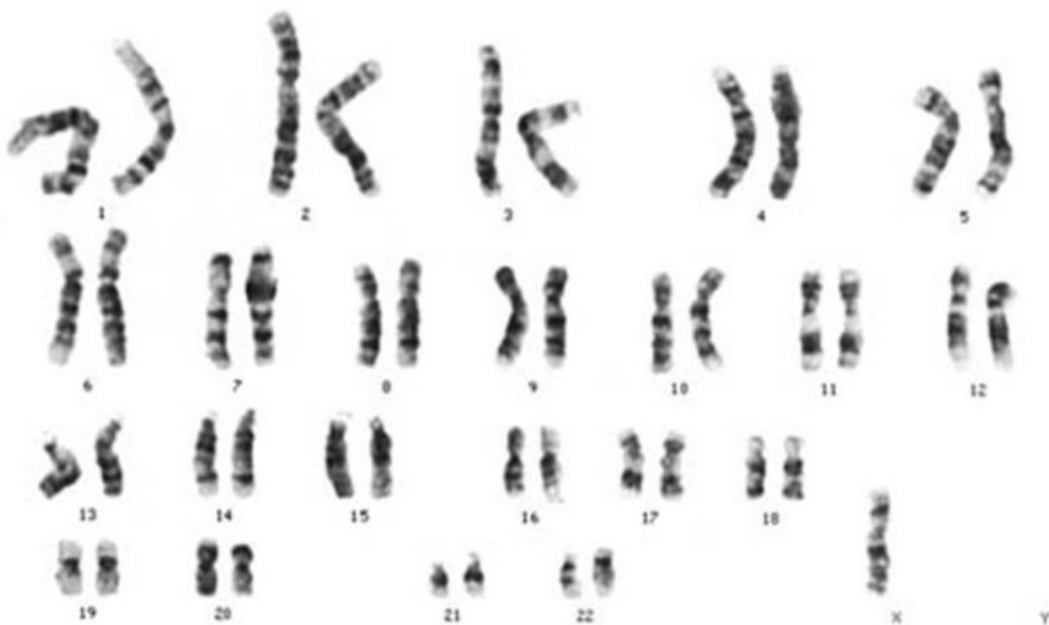


Tracking Growth, Understanding Short Stature and Growth Delay in Children

[See online here](#)

While short stature only affects 2.5% of the population, it is a common reason for referral to a pediatric endocrinologist. Short stature is defined as a child being in the 3% for growth on a growth chart with normal growth velocity. Bone age is often used to assess children with short stature. Growth hormone injections are an expensive therapy that can mildly increase a child's adult height.



Introduction

Even though only **2.5%** of the population fit the diagnostic criteria for short stature, it is one of the most common reasons for referral to a **pediatric endocrinologist**. Parents and children alike are worried about the **social implications** of reduced adult height. Sports activities, stress level, and partner choices are all affected by height.

Boys are more likely than girls to be referred to the endocrinologist for short stature; however, just because a child is considered “short” does not mean that he/she is outside of average, but how does a pediatrician determine the average to which the child is compared?

Growth Charts

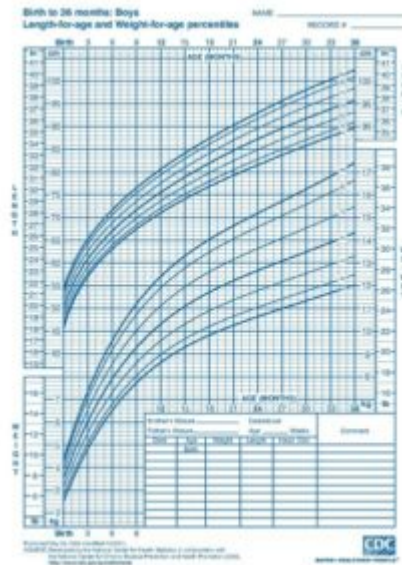


Image: "CDC growth chart for boys from birth to 36 months." by CDC via Wikimedia Commons.
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Types of growth charts

Growth charts are the **standard way** to measure growth. While older growth charts were controversial, the cornucopia of replacements has firmly established the growth chart as an integral tool in the pediatrician's toolbox. Each pediatric visit should include **weight, height, and head circumference measurements** that are tracked on a standardized growth chart.

Growth charts are accumulated data from thousands of healthy children. These charts are **separated** by gender, ethnicity, and feeding type (breastfed versus formula-fed). Certain countries have formed their own charts. Separate charts have even been constructed for children with certain conditions (small for gestational age, Turner syndrome, [Down syndrome](#), etc.).

There are two kinds of charts: **standard** and **reference**. Standard charts refer to the ideal growth for that child's demographic, in the absence of **over-nutrition, malnutrition**, and other stressors.

Reference charts are **population-based charts**. For example, an American reference chart would have higher values for weight and BMI than less-developed countries. Picking the correct growth chart for your patient is important in order to assess how the child compares to his or her peers.

Following weight is critical, and can give you clues about disordered eating, from obesity to eating disorders and for several medical diseases as well.

Growth velocity (growth rate)

These growth charts not only show how the child's height, weight, and head circumference compares to their peers, but **serial measurements** show the child's

growth velocity. Normal velocity by percentage is showed on the chart by the **S-shaped curves**.

When a child crosses those percentage lines, this indicates a **change in velocity**. Normal variations in change in growth velocity are catch-up growth, catch-down growth, and constitutional delay of growth and [puberty](#).

Catch-up growth refers to a smaller infant who “catches up” to his or her peers in height and weight. Similarly, **catch-down growth** is when a larger infant’s growth slows to match his or her peers. A child with a **constitutional delay of growth and puberty** would display slower growth throughout childhood. This child would start puberty later and then reach a normal adult height.

Checking for constitutional growth delay

The human hand develops with puberty, not with age. If a hand X-ray is normal for a younger child, they may just have delayed puberty.

Other labs you might get:

- CBC: Check for anemia, evidence for chronic illness
- ESR: IBD, other chronic illness
- Thyroid studies: TSH, if high then free T₄
- Chem 7: Renal diseases
- TTG/IgA: Celiac disease
- IGF1 and IGFBP3: Growth hormone deficiency

Definition of Short Stature

With an understanding of growth chart percentiles and growth velocity, the definition of short stature is simple: **two standard deviations below average**, which is the 3rd percentile on a growth chart, with normal growth velocity.

Growth Hormone

Even though **growth hormone deficiency** is rare, this hormone is often used therapeutically for short stature.

If the eventual total height is likely to be under 5 feet and the child is growth hormone-deficient, consider growth hormone replacement.

- Standard of care in diseases like Turner’s
- Daily shots
- Extremely expensive
- Controversial “!”
- Very little benefit if not growth hormone deficiency

Function and deficiency of growth hormone

The easiest way to remember the functions of the growth hormone (GH) is to remember the **symptoms of GH deficiency**. GH is important in childhood growth. An infant with GH deficiency will be born a normal size, but then be very short in childhood.

In fact, the only symptoms of GH deficiency that would be evident at birth would be **hypoglycemia**, as GH raises blood sugar levels by interfering with insulin, and **micropenis**.

Since GH increases protein production and use of fat stores, a child with GH deficiency will become **overweight** if not treated. Moreover, GH promotes the **growth of bone and cartilage**. Children with a GH deficiency have **immature bones**. This bone growth delay leads to a **small maxilla** and **prominent forehead**. Clinically, the look of a GH-deficient patient – short, overweight, small jaw, prominent forehead – is described as having a “**cherub appearance**”.

Growth hormone function	Symptom of growth hormone deficiency
Raises blood sugar levels Interferes with insulin	Hypoglycemia
Bone and cartilage maturation	Immature bone and cartilage Short stature Small jaw Prominent forehead
Fat utilization and protein production	Increased subcutaneous fat
Increases IGF-1	Low IGF-1 (used for diagnosis)

Regulation of growth hormone

GH is secreted by the **anterior pituitary gland** in response to the secretion of the **growth hormone-releasing hormone (GHR)**. The secretion of GH is also stimulated by **ghrelin** and enhanced by **adrenergic stimulation, hypoglycemia, starvation, exercise, early stages of sleep,** and **stress**.

Thyroid hormone is also required for the secretion of GH, so children with **hypothyroidism** also have short stature. GH secretion is inhibited by **somatostatin** and **somatotropin-releasing inhibiting factor** and decreased by **hyperglycemia** and **beta-adrenergic stimulation**.

IGF-1

GH peaks in the middle of the night, which makes it difficult to measure. GH stimulates the production of IGF-1, which is used to measure GH levels. IGF-1 is associated with postnatal growth and is altered by several disease states, including **malnutrition, chronic renal and liver disease, hypothyroidism,** and **obesity**.

Etiologies of Short Stature

In the Utah Growth Study, it was found that, out of 555 children with short stature, only 5% had a true endocrine disorder; therefore, it is important to be familiar with the vast number of etiologies of short stature. The most common cause for short stature is **variants of normal growth patterns**, such as constitutional delay or genetic (short parents).

Normal variants

- Constitutional delay of growth and **puberty**
- Genetic (familial short stature)

GH deficiency

- Genetic (e.g. isolated GH deficiency)
- Hypothalamic or pituitary issues (e.g. pituitary agenesis, trauma)
- [Neoplasm](#) (e.g. Langerhans cell histiocytosis, pituitary or hypothalamic tumors)
- Acquired (e.g. [CNS infection](#), [head trauma](#), [CVA](#), [hydrocephalus](#), [autoimmune diseases](#), amphetamine treatment for hyperactivity)

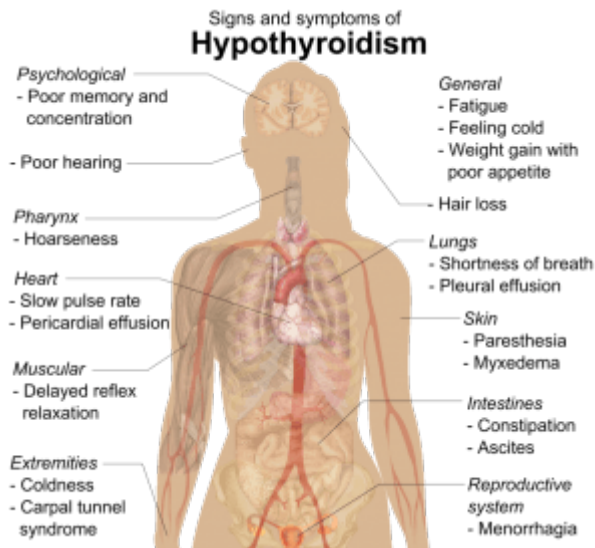


Image: "Symptoms and signs of hypothyroidism." by Mikael Häggström. License: [CC0 1.0](#)

Other endocrine causes

- Glucocorticoid excess
- Poorly controlled [diabetes mellitus](#)
- Untreated [diabetes insipidus](#)
- [Hypothyroidism](#)
- Prolactinoma
- Congenital adrenal hyperplasia
- Laron dwarfism
- Pygmies



Image: "Osteogenesis Imperfecta Type V in an adult. This is an edited version of the source image made for use in the "Anatomist" iOS and Android app and shared here under the terms of the source image's Share Alike Creative Commons license." by ShakataGaNai – <https://commons.wikimedia.org/wiki/File:XrayOITy peV-Audult.jpg>. License: [CC BY-SA 4.0](https://creativecommons.org/licenses/by-sa/4.0/)

Syndromes of short stature

- Turner syndrome
- Noonan syndrome
- [Trisomy 21](#)
- Trisomy 18
- Bardet-Biedl syndrome
- [Prader-Willi syndrome](#)
- Pseudohypoparathyroidism
- Osteogenesis imperfecta
- Osteochondrodysplasias
- Lysosomal storage disease
- Mucopolysaccharidoses
- Fetal alcohol syndrome

Chronic diseases

Health Problems with Cystic Fibrosis

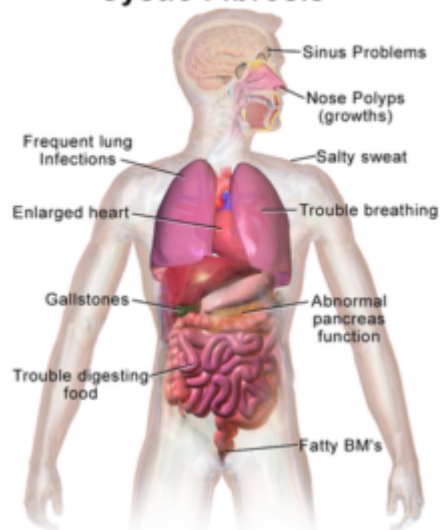


Image: "Health problems with cystic fibrosis" by Blausen.com staff. "Blausen gallery 2014". Wikiversity Journal of Medicine. DOI:10.15347/wjm/2014.010. License: [CC BY 3.0](https://creativecommons.org/licenses/by/3.0/)

- [Left-to-right shunt](#)
- Heart failure
- [Cystic fibrosis](#)
- [Asthma](#)
- Celiac
- Disorders of swallowing
- [IBD](#)
- Hepatic disorders
- [Sickle cell anemia](#)
- [Thalassemia](#)
- Renal tubular acidosis
- Chronic uremia
- Connective tissue diseases
- Juvenile idiopathic arthritis
- Chronic infections
- [AIDS](#)
- Hereditary fructose intolerance
- Poor nutrition
- Iron deficiency
- Zinc deficiency
- [Anorexia](#)
- [Cerebral palsy](#)
- Psychosocial dwarfism

Approach to Short Stature

History taking for short stature

Maternal history and **perinatal history** should be taken at length to determine if any infections or toxic exposures occurred. Questions about **prenatal genetic testing** and

genetic conditions in the family should also be asked.

Next, examine the child's **growth pattern before 3 years old**, as there could be signs of catch-up or catch-down growth. After three years old, children normally do not cross percentile lines. If a **chronic disease** is suspected, this could give the physician a clue as to when the disease may have begun.

As **nutrition** is the most common cause for short stature worldwide, history should be taken on the child's nutritional status and living situation. The patient should report all the food they have eaten in the past 24 hours. This will give the clinician a sample of the child's eating habits.

A detailed review of systems should be taken to search for any chronic diseases. Take a family history about growth. (e.g. "Was the child's father shorter than his peers in childhood but reached a normal adult height?").

Finally, **social history** is important to evaluate the **child's stress level**. Severe stress may cause psychosocial dwarfism. A thorough review of systems should be taken to rule out chronic disease.

- Identify any evidence of **growth hormone deficiency** or **hypopituitarism**
- Ask about **abnormal development**
- Ask about **diet**

Height and weight measurements

The height and weight should be assessed to determine if they are in the same percentile; changes in height velocity should also be noted. If the **height is greater than weight**, then the child has a **failure to thrive**, and the child should have a **thorough physical exam** with a focus on finding a chronic disease and undergo a **full laboratory workup for thyroid, kidney and bowel function** before doing a **hand X-ray**.

If **weight is greater than height**, then the child has a **failure to grow**, and the child needs a **hand X-ray** along with the basic labs. The mid-parental height is an important tool to predict the child's projected adult height. Calculate the mid-parental height using the following equations:

Mid-parental height (female) = ((father's height + mother's height)/2) - 2.5 in (6.5 cm)

Mid-parental height (male) = ((father's height + mother's height)/2) + 2.5 in (6.5 cm)

Once the mid-parental height has been calculated, track the child's percentile on the growth chart and see if their adult percentile height projection matches the calculated mid-parental height. Disparity between those two heights raises suspicion for **non-familial causes** of short stature.

Physical examination for short stature

After completing the history, a thorough physical exam should include the following:

- Current height and weight.
- Ratio of upper to lower body, which may help diagnose **bone dysplasia** or

Turner syndrome.

- Characteristics of genetic conditions (e.g. **single palmar crease** for Down syndrome).
- **Thyroid size** and signs of **hypothyroidism**.
- Signs of chronic disease in each system (e.g. clubbing for **cystic fibrosis**).

Symptoms of Turner syndrome:

- Webbed neck
- High arched palate
- Short 4th metacarpal
- Shield chest/wide-spaced nipples

Initial workup of short stature:

- **Complete blood count** with differential to rule out hematologic disorders and infection.
- **Basic metabolic panel** to rule out renal pathologies, metabolic disorders and diabetes insipidus.
- **Liver function test** to rule out liver disease.
- **Celiac panel** (if suspected).
- **Folate and carotene levels** to assess nutritional status.
- **Urinalysis** and **urine pH** to rule out renal infections and renal tubular acidosis.
- **ESR** to check for a chronic inflammatory state.
- **TSH** (if hypothyroidism is suspected).

Bone age as a diagnostic tool

Bones grow under the influence of a variety of factors, such as growth hormone. Similarly to growth charts, bone growth has been tracked and recorded in many children in order to be able to assign specific radiographic findings to a child's age. In other words, the bone age tells the physician how far along the child is in his growth.

The radiologist specifically examines the **epiphyseal growth centers** to determine the age. All children with a failure to grow should have a **hand X-ray**. If the child presents with **failure to thrive**, and had normal or non-specific values, the child should also receive a hand X-ray.

Interpreting bone age results

If the child has normal or near-normal growth velocity and a bone age that matches the child's chronological age, suspect **genetic causes** (e.g. familial short stature or [Down's syndrome](#)) or **congenital disorders**.

If the child has normal growth velocity, but a delayed bone age, suspect **constitutional delay of growth and puberty, mild chronic disease, or resolved chronic disease**.

If the child has reduced growth velocity and delayed bone age, suspect **endocrine disorders, severe chronic diseases, medications, or pathologic delay of puberty**. If, after a thorough workup, no specific pathology is found, the child should be diagnosed with **idiopathic short stature**.

Therapy of Short Stature

Observation and reassurance

Children with familial short stature or constitutional delay of growth and puberty may be treated with observation and reassurance, since **growth hormone** is expensive and only provides minor gains. Children with this condition usually reach to the lower end of the normal height range.

Counseling is recommended for these children. Some studies show that adults with below-average height experience **greater psychological stress**, and children may already have psychosocial stressors as a result of their height deficiency.

Growth hormone therapy

Recombinant human growth hormone (r-hGH) is only FDA approved for children below the 1st percentile of height and diagnosed with idiopathic short stature; however, many families who are wealthy request this treatment, and, subsequently, their children are treated.

Children who use r-hGH only have **modest gains** (1.2 to 2.8 inches above predicted height). Moreover, when compared to the untreated group, children with GH treatment do not have superior psychological health.

The **adverse effects** of growth hormone include **intracranial hypertension, glucose intolerance**, and **slipped capital femoral epiphysis**. While one study found that growth hormone use is associated with **bone cancer**, this is very controversial. Other studies suggest that this treatment increases the child's risk of **obesity** and **diabetes mellitus**. Growth hormone replacement is quite expensive. Depending on the protocol, the total regiment cost could range from \$76,000 to over \$250,000.

References

Allen D and Cuttler L. **Short Stature in Childhood—Challenges and Choices**. N Engl J Med 2013; 368:1220-1228.

Marcdante K and Kliegman R. **Short Stature**. Nelson Essentials of Pediatrics. 7th Edition. Philadelphia: 2015.

Nwosu B and Lee M. **Evaluation of Short and Tall Stature in Children**. Am Fam Physician 2008 Sep 1;78(5):597-604.

Short Stature via medscape.com

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