more common than delays in other areas. Gross motor development is the least correlative with cognitive potential.

### Sources


QUESTIONS

1. Primitive reflexes in the infant should not persist beyond the age of:
   A) 1 month
   B) 2 months
   C) 4 months
   D) 6 months
   E) 9 months

2. Development in which of the following domains has the best predictive value of future intellectual potential?
   A) Gross motor
   B) Visuomotor
   C) Language
   D) Adaptive
   E) Social

3. Which of the following statements regarding growth parameters in children is FALSE?
   A) All patients should be weighed at each health maintenance visit.
   B) Supine length may be used to measure children up to 3 years of age.
   C) Stature (height) may be used in children ≥2 years old.
   D) Head circumference should be measured at each health maintenance visit from birth until the age of 2 years.
   E) BMI should be calculated and recorded for children ≥2 years of age.

4. Patients with BMIs above what percentile for age and gender should be considered "overweight"?
   A) 50%
   B) 66%
   C) 75%
   D) 85%
   E) 95%

5. You are seeing a 1-month-old female infant for a health maintenance visit. The mother reports that the child watches her face while bottle-feeding and at other times seems to respond to her voice. The baby raises her head slightly while in the prone position on the examining table. Of the following, she most likely also can:
   A) follow objects to the midline
   B) track objects horizontally but not vertically
   C) briefly retain a rattle placed in her hand
   D) smile socially
   E) recognize her parent

6. You are seeing a 2-month-old boy for a health maintenance visit. His parent reports that the child is beginning to coo and participate in reciprocal vocalizations. The boy knows his parents and smiles socially. Of the following, he most likely also can:
   A) raise his shoulders, chest, and head off the examining table in the prone position
   B) reach for objects
   C) bat at objects
   D) localize sound
   E) recognize the examiner as an unfamiliar person

7. You are seeing a 4-month-old boy for a health maintenance visit. The child is squealing and laughing when you enter the room. He looks around for you when he hears you speak. The mother tells you that her baby initiates social interaction with her and his brother. Of the following, he most likely also can:
   A) roll over back to front
   B) understand that his name refers to him
   C) reach for objects with both hands together
   D) babble
   E) sit with support

8. You are seeing a 6-month-old girl for a health maintenance visit. Her parent reports that the child babbles and sits with support. She can also roll over in both directions. You notice that she can transfer her teething ring from one hand to the other. Of the following, she most likely also can:
   A) understand "no"
   B) understand her own name
   C) imitate speech sounds
   D) recognize the examiner as an unfamiliar person
   E) sit without supporting herself with her hands

9. You are seeing a 9-month-old boy for a health maintenance visit. When you enter the room, the patient is crawling about the floor. While you are talking with his mother, you notice him pull to standing using a stool. His mother reports that he finger-feeds himself and has started saying "dada," although not in reference to his father. Of the following, he most likely also can:
   A) voluntarily release items
   B) understand object permanence
   C) stand alone for a few seconds
   D) follow commands with a gesture
   E) come when called

10. You are seeing a 12-month-old girl for a health maintenance visit. Her mother reports that, in some ways, things are getting easier. The child is able to come when called and cooperate with dressing. She can pick up something if the mother asks her to while pointing to it. Of the following, she most likely also can:
    A) take a few independent steps
    B) scribble with a pen
    C) use a cup
    D) use a spoon
    E) use jargon
11. You are seeing a 15-month-old boy for a health maintenance visit. The child can walk about the room independently. His mother reports that he can say eight words including "mama" and "dada." You would also expect this child to be able to:
A) walk up stairs with his hand held
B) point to three body parts when asked
C) build a tower of three blocks
D) throw a ball underhanded
E) play well with other children

12. You are seeing an 18-month-old girl for a health maintenance visit. You note that she can stoop and recover her cup by herself. Her mother reports that she runs well and can use a spoon. She uses words and gestures to communicate her needs. You would expect her to be able to use at least how many words?
A) 10 to 25
B) 25 to 50
C) 50 to 75
D) 75 to 100
E) >100

13. You are seeing a 24-month-old boy for a health maintenance visit. The parent reports that the child can kick and throw a ball, use a fork and spoon, remove simple clothing, and use two- and three-word phrases. Of the following, he most likely also can:
A) balance on one foot
B) use ≥100 words
C) use the words "I" and "me"
D) copy a circle
E) broad jump

14. You are seeing a 3-year-old girl for a health maintenance visit. She can tell you her name and gender and speaks in sentences five to eight words in length. Based on this information, you would expect to be able to understand at least:
A) 50% of her speech
B) 75% of her speech
C) 90% of her speech
D) 100% of her speech
E) none of the above

15. You are seeing a 4-year-old boy for a health maintenance visit. The child can balance on each foot for 3 seconds. He is excited to tell you about how he scored a goal in his soccer game. His mom reports that he can dress himself in simple clothing and put on his shoes, although he cannot yet tie them. He should be able to copy which of the following figures that you draw?
A) A straight line
B) A circle
C) A straight line and a circle
D) A circle and a cross
E) A straight line, a circle, and a cross

16. You are seeing a 5-year-old girl for a health maintenance visit. Her mother is concerned about the way she plays with other children. You remember that at this age, most developmentally normal children primarily engage in:
A) nonconnected play
B) side-by-side (but not interactive) play
C) solitary play
D) cooperative play
E) nonimaginative play

17. At what age would you expect a developmentally normal child to be able to write his or her name, identify written letters, know right from left, and ride a bicycle without training wheels?
A) 4 years
B) 5 years
C) 6 years
D) 7 years
E) 8 years

18. Which of the following scenarios is suggestive of an underlying condition that may be interfering with development?
A) A 15-month-old who primarily reaches for things with his left hand
B) A 4-month-old who rolls over both ways
C) A 5-year-old who skips with alternating feet
D) A 24-month-old who scribbles with his right hand only
E) A 12-month-old who walks well independently

19. The average weight of a full-term newborn born in the United States is closest to:
A) 2,150 g
B) 2,800 g
C) 3,000 g
D) 3,500 g
E) 4,000 g

20. Which of the following patients does not merit particular concern regarding growth?
A) A 14-month-old girl who weighs triple her birthweight
B) A 5-year-old girl whose height is double her birth length
C) A 6-month-old girl with a head circumference measurement that is consistently tracking the third percentile line
D) An infant whose head circumference went from 36 cm at birth to 42 cm at age 12 months
E) A breast-fed infant who loses 12% of her birth weight in the first 72 hours of life

21. A father brings his 18-month-old son to your office because he is concerned that the child "cannot do things that other children can do." In screening the child, you note that he can walk up stairs, although he needs to hold his father's hand to do so. He can build a
three-block tower. He can point to his eyes, nose, and mouth when asked to do so by his father. His father reports that his son likes to watch and play around other children but does not play with them. The child uses “mama” and “dada” appropriately and has three other words. You decide to refer the child for developmental testing. Given the information above, you expect his results to be most consistent with which of the following?
A) Global developmental delay
B) Isolated developmental delay
C) Atypical delay
D) Mental retardation
E) No delay

22. A full-term newborn has a weight of 3,400 g, a length of 19.5 cm, and a head circumference of 30 cm. Which of the following statements regarding the child’s apparent microcephaly is TRUE?
A) The infant cannot have secondary microcephaly because he was born with a small head.
B) The infant has microcephaly because he is small for gestational age.
C) Cranial ultrasonography is the initial study of choice for determining the cause of this child’s microcephaly.
D) The cause of the child’s microcephaly is likely to have occurred only shortly before birth.
E) This infant has isolated microcephaly.

23. A 2-month-old infant who comes to your office for a health maintenance visit has a head circumference at the 98th percentile for age. He is at the 75th percentile for weight and height. At birth, his head circumference was slightly above the 95th percentile. His father and mother have large heads. The child has achieved appropriate developmental milestones for his age, and his physical examination is normal. When the parents ask you about his large head size, you tell them that:
A) the child needs a cranial ultrasound to rule out hydrocephalus
B) the child is likely to have subtle cerebral anomalies
C) the child is at risk for learning disabilities later in life
D) the child most likely has familial macrocephaly and needs no further workup
E) the child is at risk for craniosynostosis

24. Which of the following statements regarding the BMI value is FALSE?
A) BMI is not a reliable measurement of abnormal growth in children younger than 2 years of age.
B) BMI is calculated by dividing the patient’s weight in kilograms by the patient’s height in meters squared.
C) Stature is preferred to supine length for calculation of the BMI.
D) Gender does not affect the normal range for BMI.
E) A patient whose BMI falls at the 90th percentile is at risk for being overweight.

25. Secondary microcephaly may result from all of the following EXCEPT:
A) Down syndrome
B) Teratogen exposure
C) Congenital infection
D) Hypoxic encephalopathy
E) Meningitis

26. Isolated hearing impairment can affect early development by:
A) interfering with testing for delay in motor skills
B) interfering with social development
C) interfering with adaptive development
D) interfering with the ability to use consonants clearly
E) All of the above

27. Which of the following patients should receive further evaluation to rule out an abnormality that may be affecting his or her development?
A) A 2-month-old boy with a head lag
B) A 1-month-old boy who generally keeps his hands fisted
C) A 1-month-old boy who rolls back to front
D) A 15-month-old boy who uses jargon
E) A 3-year-old boy who cannot copy a triangle

28. Which of the following is not considered an example of atypical development?
A) Echolalia
B) Perseveration
C) Loss of skills previously achieved
D) Skipping skills
E) All are examples of atypical development.