Abnormal growth pattern

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Outline

- Definition of short stature
- Important Terminologies
- Short stature approach
- Normal variant of short stature
- Suggested evaluations
- Definition of tall stature
- Tall stature approach

Definition :short statue

Short stature is defined as height that is 2 standard deviations (SD) or more below the mean height for children of that sex and chronologic age in a given population

Use height-for-age growth curves or Z score calculator or Z score curves

A child is considered short if:

The height is less than 3rd percentile or 2 standard deviations below the mean height for that age.

The height is within normal percentiles but growth velocity is consistently below 25th percentile over 6-12 months of observation.

The patient is excessively short for the mid-parental height, though his absolute height may be within the normal percentiles.

Terminologies

- **Height Age**: The age at which the patient's height is at the 50th percentile.
- **Bone age**: Refers to the age at which the skeletal maturation shown in patient's radiographs is normally attained. Greulich Pyle charts are the most commonly used method, which examines the epiphyseal maturation of the hand & wrist.
- **Mid-parental height (MPH):** The child's probable inherited growth potential can be estimated by mid-parental height percentile.

  For males: [(mother's height + 13 cm[a]) + father's height] divided by 2
  For females: [(father's height - 13 cm[a]) + mother's height] divided by 2

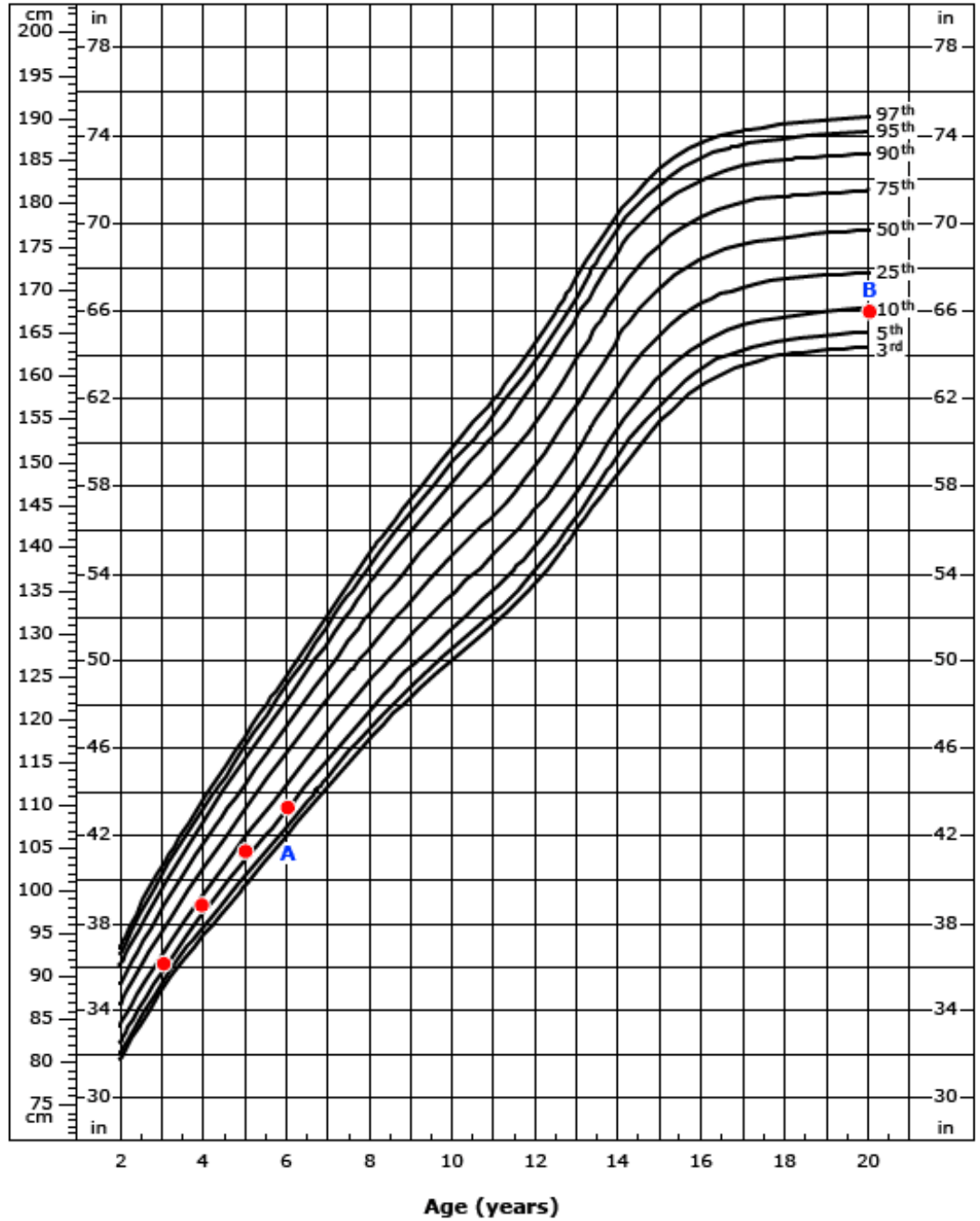
- **Mid-parental (target) height**. For both girls and boys, 8.5 cm on either side of this calculated value (target height) represents the 3rd to 97th percentiles for anticipated adult height

- **Growth velocity/Height velocity**: Observation of a child's height over a period of time .Therefore, the determination of height velocity requires at least 6 months of observation.

- **Project height** Projected height can be estimated by projecting the current growth curve to adulthood in children with normal bone age, or by using a bone age atlas in those with delayed bone age**:**If the child's bone age is delayed or advanced, then the projected height should be plotted based on the bone age rather than the chronologic age

- **Predict height**:The bone age can be used to predict the child's adult height. The technique developed by Bayley-Pinneau (BP) is most commonly used for children approximately six years and older

Stature-for-age percentiles, males, 2 to 20 years, CDC growth charts: United States



Age	*Growth velocity per year*
Birth to 12 months	23 to 27 cm (9.06 to 10.63 in)
12 months to 1 year	10 to 14 cm (3.94 to 5.51 in)
2 to 3 years	8 cm (3.15 in)
3 to 5 years	7 cm (2.76 in)
5 years to puberty	5 to 6 cm (1.97 to 2.36 in)
Puberty	Girls: 8 to 12 cm (3.15 to 4.72 in)
	Boys: 10 to 14 cm (3.94 to 5.51 in)

Differential diagnosis of short stature

Secondary (systemic) causes

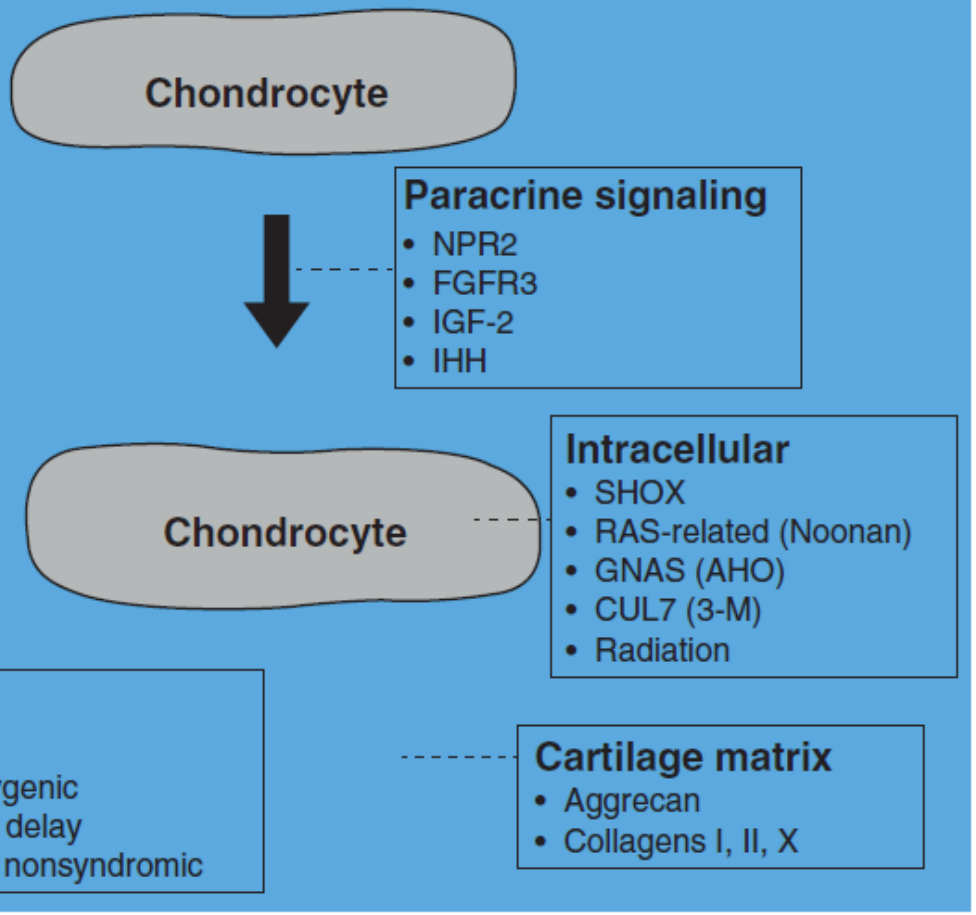
Endocrine
- GH deficiency, resistance
- IGF-1 deficiency, resistance
- Thyroid hormone deficiency, resistance
- Glucocorticoid excess
- Androgen/estrogen deficiency

Nutrition
- Inadequate intake (calories, protein, micronutrients)
- Malabsorption (e.g., celiac disease)

Cytokines
- Crohn disease
- Juvenile idiopathic arthritis
- Cystic fibrosis

Extracellular fluid
- Chronic kidney disease
- Renal tubular acidosis

Primary (growth plate) causes



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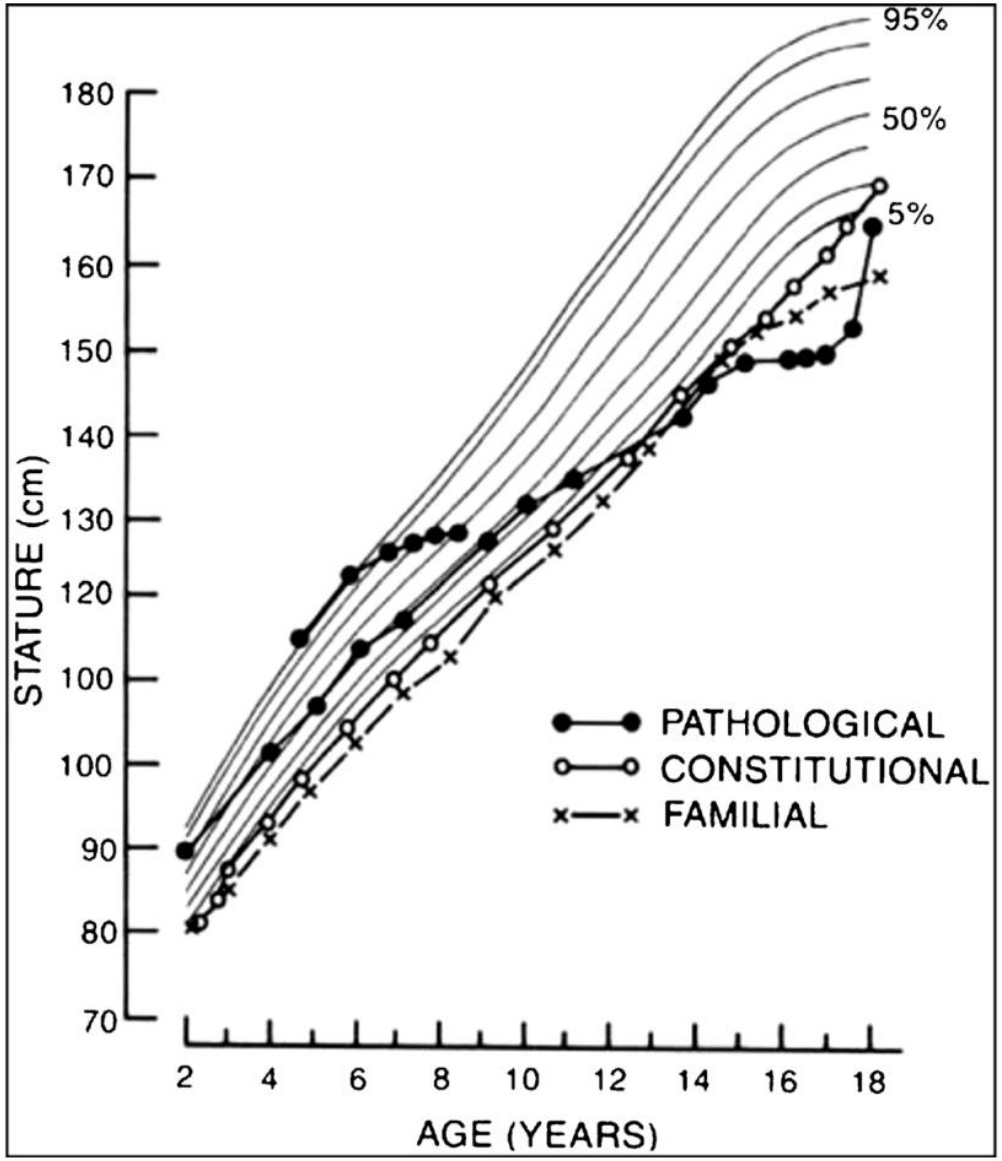

95%
50%
5%
180
170
160
150
140
130
120
100
100
90
80
70
STATURE (cm)
PATHOLOGICAL
CONSTITUTIONAL
FAMILIAL
2
4
6
8
10
12
14
16
18
AGE (YEARS)

Short Stature

Normal Variants
- Familial Short Stature
- Constitutional Growth Delay

Pathologic

Proportionate

1. **Systemic diseases**
   - Chronic Anemia
   - Chronic renal failure
   - Renal tubular acidosis
   - Chronic Asthma
   - Congenital heart disease
   - Chronic infections
   - Malabsorption
   - Chronic liver disease.
2. **Malnutrition**
3. **Endocrine disorders**
   - Growth hormone deficiency
   - Hypothyroidism
   - Cushing syndrome
   - Diabetes mellitus
   - Diabetes insipidus (due to tumors, neonatal insult)
   - Hypopitutarism
   - Hypogonadism.
4. **Intrauterine growth retardation (IUGR)**
5. **Genetic syndromes – common examples:**
   - Turner's syndrome
   - Noonan's syndrome
   - Russel Silver syndrome
   - Seckel's syndrome
   - Down's syndrome
6. **Inborn error of metabolism**
7. **Psychosocial dwarfism**
8. **Idiopathic Short Stature**

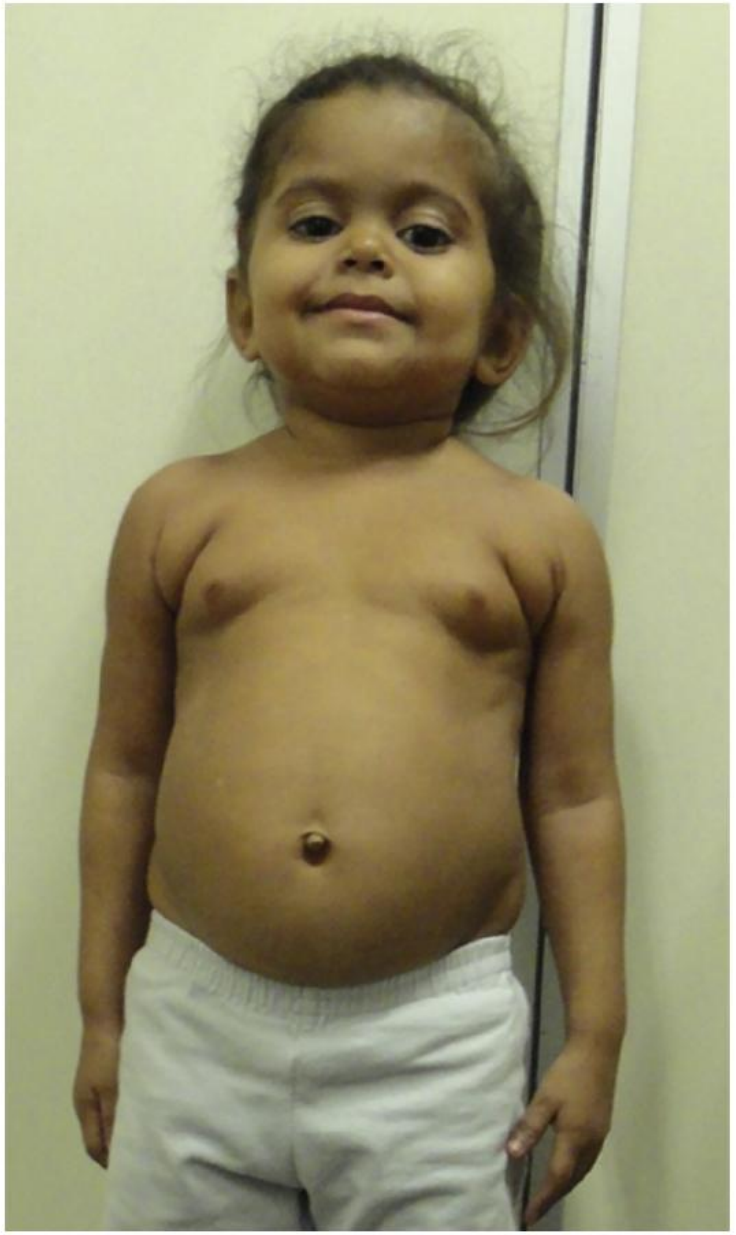
Disproportionate
- Skeletal dysplasias
- Rickets

Sign/symptom	Differential diagnosis
Normal GV with short stature (normal variants)	Familial short stature (FSS) Constitutional delay of growth and puberty (CDGP)
Decreased GV with normal or increased weight for height	Endocrine disorders Hypothyroidism (primary or central) Growth hormone-IGF-1 axis abnormalities Growth hormone deficiency Growth hormone insensitivity IGF-1 deficiency/decreased bioavailability IGF-1 insensitivity Hypercortisolism Endogenous (Cushing syndrome or disease) Exogenous (iatrogenic)
Decreased GV with low weight for height or poor weight gain	Nutritional Calorie-protein malnutrition Malabsorption Stimulant medications for ADD and ADHD Eating disorders Acquired rickets (Vitamin D deficiency, calcium deficiency) Chronic illnesses [5] Gastrointestinal (e.g., Celiac disease, Crohn's disease, cystic fibrosis, short gut syndrome) Hepatic (e.g., biliary atresia, liver transplant) Cardiac (e.g., cyanotic congenital heart disease) Pulmonary (e.g., cystic fibrosis, asthma, bronchopulmonary dysplasia) Metabolic (e.g., uncontrolled diabetes mellitus, untreated central diabetes insipidus) Hematologic (e.g., chronic severe anemia) Oncologic (e.g., leukemias, bone marrow transplant) Renal (e.g., renal tubular acidosis, chronic kidney disease, nephrogenic diabetes insipidus, hypophosphatemic rickets like X-linked hypophosphatemia [XLH]) Neurologic (e.g., cerebral palsy) Rheumatologic (e.g., juvenile arthritis) Psychosocial short stature Child neglect, child abuse, poverty, domestic violence, orphanages, etc.

Disproportionate short stature	Congenital: Skeletal dysplasias Increased upper-to-lower segment ratio for age (short extremities, epiphyseal/ metaphyseal dysplasias) Decreased upper-to-lower segment ratio for age (short trunk, spondylo-dysplasias) Acquired Spinal radiation Skeletal neoplasia
Short stature with dysmorphic features	Genetic syndromes/chromosomal abnormalities Turner syndrome Down syndrome Prader-Willi syndrome Russel-Silver syndrome Noonan syndrome Williams-Beuren syndrome Others

Endocrine Conditions in Pediatrics A Practical Guide (Takara Stanley, Madhusmita Misra)

Phenotype of a patient with severe growth hormone ,deficiency or insensitivity: frontal bossing, depressed nasal bridge , midfacial hypoplasia, and truncal obesity.



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Normal variant of growth

	Distinguishing features	Typical evaluation	Treatment	Bone age	Height velocity
Normal variants of growth					
Familial short stature*	Short parent(s), often below the 10th percentile. Adult height short for population but within the range predicted by parents' height.	Hx, PE, bone age.	None needed. Reassurance; monitor growth.	Normal	Low-normal Eg, from age 6 until puberty: Girls approximately 4 to 5 cm/year Boys approximately 3.5 to 4.5 cm/year
Constitutional delay of growth and puberty*	Normal height for bone age but not for chronologic age. Often, family history of delayed growth and/or puberty. Adult height usually normal.	Hx, PE, bone age. Be alert for the possibility of underlying systemic disease Laboratory screening if height velocity is slow	None needed. Reassurance; monitor growth; +/− treatment with sex steroids during puberty.	Delayed	Slow during first 3 to 5 years of life; normal during childhood; pubertal growth spurt is delayed but prolonged, often resulting in normal adult height

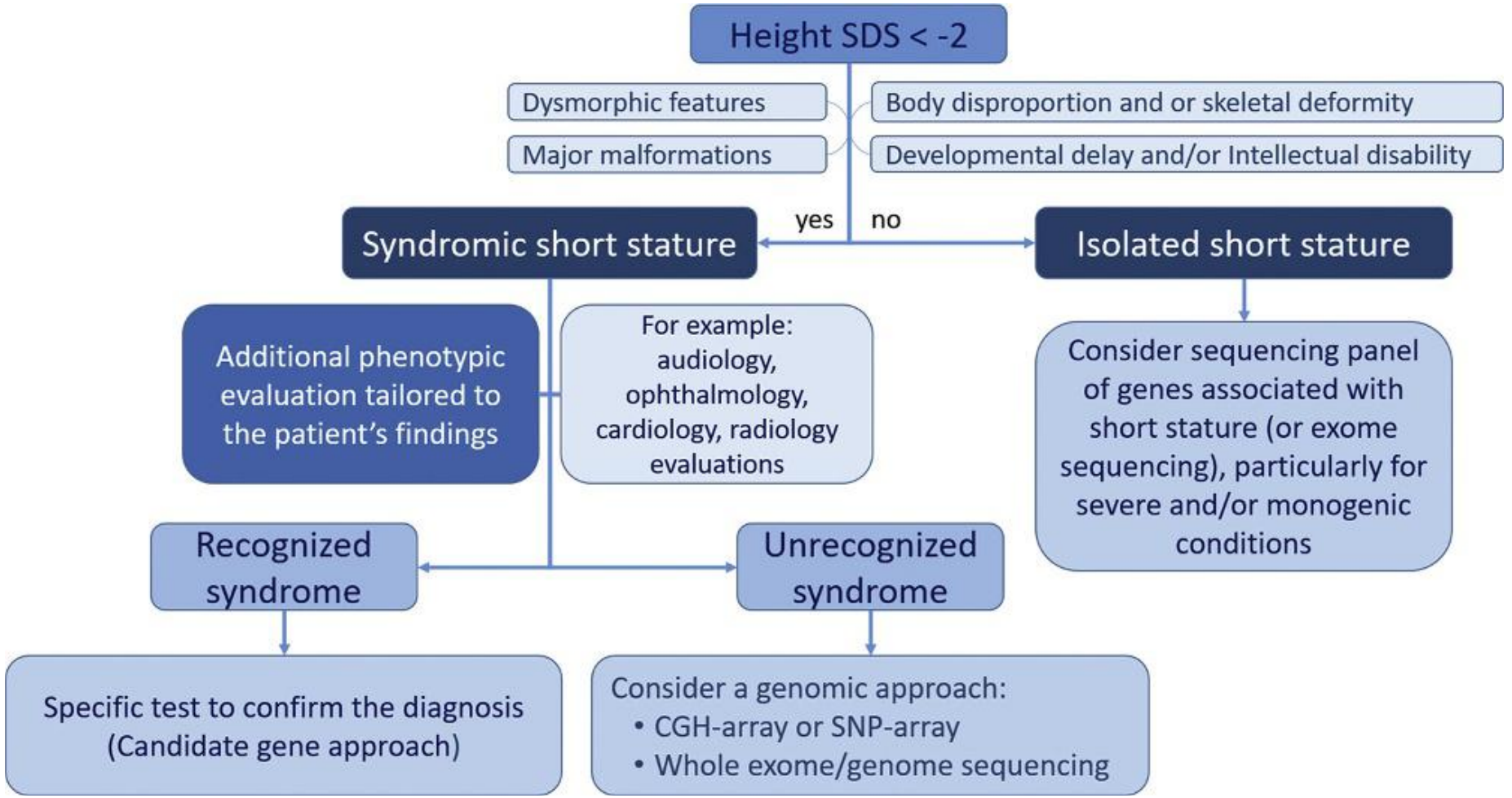
Up to date 2025

Suggested Evaluations

- CBC diff ,ESR, FBS,BUN, creatinine, Ca, Phosphorus, Alk Phos,VIT D, VBG, electrolyte, TFTs ,LFT, TTG IgA,U/A&U/C,S/E
- IGF1,IGFBP3& other lab tests as per clinical findings
- Karyotype R/0 Turner
- X-rays for bone age

SUGGESTED LAB TEST

Test	*Indication*
Short stature	
Complete blood count	Anemia
Comprehensive metabolic panel	Hepatic and renal diseases
Erythrocyte sedimentation rate, C-reactive protein	Inflammatory bowel disease
Follicle-stimulating hormone, karyotyping	Turner syndrome
Insulinlike growth factor 1*	Growth hormone deficiency
Thyroid-stimulating hormone, free thyroxine (T4)	Hypothyroidism
Tissue transglutaminase and total immunoglobulin A	Celiac disease
Urinalysis	Renal disease



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Suggestion: referral to pediatric endocrinologist

Children with intrauterine growth retardation who do not catch up to the growth curve by 2 years of age

Height more than 3 standard deviations below the mean for age

Growth velocity < 5 cm (2 in) per year

No onset of puberty by 14 years of age for boys or 13 years of age for girls

Projected height more than 2 standard deviations (10 cm [4 in]) below the midparental height

Bone age more than 2 standard deviations below chronologic age

Diagnosis of conditions approved for recombinant growth hormone therapy*

**—Turner syndrome, chronic renal failure, Prader-Willi syndrome, small for gestational age, Noonan syndrome, short stature homeobox-containing gene deficiency, idiopathic short stature.*

Evaluation of Short and Tall Stature in Children, *Am Fam Physician*. 2015;92(1):43-50

Tall stature definition:

Tall stature as a height SDS over 2

in the absence of other symptoms and signs, the large majority of tall children and adolescents are healthy and have familial tall stature or constitutional advance in growth.

Key Findings	Disorders
Family history suggesting an autosomal recessive inheritance and/or presence of consanguinity	Homocystinuria, CATSHL syndrome
Family history suggesting an autosomal dominant inheritance of tall stature	Familial tall stature, Marfan syndrome, epiphyseal chondrodysplasia, Miura type (increase of signal by CNP/NPR-B)
Developmental delay, intellectual disability and behavior problems	Sotos, Weaver syndrome, homocystinuria, fragile X-chromosome, DNMT3A mutations, and others
Increased birth weight and length SDS for gestational age	Beckwith-Wiedemann, Sotos, Weaver syndromes, *IGF1R* duplications, and others
Head circumference SDS	Macrocephaly is observed in Sotos, Weaver, DNMT3A mutations, and fragile-X syndromes Microcephaly is observed in CATSHL syndrome

Key Findings	Disorders
Presence of precocious secondary sexual characteristics	Precocious sex steroids exposure (precocious puberty, virilizing disorders)
Signs of hypogonadism (small testes, amenorrhea, underdevelopment of breast and body hair)	Several different causes; in males, mainly Klinefelter syndrome
Marfanoid habitus (arm span that exceeds the height, arachnodactyly and hyperlaxity)	Marfan, Sotos, homocystinuria, epiphyseal chondrodysplasia, Miura type
Macrodactyly of the great toes	Epiphyseal chondrodysplasia, Miura type (increase of signal by CNP/NPR-B)
Body disproportion (arm span that exceeds the height and/or sitting height : total height SDS < -2)	Klinefelter syndrome
Dysmorphic facial features	Several syndromic forms of overgrowth conditions, each one with particular features
Severe kyphoscoliosis	CATSHL syndrome, epiphyseal chondrodysplasia, Miura type

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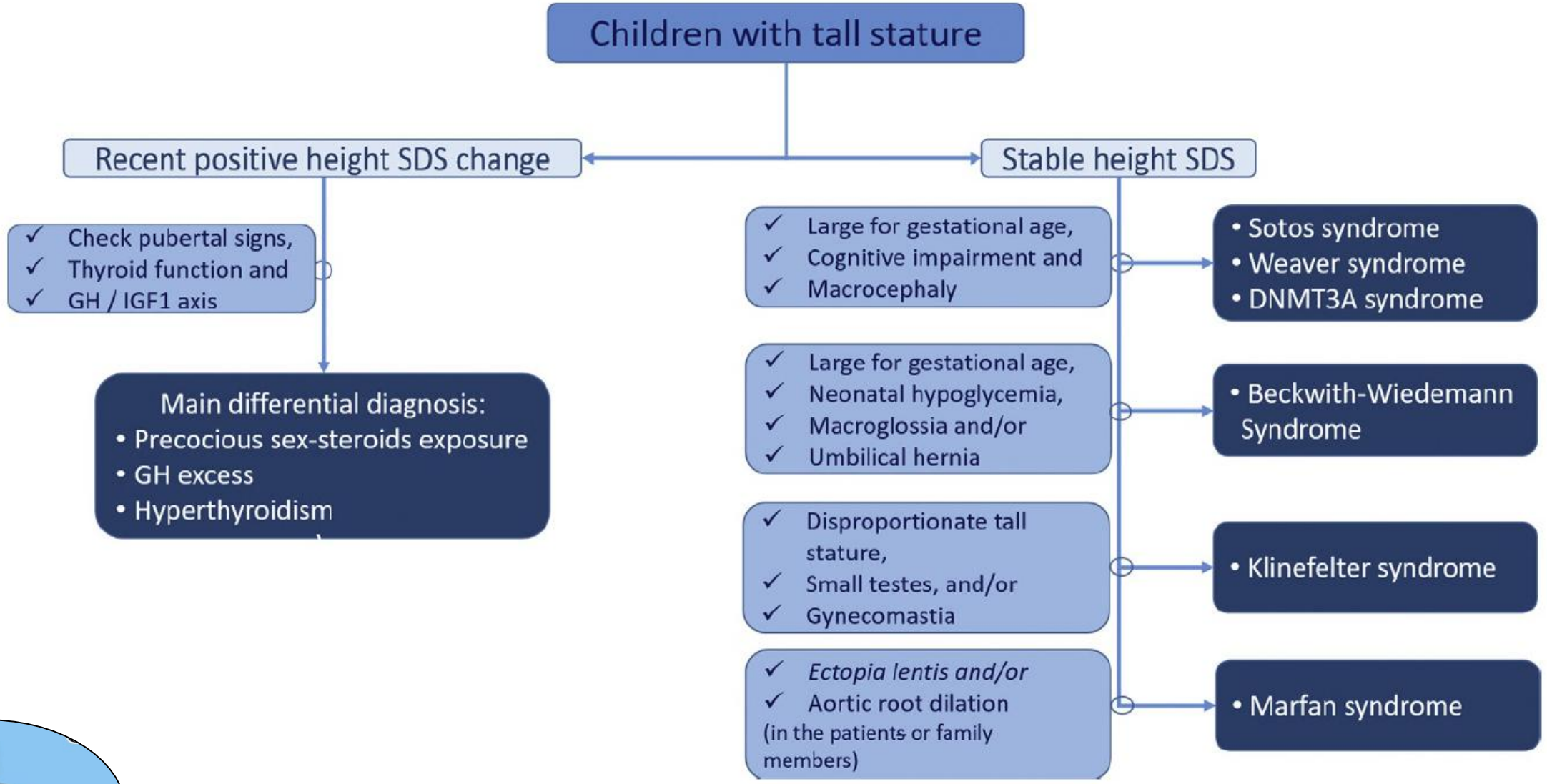

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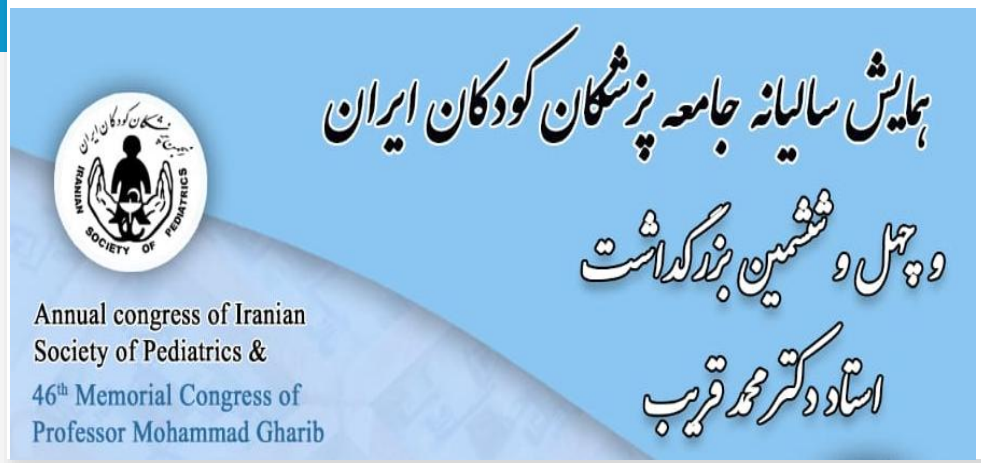

Thanks for your attention