# Short Stature

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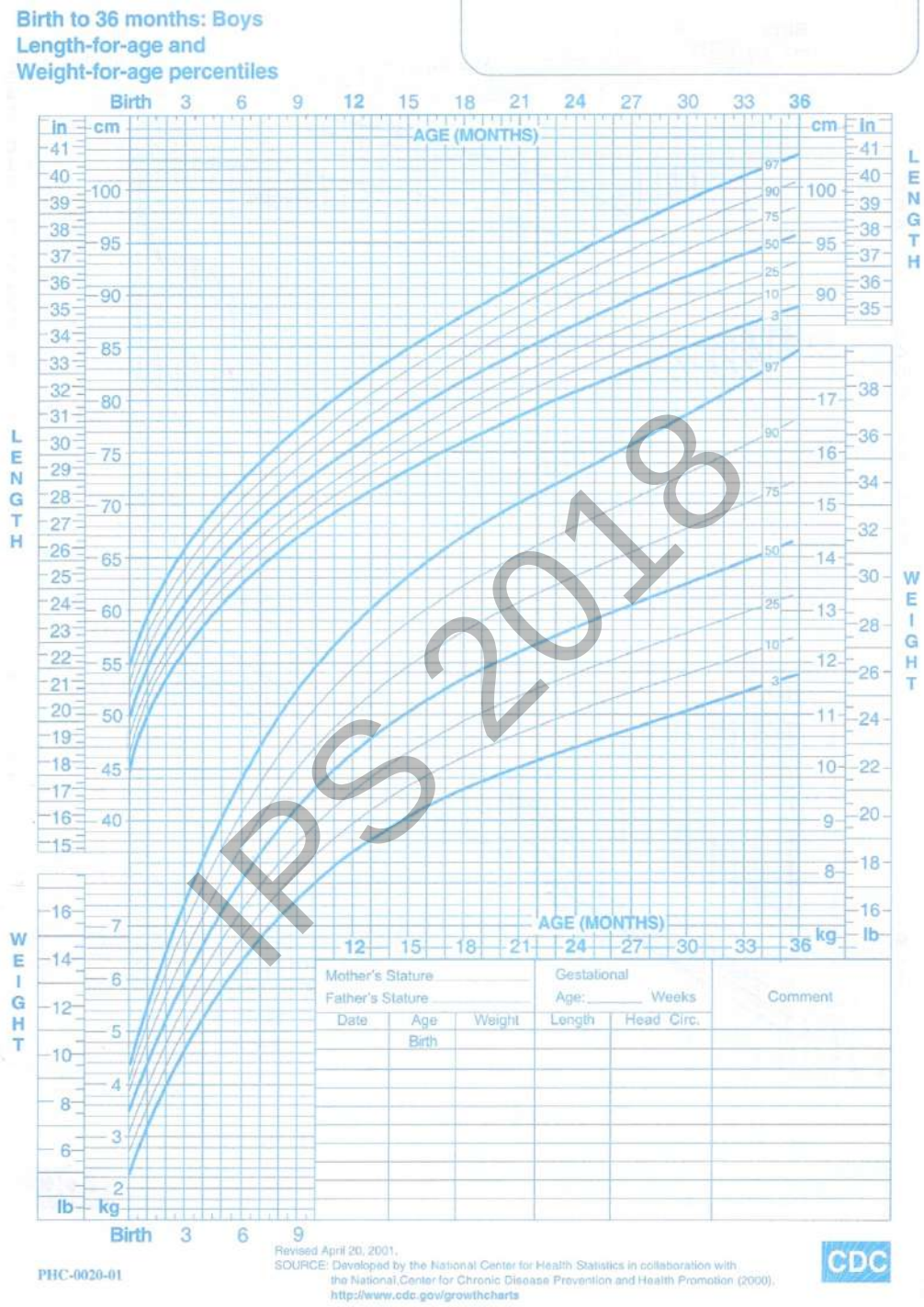
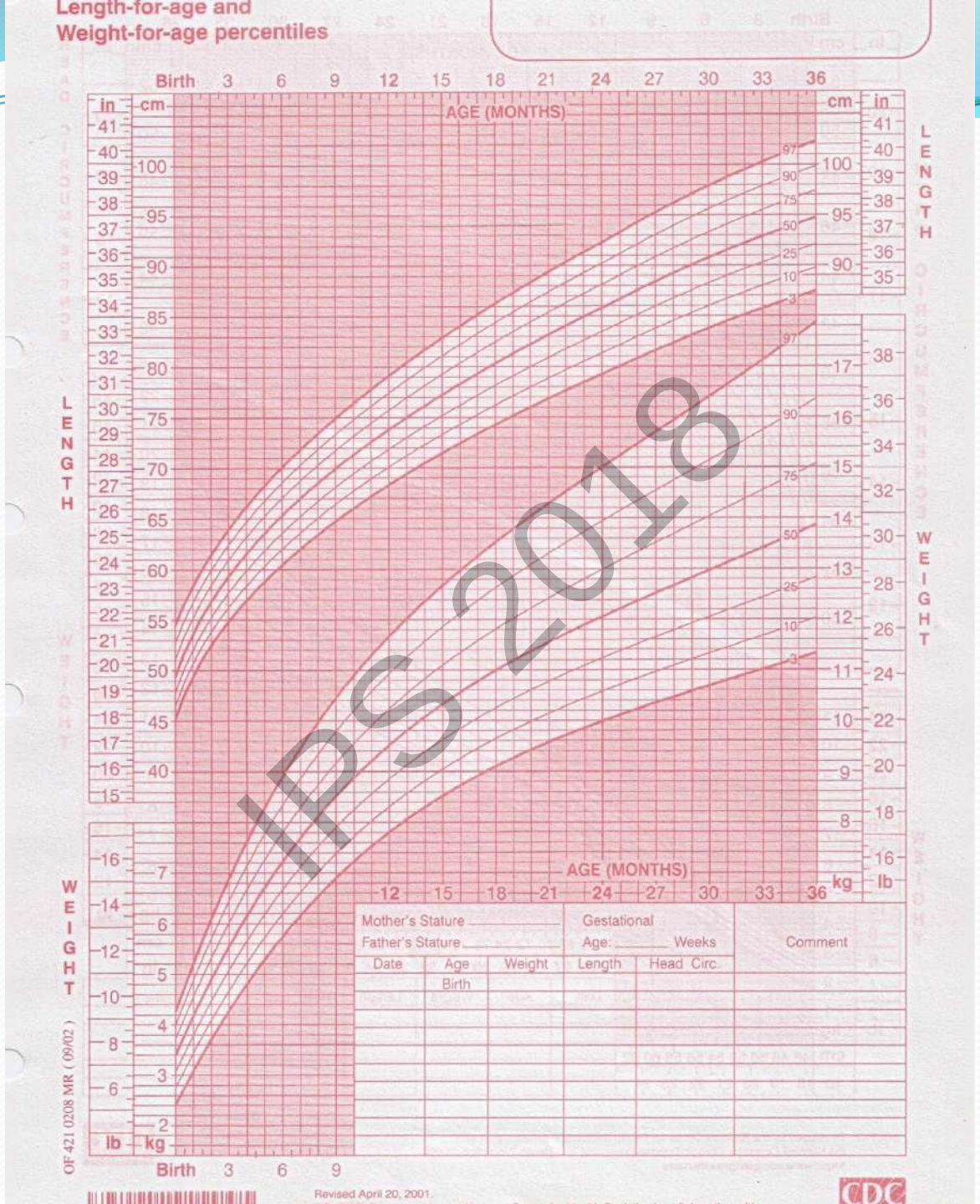
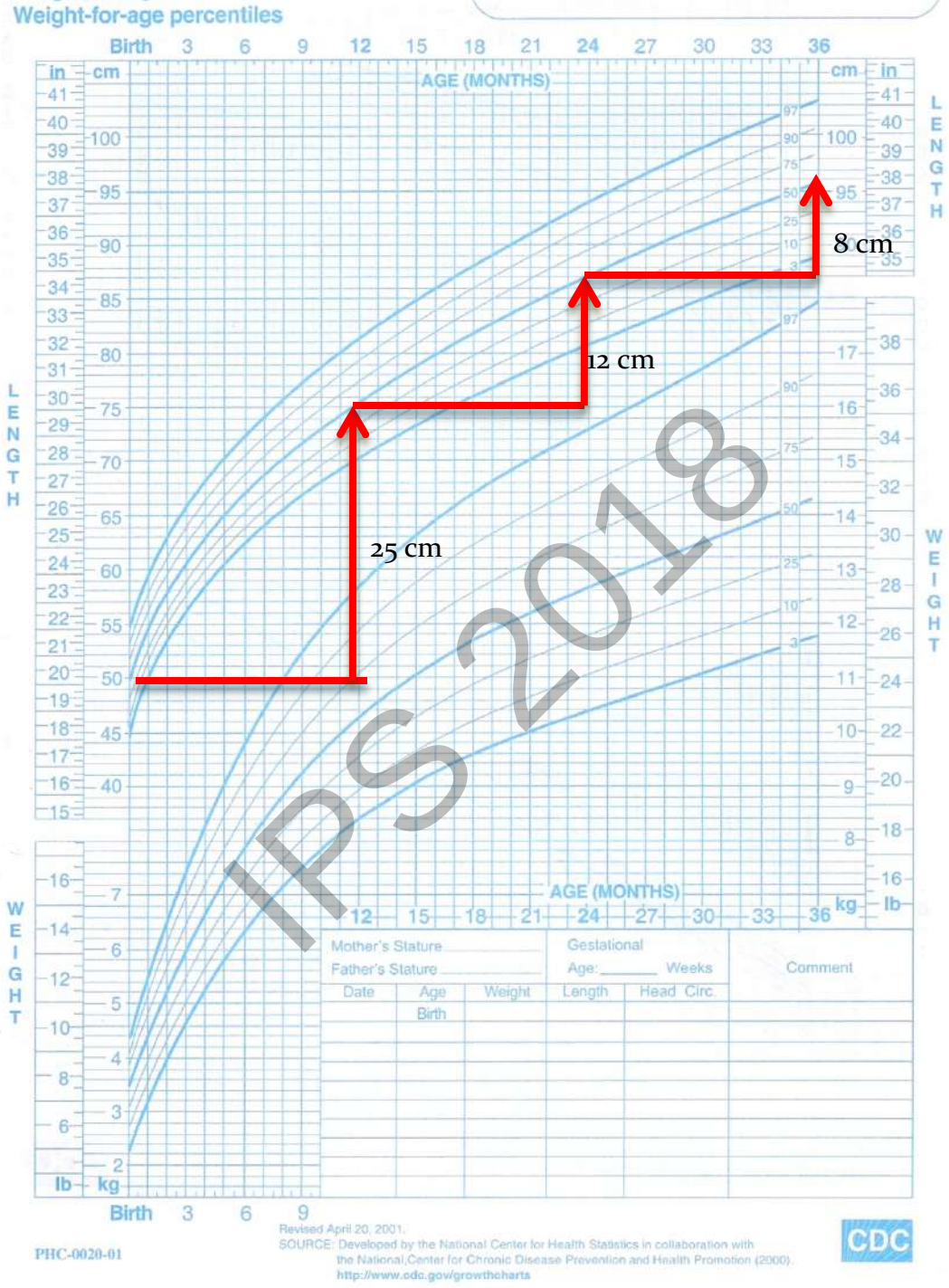
# Objectives

- Normal and abnormal growth patterns.
- Short stature and growth failure.
- Causes of growth failure.
- Evaluation process.

# What is normal growth?


Birth to 36 months: Boys
Length-for-age and
Weight-for-age percentiles
AGE (MONTHS)
LENGTH
WEIGHT
Mother's Stature
Father's Stature
Gestational
Age: Weeks
Date
Age
Weight
Length
Head Circ.
Comment
Birth
PHC-0020-01
Revised April 20, 2001.
SOURCE: Developed by the National Center for Health Statistics in collaboration with the National Center for Chronic Disease Prevention and Health Promotion (2000).
http://www.cdc.gov/growthcharts
CDC
IPS 2018


Length-for-age and
Weight-for-age percentiles
Birth 3 6 9 12 15 18 21 24 27 30 33 36
AGE (MONTHS)
in cm
cm in
LENGTH
97 90 75 50 25 10 3
WEIGHT
lb kg
kg lb
Mother's Stature
Father's Stature
Gestational Age: Weeks
Comment
Date Age Weight Length Head Circ.
Birth
OF 421 (0208 MR ( 09/02 )
Revised April 20, 2001.
CDC
IPS 2018


Weight-for-age percentiles
AGE (MONTHS)
LENGTH
WEIGHT
8 cm
12 cm
25 cm
IPS 2018
Mother's Stature
Father's Stature
Gestational Age: Weeks
Comment
Date
Age
Weight
Length
Head Circ.
Birth
PHC-0020-01
Revised April 20, 2001.
SOURCE: Developed by the National Center for Health Statistics in collaboration with the National Center for Chronic Disease Prevention and Health Promotion (2000).
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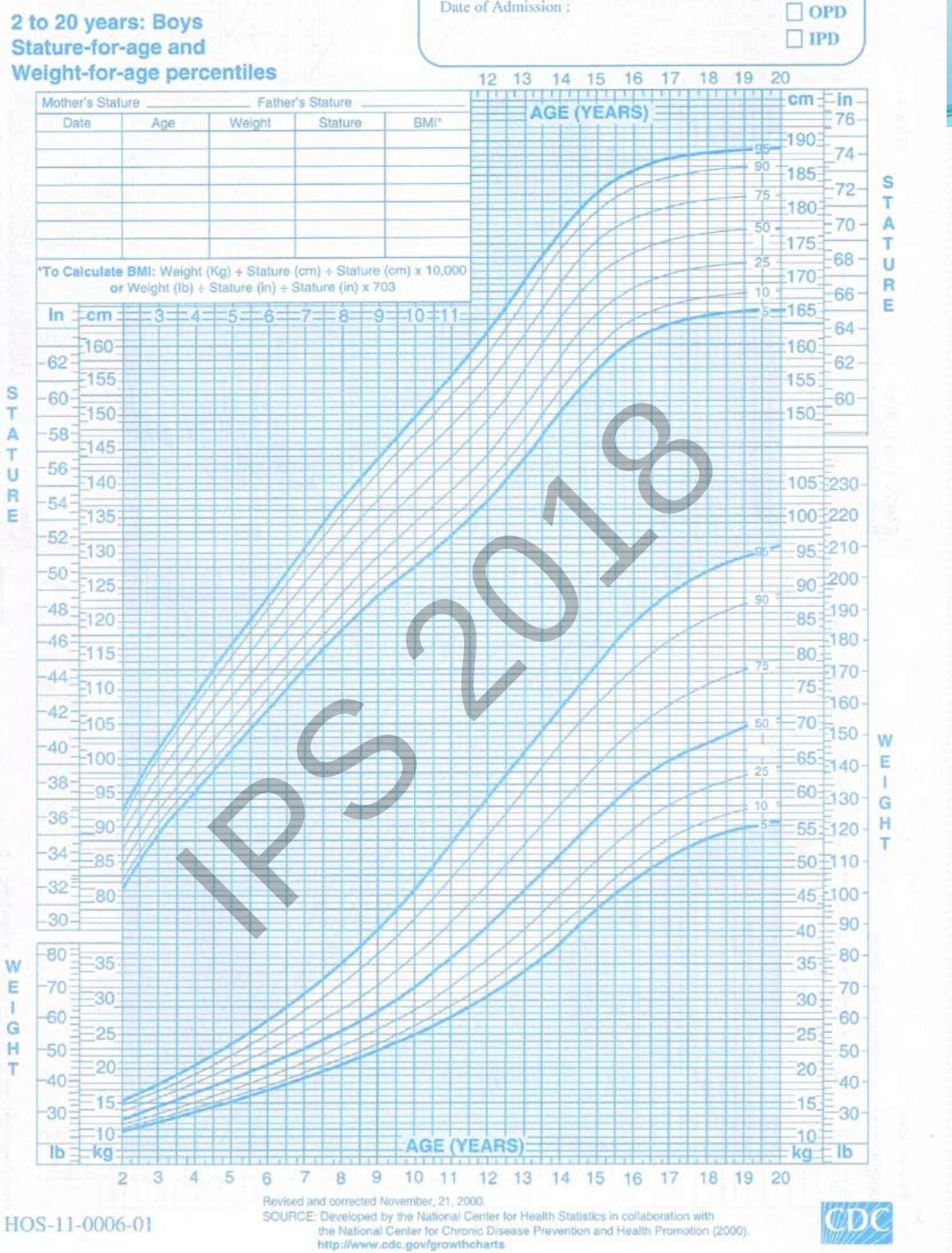
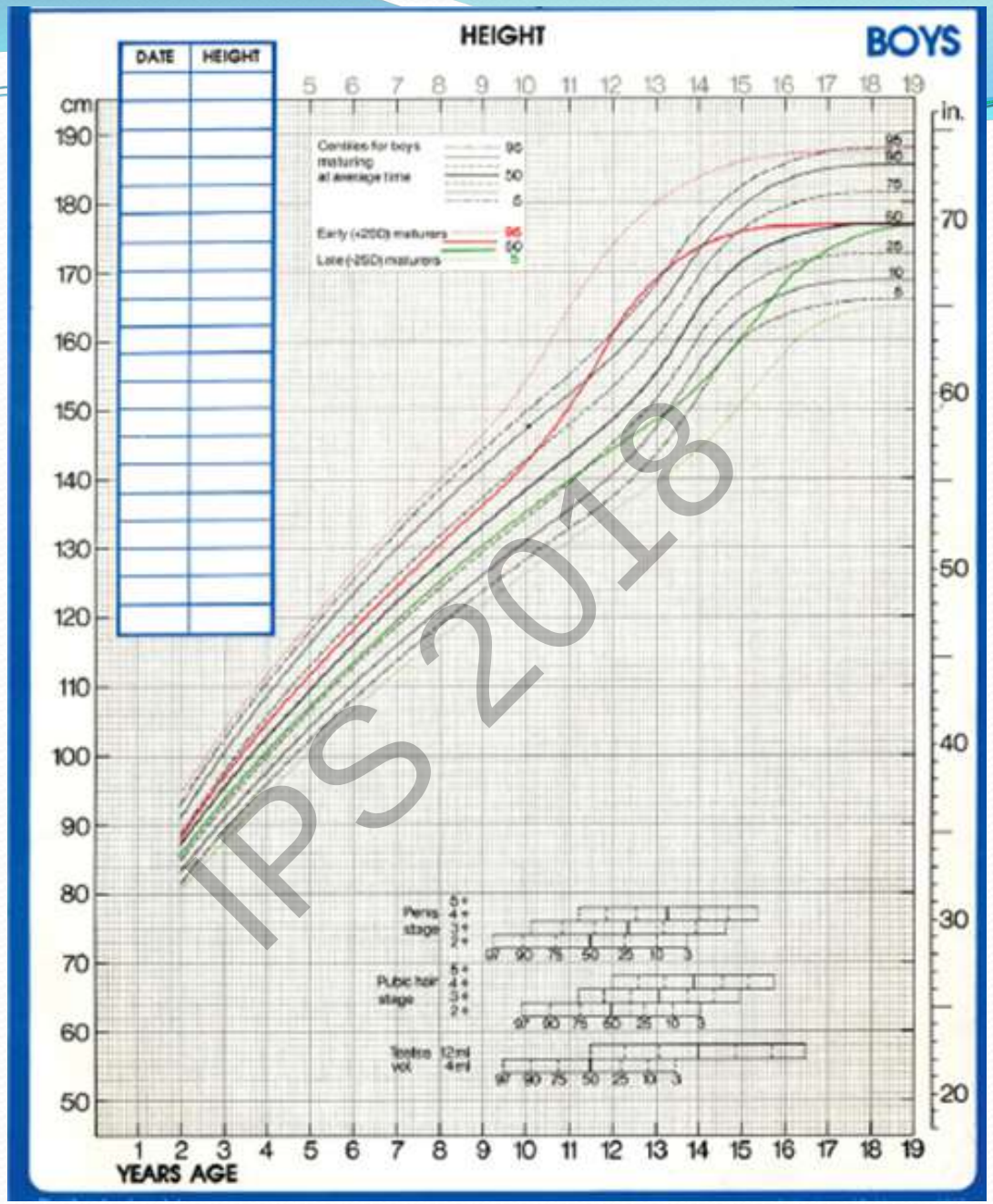

Date of Admission :
OPD
IPD
2 to 20 years: Boys
Stature-for-age and
Weight-for-age percentiles
Mother's Stature
Father's Stature
Date
Age
Weight
Stature
BMI*
*To Calculate BMI: Weight (Kg) ÷ Stature (cm) ÷ Stature (cm) x 10,000
or Weight (lb) ÷ Stature (in) ÷ Stature (in) x 703
AGE (YEARS)
STATURE
WEIGHT
IPS 2018
Revised and corrected November, 21, 2000.
SOURCE: Developed by the National Center for Health Statistics in collaboration with
the National Center for Chronic Disease Prevention and Health Promotion (2000).
http://www.cdc.gov/growthcharts
HOS-11-0006-01
CDC


HEIGHT
BOYS
DATE
HEIGHT
cm
in.
YEARS AGE
IPS 2018

# Growth Velocity curves

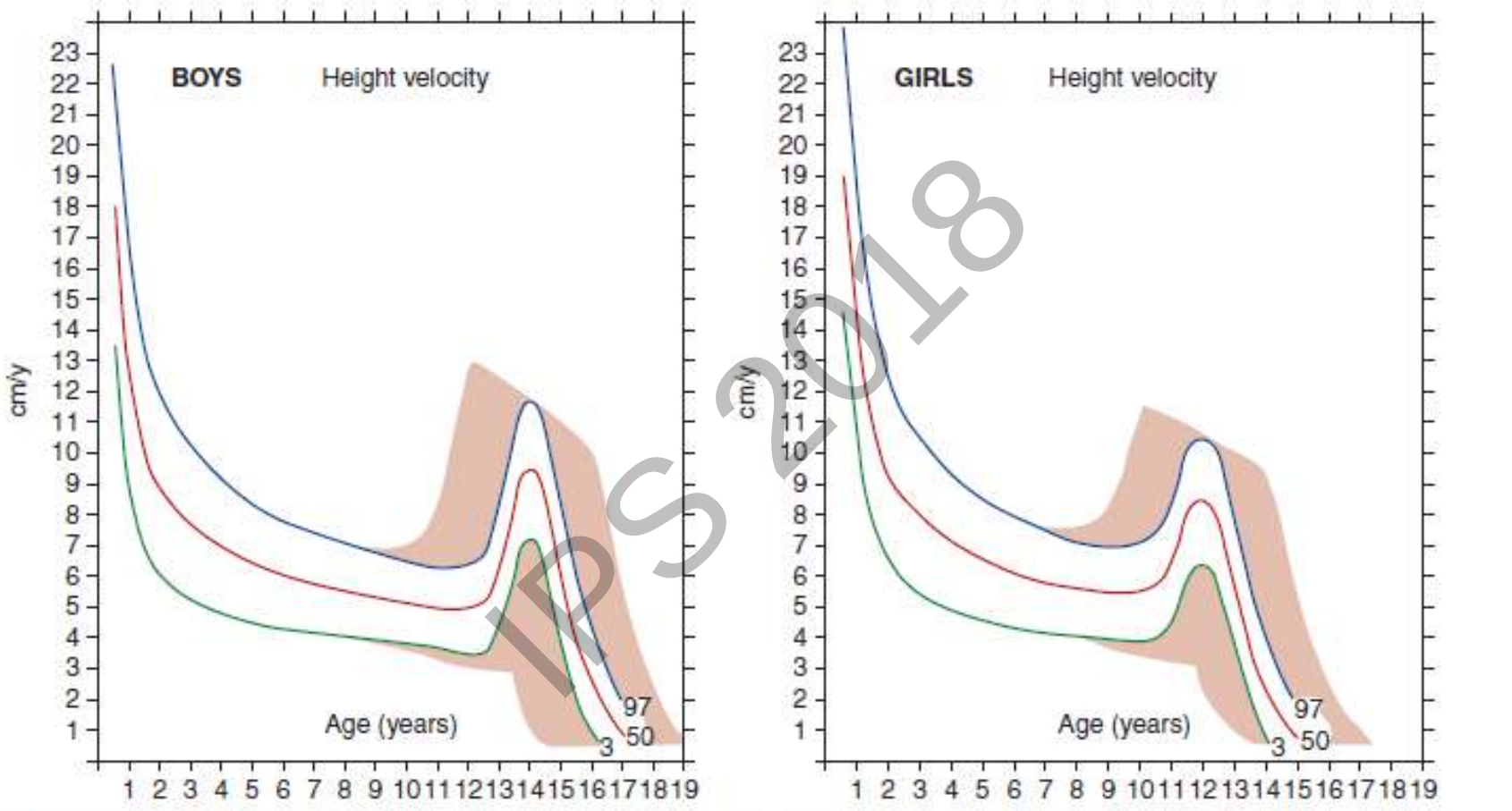





FIGURE 2-2 ■ Ranges of linear growth velocities in males and females. (*Modified from charts prepared by Tanner and Whitehouse, 1976, and reproduced with permission of Tanner JM and Castlemead Publications, Ward's Publishing Services, Herts, UK.*)

## Table 1. Normal Growth Velocity at Various Life Stages

| *Life stage* | *Growth velocity per year* |
|---|---|
| In utero | 60 to 100 cm (24 to 40 in) |
| First year | 23 to 27 cm (9 to 11 in) |
| Second year | 10 to 14 cm (4 to 6 in) |
| Fourth year | 6 to 7 cm (2 to 3 in) |
| Prepubertal nadir | 5 to 5.5 cm (2 to 2.2 in) |
| Pubertal growth spurt | Girls: 8 to 12 cm (3 to 5 in)<br>Boys: 10 to 14 cm (4 to 6 in) |

## Upper to Lower Extremity Ratios in Boys and Girls

| | Boys | Girls |
|---|---|---|
| Age (Years) | U/L Ratio | U/L Ratio |
| Birth | 1.70 | 1.70 |
| 1/2 | 1.62 | 1.60 |
| 1 | 1.54 | 1.52 |
| 1 1/2 | 1.50 | 1.46 |
| 2 | 1.42 | 1.41 |
| 2 1/2 | 1.37 | 1.34 |
| 3 | 1.35 | 1.30 |
| 3 1/2 | 1.30 | 1.27 |
| 4 | 1.24 | 1.22 |
| 4 1/2 | 1.22 | 1.19 |
| 5 | 1.19 | 1.15 |
| 6 | 1.12 | 1.10 |
| 7 | 1.07 | 1.06 |
| 8 | 1.03 | 1.02 |
| 9 | 1.02 | 1.01 |
| 10 | 0.99 | 1.00 |
| 11 | 0.95 | 0.90 |
| 12 | 0.98 | 0.99 |
| 13 | 0.97 | 1.00 |
| 14 | 0.97 | 1.01 |
| 15 | 0.95 | 1.01 |
| 16 | 0.99 | 1.01 |
| 17 | 0.99 | 1.01 |

*Adapted from Wilkins L. The Diagnosis and Treatment of Endocrine Disorders in Childhood and Adolescence. IL: Springfield, Charles C. Thomas, Publisher; 1957.*

# How to measure length and height?

# Measurement of length




Rogol and Hayden www.jpeds.com Vol. 164, No. 5, Suppl. 1

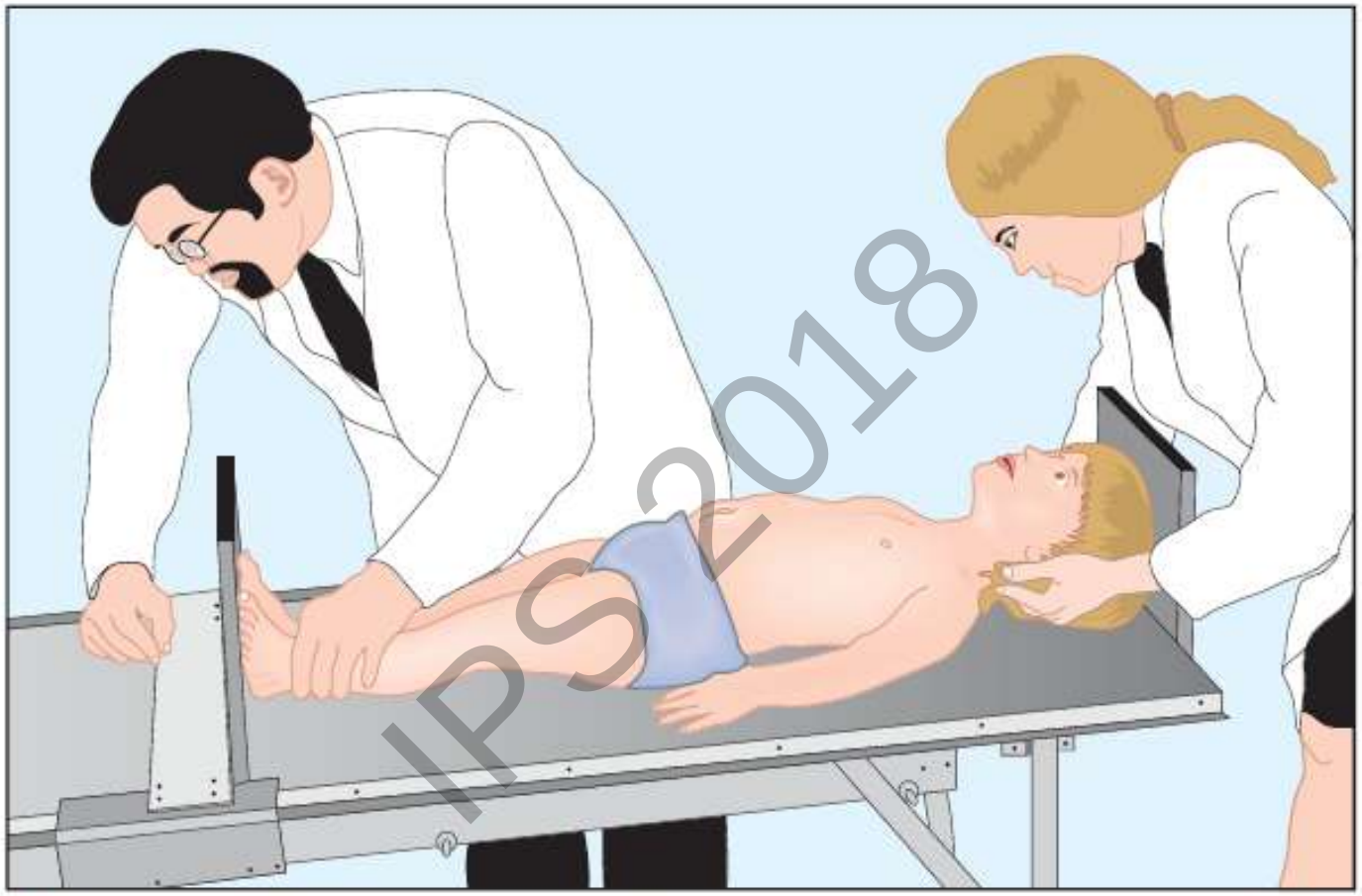
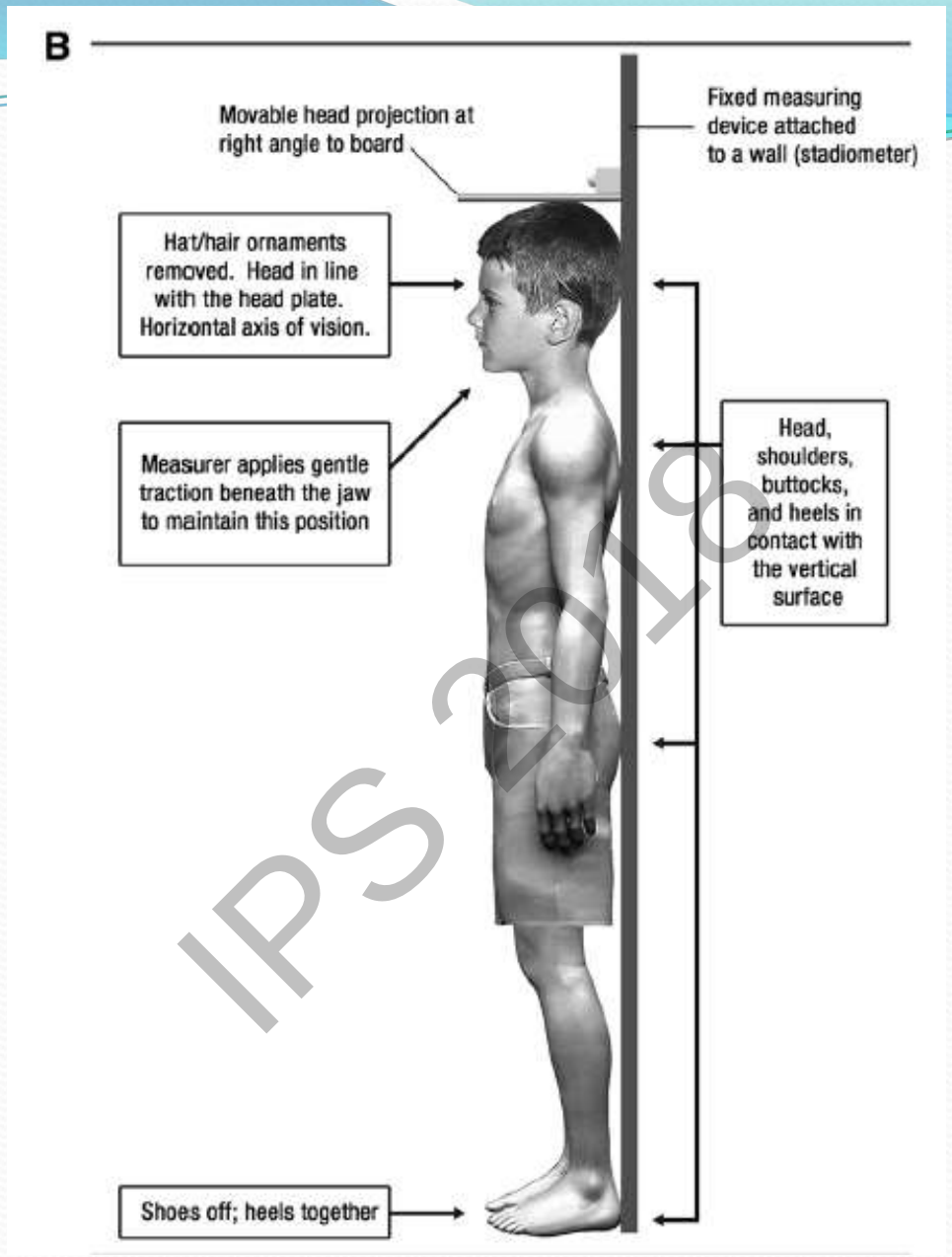




FIGURE 2-3 ■ Measurement of children less than 2 years of age should be obtained in the "Frankfurt plane" which places children in the supine position in full extension and other canthus of the eyes and the external auditory meatus perpendicular to the long axis of the trunk.

**Kappy et al.** ■ *Pediatric Practice: Endocrinology 2010: 25*






Rogol and Hayden www.jpeds.com Vol. 164, No. 5, Suppl. 1

# Measurement accuracy

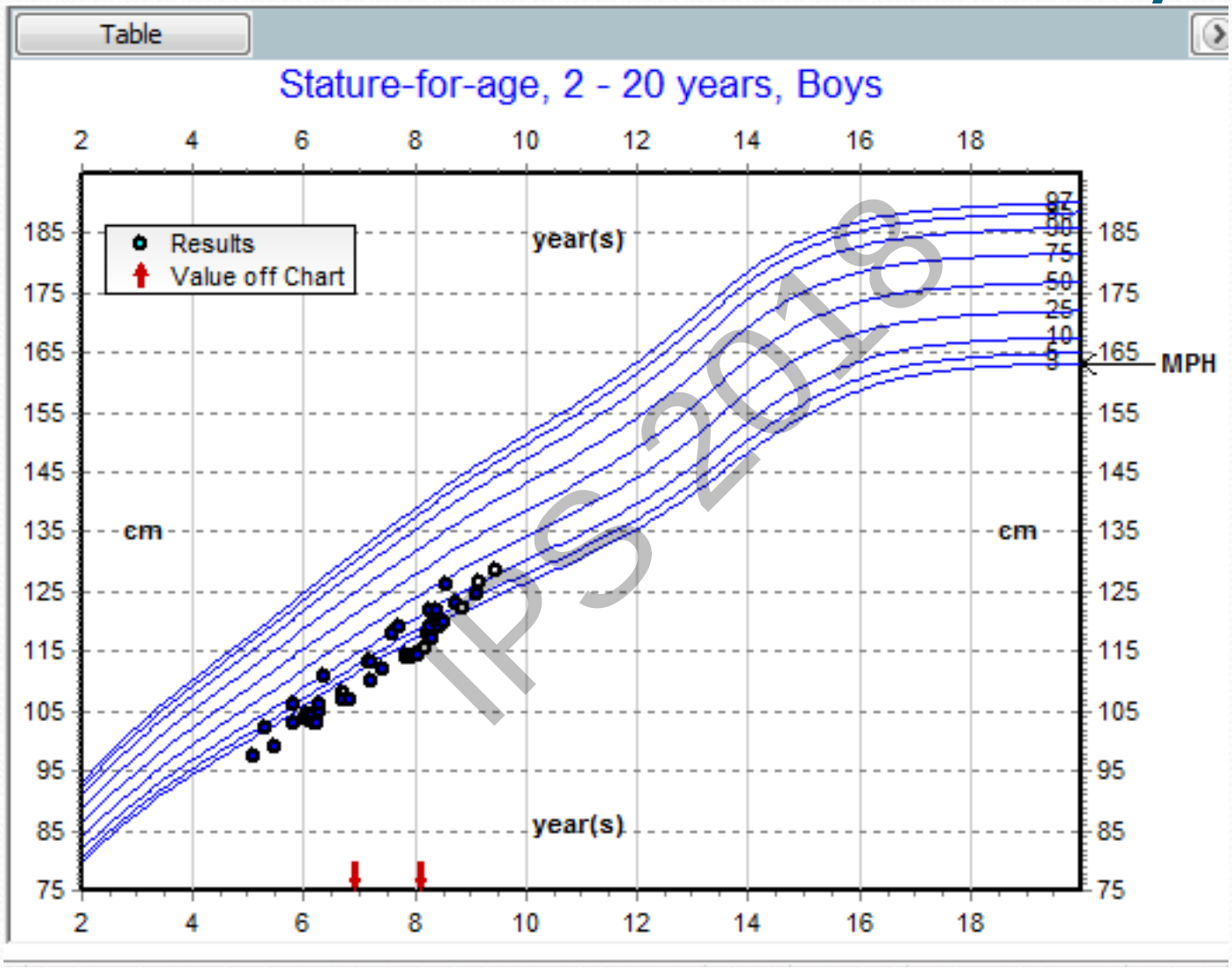
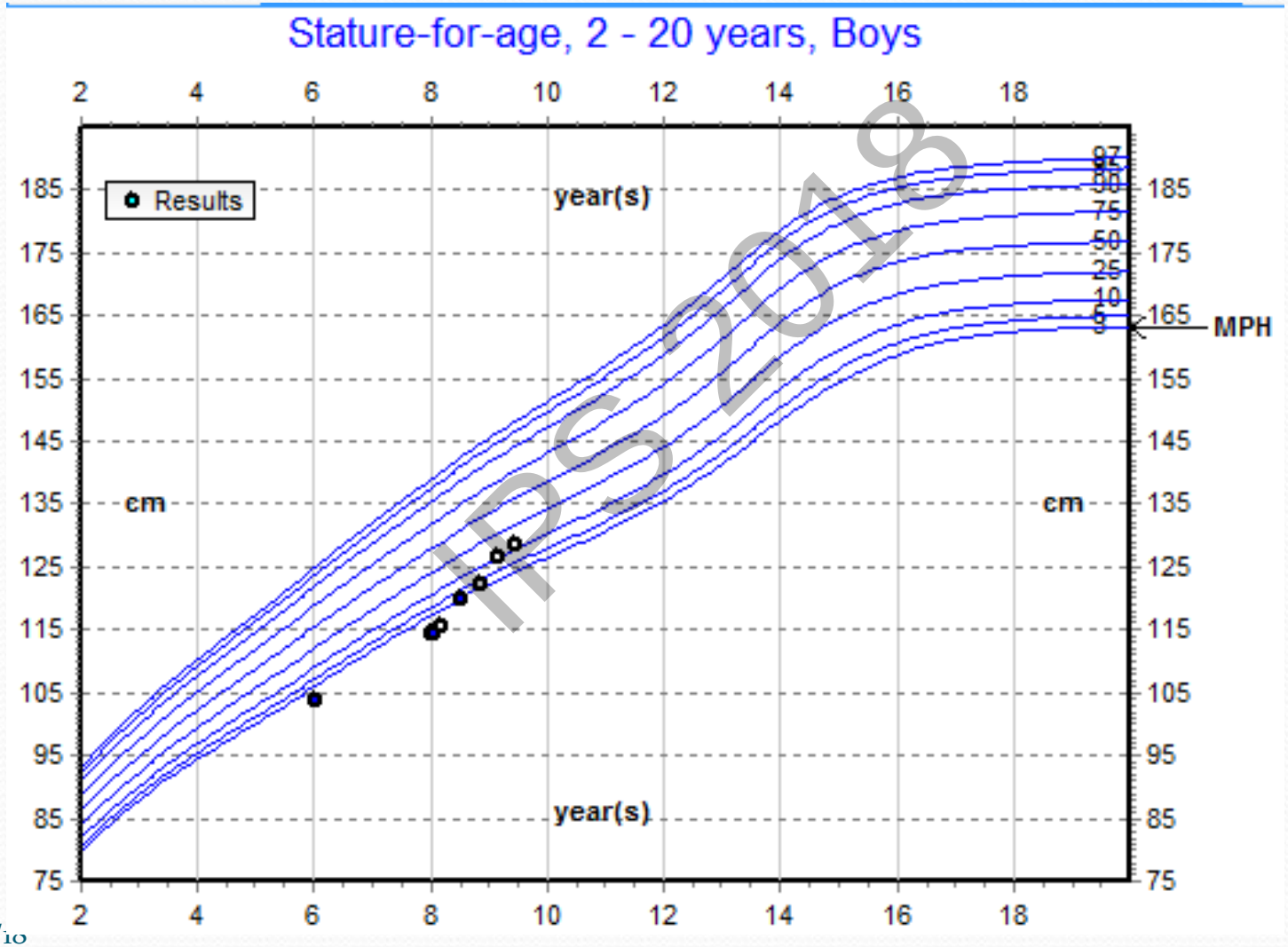


Chart | Calculate GV | Plot All

Stature-for-age, 2 - 20 years, Boys

| Date | Age | Value | Centile | z-score/SD | GV | Calculation | Medical Service | Plot |
|---|---|---|---|---|---|---|---|---|
| 17/03/2013 | 8 years | (c) 115.40 cm | 0.78 | -2.42 | ☐ | | Paediatrics-Endocrinology | ☑ |
| 08/04/2013 | 8 years | 118.00 cm | 2.58 | -1.95 | ☐ | | Family Practice | ☐ |
| 15/04/2013 | 8 years | 119.00 cm | 3.26 | -1.84 | ☐ | | Family Practice | ☐ |
| 16/04/2013 | 8 years | 122.00 cm | 9.48 | -1.31 | ☐ | | Family Practice | ☐ |
| 09/05/2013 | 8 years | 117.00 cm | 1.38 | -2.20 | ☐ | | Med-Dermatology | ☐ |
| 05/06/2013 | 8 years | 122.00 cm | 8.25 | -1.39 | ☐ | | Med-Dermatology | ☐ |
| 08/06/2013 | 8 years | 120.00 cm | 4.08 | -1.74 | ☐ | | Pharmacy | ☐ |
| 18/06/2013 | 8 years | 119.00 cm | 2.31 | -1.99 | ☐ | | Family Practice | ☐ |
| 14/07/2013 | 8 years | 120.00 cm | 2.95 | -1.89 | ☐ | | Paediatrics-Endocrinology | ☑ |
| 27/07/2013 | 8 years | 126.00 cm | 19.87 | -0.85 | ☐ | | Family Practice | ☐ |
| 03/10/2013 | 8 years | 123.00 cm | 6.58 | -1.51 | ☐ | | Family Practice | ☐ |
| 24/11/2013 | 8 years | (c) 122.40 cm | 4.01 | -1.75 | ☐ | | Paediatrics-Endocrinology | ☑ |
| 17/02/2014 | 9 years | 124.50 cm | 5.59 | -1.59 | ☐ | | Paediatrics-General | ☐ |
| 09/03/2014 | 9 years | (c) 126.60 cm | 10.76 | -1.24 | ☐ | | Paediatrics-Endocrinology | ☑ |
| 22/06/2014 | 9 years | (c) 128.40 cm | 11.51 | -1.20 | ☐ | | Paediatrics-Endocrinology | ☑ |


Stature-for-age, 2 - 20 years, Boys
Results
year(s)
cm
MPH
IPS 2018

# Short Stature:
# Definition, causes and approach

# Short Stature

- Height more than 2 SD below mean for the same age and sex compared to genetically relevant population (< 2.3 %)

# Growth evaluation

- Accurate measurement of child's height and weight.
- Accurate plotting on appropriate growth chart.
- Assessment of longitudinal growth (growth velocity):
  Accurate heights measured at 6 - 12 month interval
- Measuring parent's height.

# Familial (genetic) Short stature

- Parents are short
- Child is growing within target height range.
- Child's bone age = Chronological age

# Midparental height (Boys)

- F: Father's height (cm)
  M: Mother's height (cm)

- Midparental height in cm for boys
- = (F + M + 13) / 2

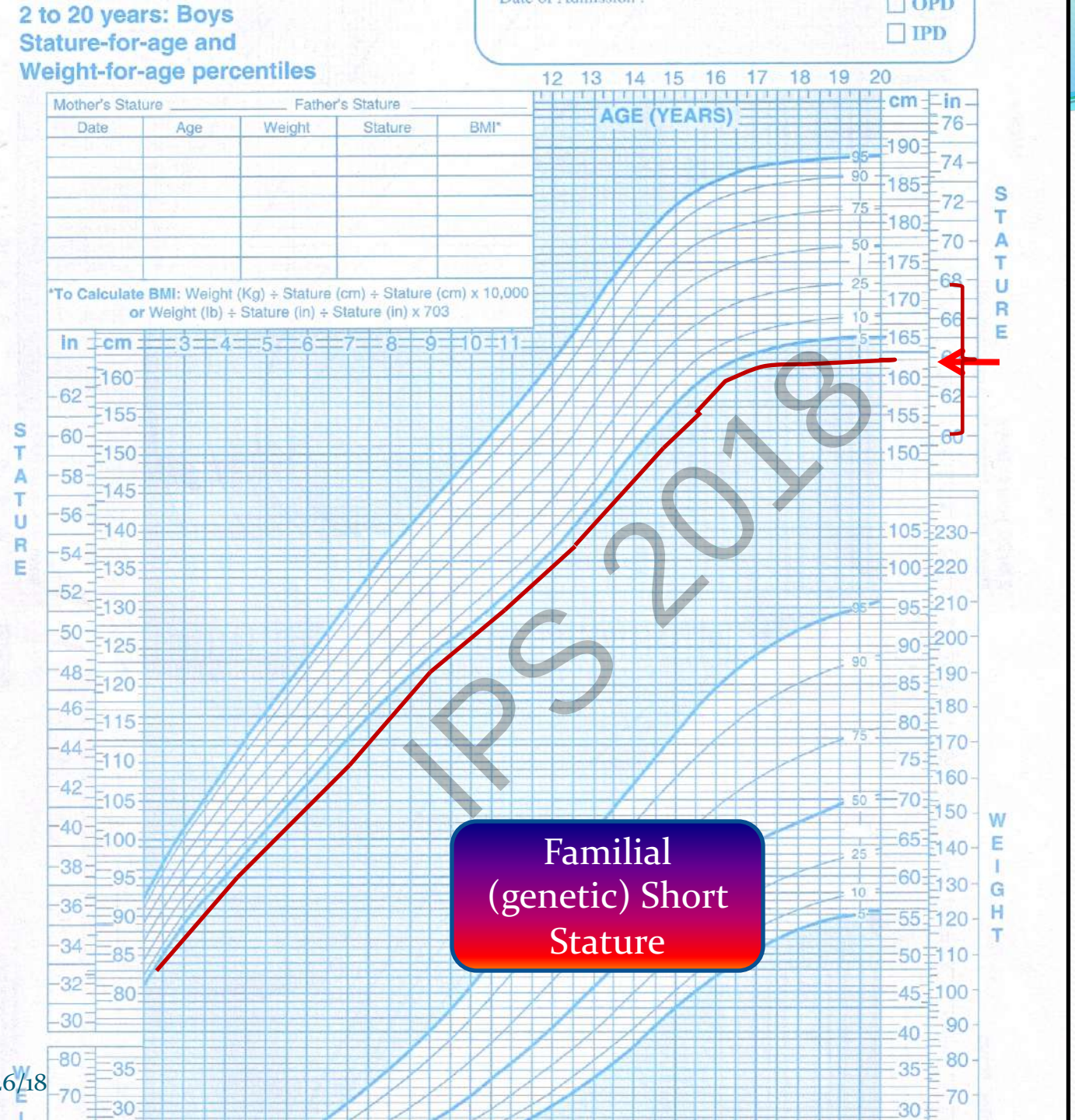
- = (F + M) / 2 + 6.5

# Midparental height (Girls)

- F: Father's height (cm)
  M: Mother's height (cm)

- Midparental height in cm for Girls
- = (F + M - 13) / 2

- = (F + M) / 2 - 6.5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Weight-for-age percentiles
OPD
IPD
Mother's Stature
Father's Stature
Date
Age
Weight
Stature
BMI*
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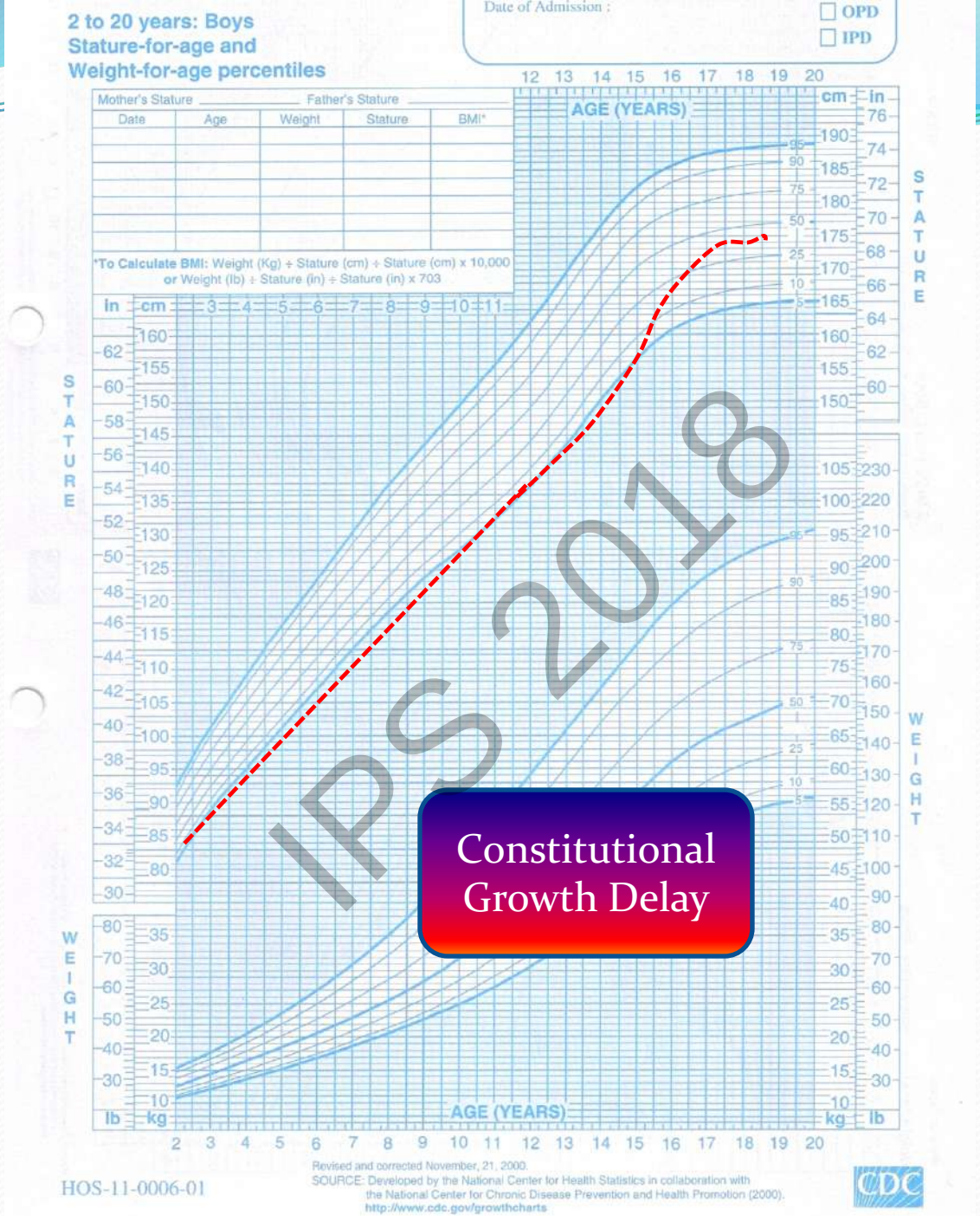
AGE (YEARS)
STATURE
WEIGHT
IPS 2018
Familial (genetic) Short Stature

# Constitutional Delay of Growth and Puberty (CDGP)

- Normal growth velocity.
- Delayed bone age.
- Delayed puberty (Often runs in the family)
- Normal adult (final) height


2 to 20 years: Boys
Stature-for-age and
Weight-for-age percentiles
Date of Admission :
OPD
IPD
Mother's Stature
Father's Stature
Date
Age
Weight
Stature
BMI*
*To Calculate BMI: Weight (Kg) ÷ Stature (cm) ÷ Stature (cm) x 10,000
or Weight (lb) ÷ Stature (in) ÷ Stature (in) x 703
AGE (YEARS)
STATURE
WEIGHT
Constitutional
Growth Delay
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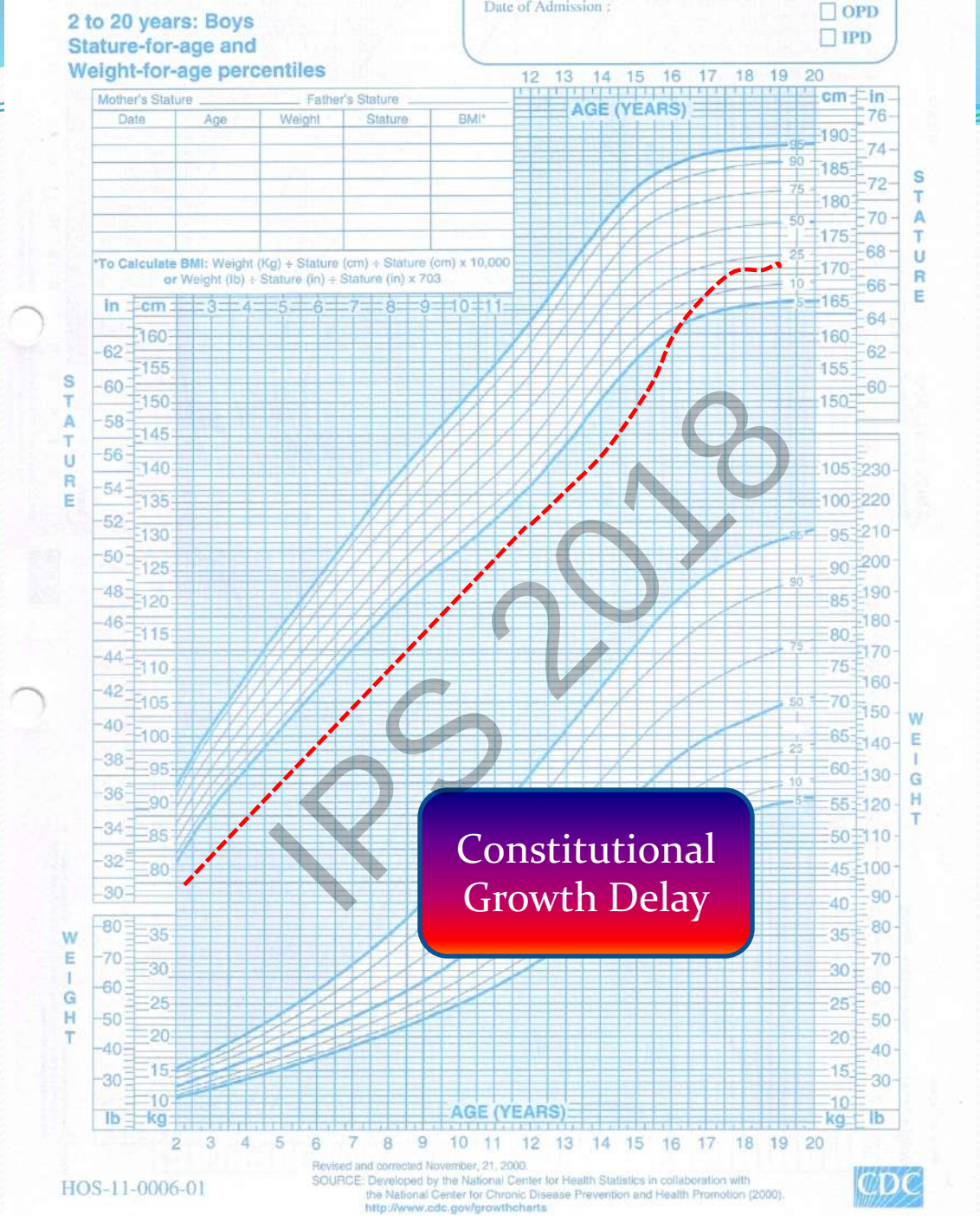
CDC


2 to 20 years: Boys
Stature-for-age and
Weight-for-age percentiles
Date of Admission :
OPD
IPD
Mother's Stature
Father's Stature
Date
Age
Weight
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BMI*
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AGE (YEARS)
STATURE
WEIGHT
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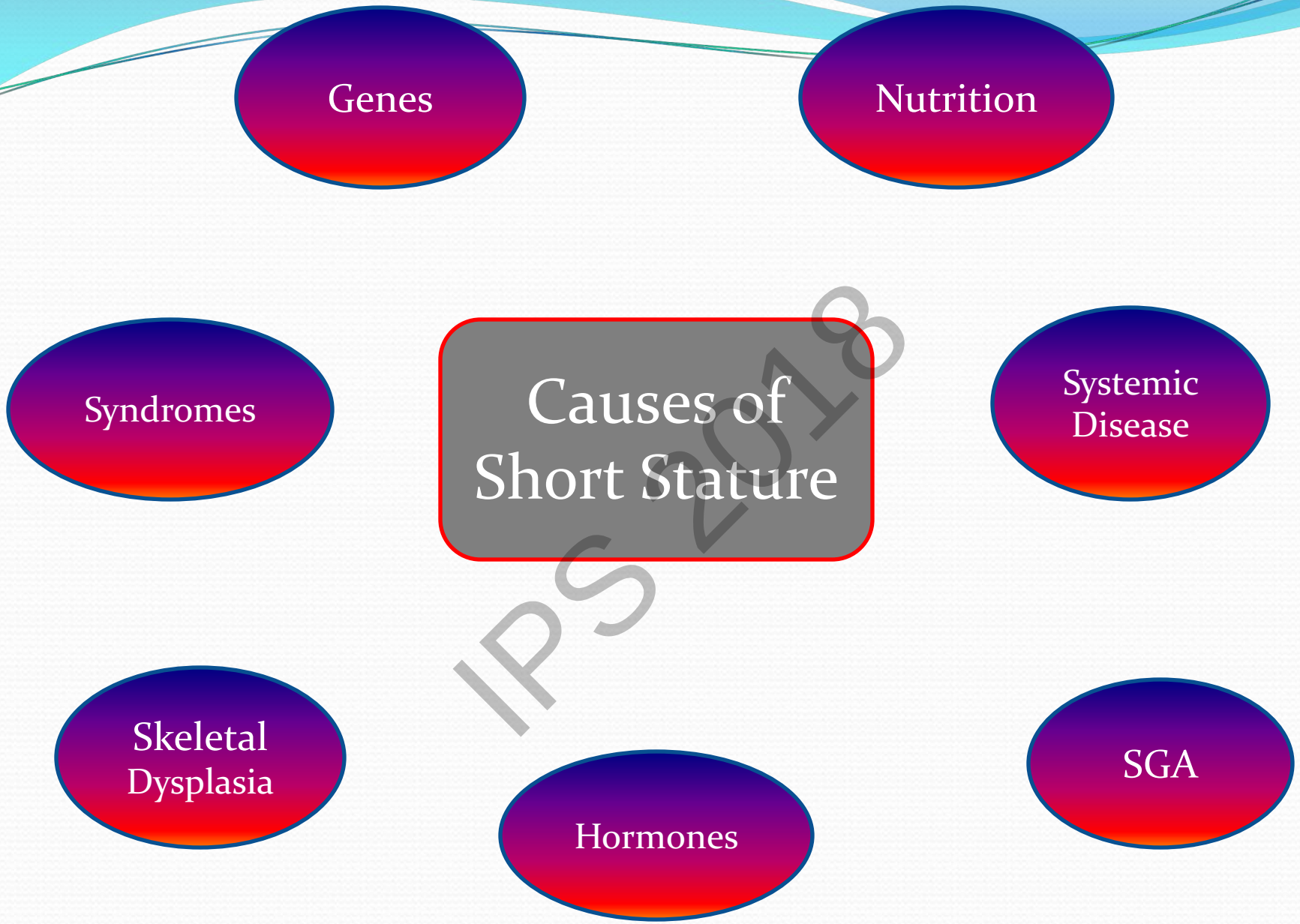
HOS-11-0006-01
CDC

# What are the causes of short stature?


Genes
Nutrition
Syndromes
Causes of Short Stature
Systemic Disease
Skeletal Dysplasia
Hormones
SGA

# Systemic Diseases

## GI

- Celiac Disease
- Malabsorption
- IBD

## Renal

- CKD
- Renal Tubular Acidosis

## Hem / ONC

- Thalassemia
- SCD
- Malignancy

## Pulmonary

- Cystic Fibrosis
- CLD

## Metabolic

- Organic Acidemia
- GSD

## Cardiac

Congenital Heart disase

# Endocrine

- Hypothyroidism
- Isolated growth hormone deficiency
- Hypopituitarism
- GH insensitivity (Laron dwarfism)
- Cushing syndrome
- Poorly controlled type 1 diabetes mellitus - Mauriac syndrome
- Rickets
- Idiopathic short stature

# Evaluation of Short Stature

Should be based on findings from History and Physical Exam

# Evaluation of Short stature

- CBC, ESR
- Electrolytes & Renal Panel, Ca, Phos.
- Thyroid (TSH, FT4)
- Celiac Screen:
  - (Tissue transglutaminase antibodies).
- Chromosomal analysis (girls).
- IGF-1, IGF-BP3
- Bone Age X ray.

## Differential diagnosis of low circulating IGF-I concentration

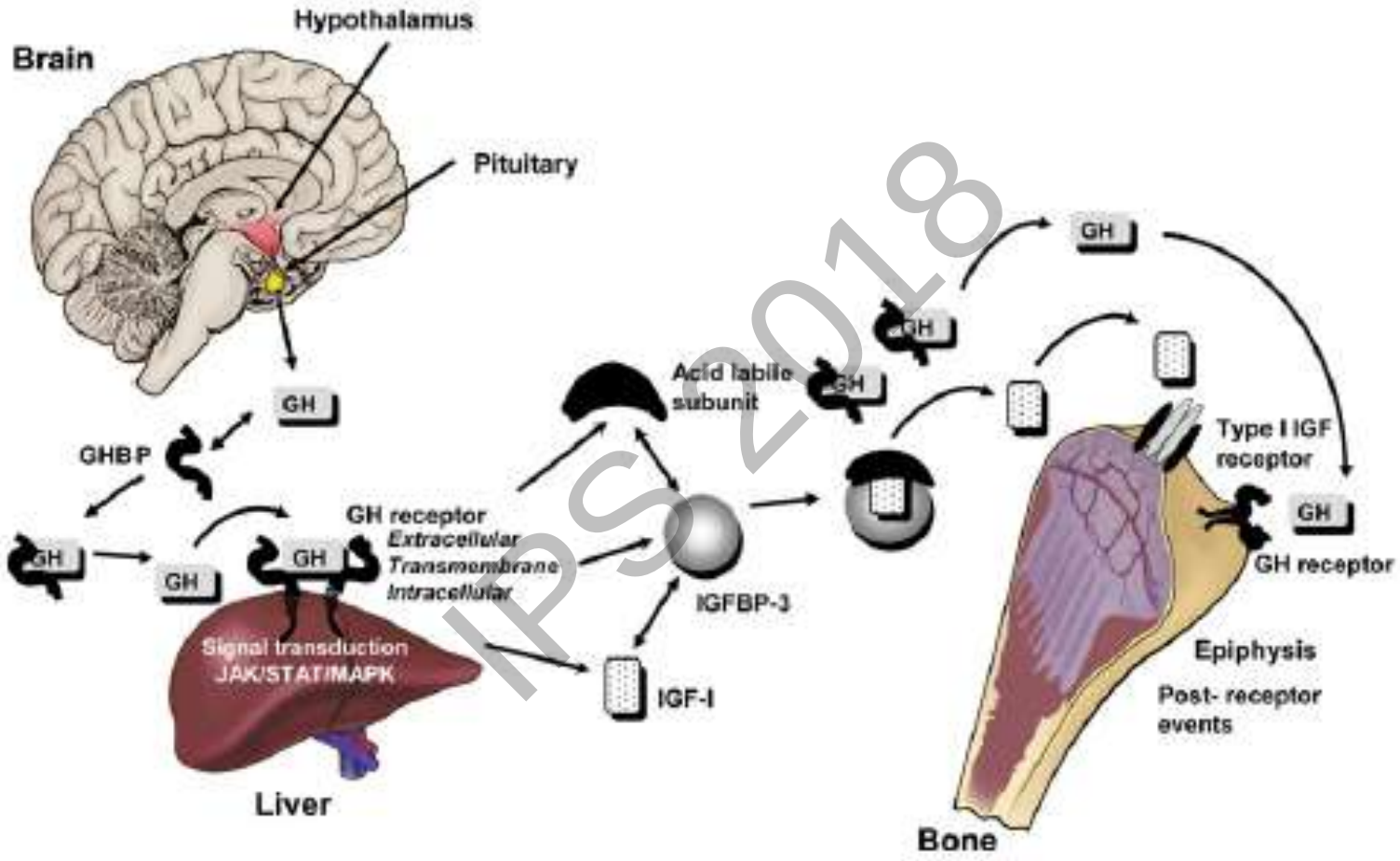
- GH deficiency
- GHR dysfunction (GH resistance/insensitivity)
- Post-GHR signaling defect (STAT5b)
- *IGF1* gene defect
- ALS deficiency
- Hepatic insufficiency (eg, cirrhosis)
- Malnutrition
- Hypothyroidism
- Delayed puberty
- Poorly controlled diabetes mellitus
- Chronic illness
- Glucocorticoid therapy



Endocrinol Metab Clin N Am 41 (2012) 265–282

# GH – IGF1 Axis

# GH – IGF1 axis






Endocrinol Metab Clin N Am 36 (2007) 131–186

# When to suspect Growth Hormone Deficiency (GHD)?

- Low growth velocity.
- Low IGF-1, IGF-BP3
- Delayed bone age.
- Other causes were excluded
- ± Evidence of pituitary abnormality.

# How to confirm GHD?

- Growth hormone stimulation testing:
- Arginine,
- Clonidine.
- Glucagon
- Levodopa
- Insulin / hypoglycemia

**Tests to Provoke Growth Hormone Secretion**

| Stimulus | Dosage | Times Samples Are Taken (min) | Comments |
|---|---|---|---|
| Exercise | Step climbing; exercise cycle for 10 min | 0, 10, 20 | Observe child closely when on the steps |
| Levodopa | < 15 kg: 125 mg<br>10-30 kg: 250 mg<br>> 30 kg: 500 mg, | 10, 60, 90 | Nausea, rarely emesis |
| Clonidine | 0.15 mgs/$m^2$ | 0, 30, 60, 90 | Tiredness, postural hypotension |
| Arginine HCl (IV) | 0.5 g/kg (mas 30 g)<br>10% arginine HCl in 0.9% NaCl over 30 min | 0, 15, 30, 45, 60 | |
| Insulin (IV) | 0.05-0.1 unit/kg | 0, 15, 30, 60, 75, 90, 120 | Hypoglycemia, requires close supervision |
| Glucagon (M) | 0.03 mg/kg (max 1 mg) | 0, 30, 60, 90, 120, 150, 180 | Nausea, occasional emesis |
| GHRH (IV) | 1 (g/kg) | 0, 15, 30, 45, 60, 90, 120 | Flushing, metallic taste |

*Tests should be performed after an overnight fast. Many investigators suggest that prepubertal children should be "primed" with gonadal steroids, eg, 5 mg Premarin orally the night before and the morning of the test or with 50 to 100 µg/d ethinyl estradiol for 3 consecutive days before testing or 100 ng depot testosterone 3 days before testing. This, of course, alters patient's steady state and performs the provocative test in a steroid-rich environment. Patients must be euthyroid at the time of testing.*

*Documentation of appropriate lowering of blood glucose is recommended. If GHD is suspected, the lower dosage of insulin is usually administered, especially in infants. D10W and glucagon should be available.*

# If GHD is confirmed

- MRI of brain (hypothalamus / pituitary)
- Start GH therapy.

# Reference


- Etiologies and Early Diagnosis of Short Stature and Growth Failure in Children and Adolescents. Alan D. Rogol, MD, PhD1, and Gregory F. Hayden, MD
  - (J Pediatr 2014;164:S1-S14).
- **Kappy et al.** ■ *Pediatric Practice: Endocrinology 2010: 25*
- Endocrinol Metab Clin N Am 41 (2012) 265–282


Thank You
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