



Physiology Team 431
Reproductive Block

Lecture 5

Puberty

Done by : Rand AL-haweal & Abdulrahman al-sharidah

Revised by : Nour Al-Khawajah & Mohammed Asiri

PPUBERTY

Reproduction Block

● Doctors' notes

● Important

● Extra info

OBJECTIVES:

- Definition of puberty.
- Terms and events (thelarche, pubarche, menarche).
- Hormonal changes (gonadal and extra gonadl).
- Female hormonal changes and male hormonal changes and secondary sexual characters.
- Staging of pubertal development (tanner) in boys and girls.
- Pubertal disorders (precocious puberty and delayed puberty).

PUBERTY _ Definition:

A stage of human development when sexual maturation and growth are completed and **result in ability to reproduce**. There is **gonadal and extra gonadal maturation**.

Accelerated **somatic growth** leads to: a) Maturation of *primary sexual characteristics* (gonads and genitals) and b) Appearance of *secondary sexual characteristics* (pubic and axillary hair, female breast development, male voice changes,...)

The signs of reaching puberty: *Menstruation and spermatogenesis* begin

Puberty – Terms & Events

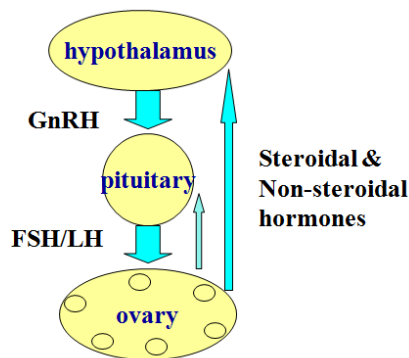
- **Thelarche**: development of breast (**first sign of maturation**).
- **Puberache**: development of axillary & pubic hair.
- **Menarche**: the first menstrual period.
- **Adrenarche**: the onset of an increase in the secretion of androgens.

Puberty – hormonal changes

- * **Hormonal changes precede physical (body) changes by several years**
- * **Increased stimulation of hypothalamo-pituitary-gonadal axis**

- Gradual activation of the GnRH (LHRH) → **pulsatile, at night and it also stimulate LH release.**
- Increases frequency and amplitude of LH pulses.
- Gonadotropins stimulate secretion of sexual steroids (females→estrogens and androgens, **males→ different types of androgens**)
- **extragonadal hormonal changes (elevation of IGF-I will stimulate the effect of GH and increases body growth in general, and adrenal steroids)**

Hypothalamic-Pituitary-Gonadal Axis



IGF-1= Insulin-like Growth Factor 1.

GH= Growth Hormone.

GnRH= Gonadotropin Releasing Hormone.

LH= Luteinizing Hormone.

Puberty – hormonal changes

- Nocturnal GnRH pulsatility (LH secretion) precedes phenotypic (**body**) changes by several years.
- First phenotypic changes: breast development (**in female**) / testicular enlargement (**in male**)
- **In young children**, LH and FSH levels insufficient to initiate gonadal function.
- **Between 9-12 yrs.**, blood levels of LH, FSH increase, and amplitude of pulses increases, especially during sleep. In addition, high levels of LH, FSH initiate gonadal development.
- GH secretion from pituitary also increases.
- TSH (thyroid stimulating hormone) secretion from pituitary increases in both sexes. Which cause:
 - Increases metabolic rate.
 - Promotes tissue growth.

Puberty – Female hormonal changes

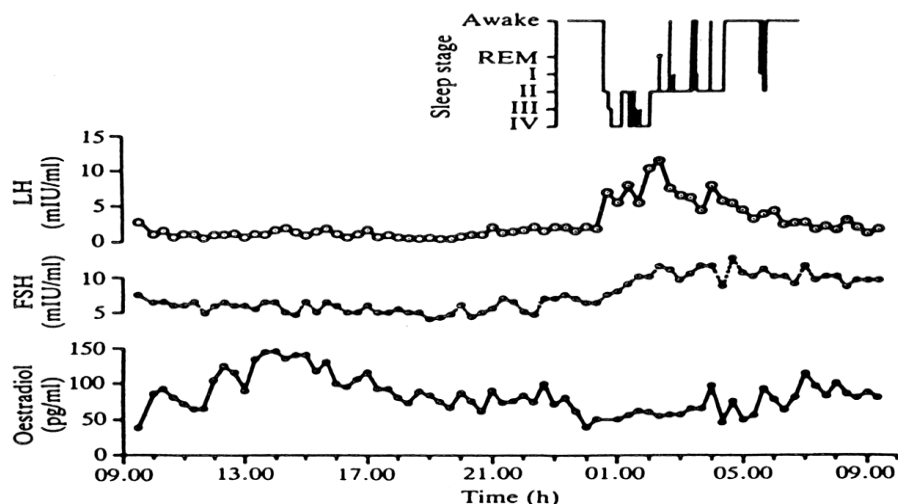
- **surge of LH release initiates 1st ovarian cycle.**

- usually not sufficient to cause ovulation during 1st cycle.
- brain and endocrine systems mature soon thereafter.
- estrogen levels in blood increase, due to growing follicles.
- Estrogen induces secondary sex characteristics:
 - Growth of pelvis. → Deposition of Ca and increase in density will give the female different shape than the male.
 - Deposit of subcutaneous fat. → In females: beneath the breast, thigh and gluteal region.
 - Growth of internal reprod. organs, external genitalia.
- Androgen release by adrenal glands increases, which causes: growth of pubic hair lowering of voice, growth of bone, increased secretion from sebaceous glands → predispose to acne.

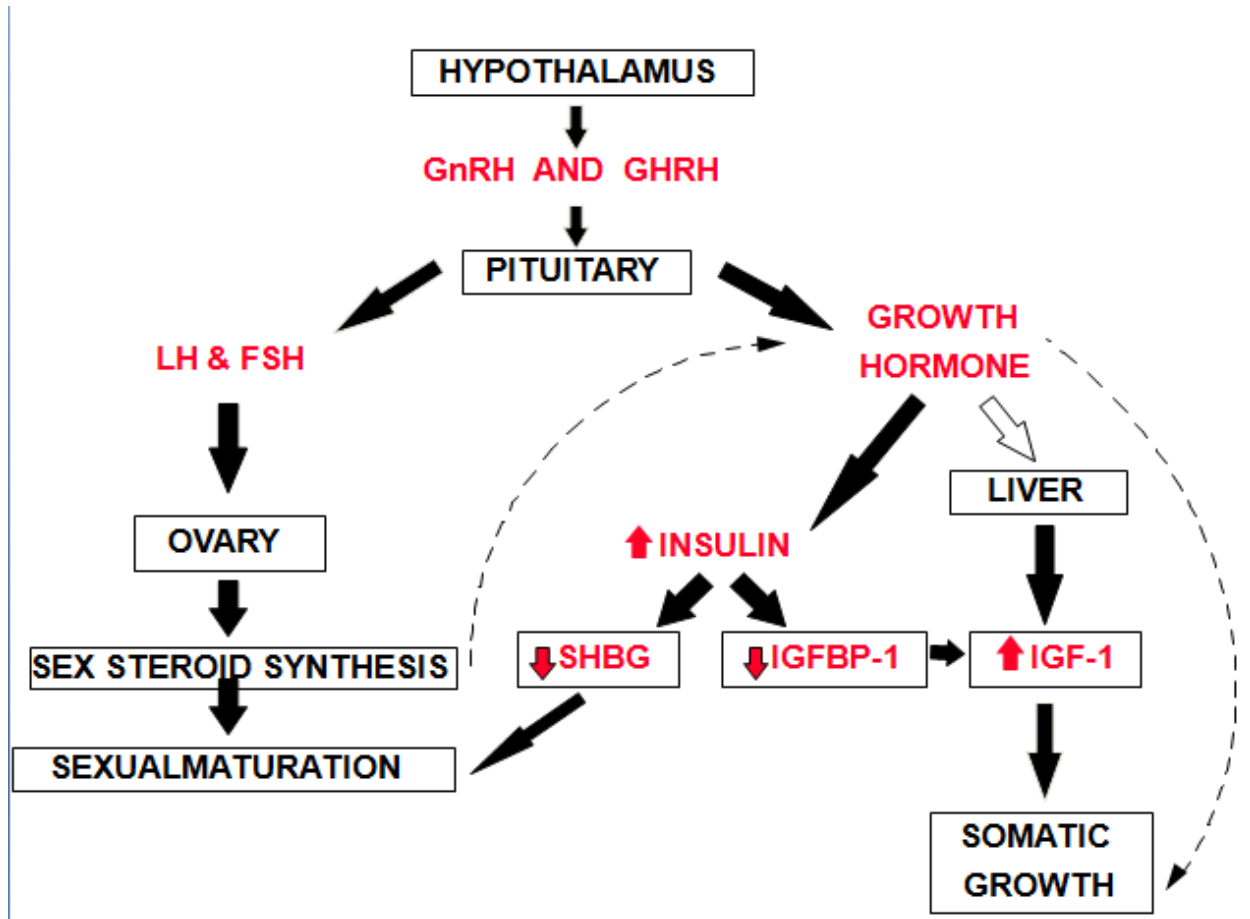
Puberty – Male hormonal changes

- LH and FSH release increases by 10 yrs. of age → this will eventually cause Spermatogenesis; androgen secretion
- Adrenals also secrete androgens. Androgens initiate growth of sex accessory structures (e.g. Prostate), male secondary sex characteristics (facial hair, growth of larynx)
- Androgens causes retention of minerals in body to support bone and muscle growth the **anabolic effect of androgens (deposition of Ca in bones and Protein in muscles)**
- Sertoli cells also secrete some estrogen

Sleep dependent nocturnal rise in LH



Puberty – hormonal changes



Staging of pubertal development (Tanner) __ you do not have to know what each stage is, **STUDY ONLY THE NUMBER OF STAGES FOR EACH CHARACTER** which is 5 for all ^^

* Pubertal development is classified according to the Tanner standard – 5 different stages:

- Girls: *breast (B₁₋₅), pubic hair (Pu₁₋₅), axillary hair (A₁₋₅), menarche*

After going through all stages for all characters, the girl reach puberty which is marked by menarche.

- Boys: *testicular volume > 4 ml (Te), penis enlargement (G₁₋₅), pubic hair (Pu₁₋₅), axillary hair (A₁₋₅), spermarche*

After going through all stages for all characters, the boy reach puberty which is marked by spermarche.

Tanner Stages

EXTRA INFO

Pubertal maturation can be described in terms of sequence, timing, and tempo (Puberty consists of a series of predictable events, and the sequence of changes in secondary sexual characteristics has been categorized by several groups. The staging system utilized most frequently is that published by Marshall and Tanner and the sequence of changes, commonly referred to as "Tanner stages").

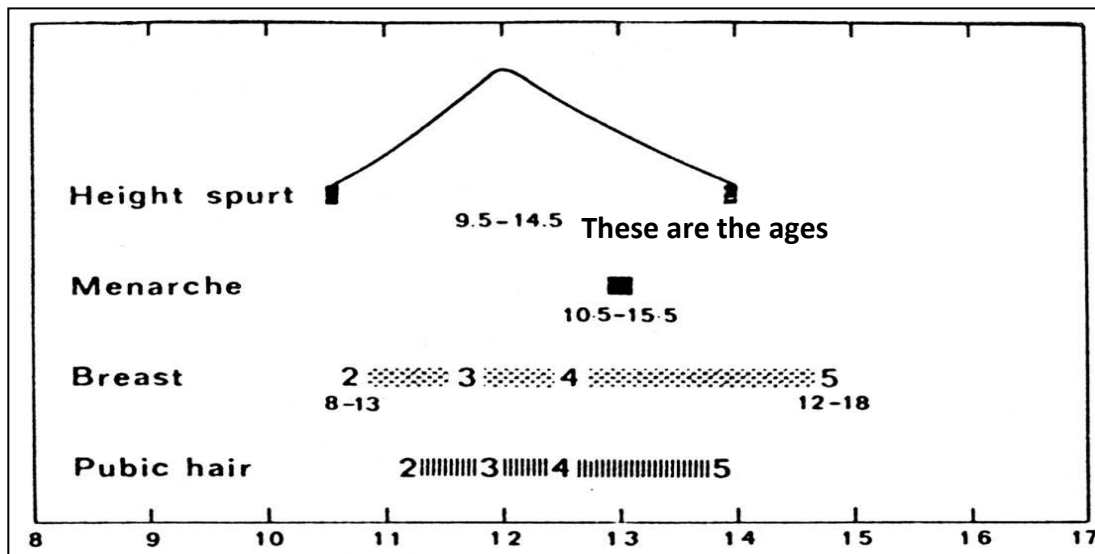
For more information about puberty and Tanner stages :

http://www.childgrowthfoundation.org/CMS/FILES/Puberty_and_the_Tanner_Stages.pdf

* Monitoring of the pubertal growth acceleration

- growth velocity is 2-3 times greater than prepubertal
- sexual dimorphism in pubertal growth

Sequence of normal puberty in girls _ for your knowledge



Normal pubertal development

	Boys	Girls
Age of start (yrs)	12,5 (10 - 14)	11,5 (9 - 13)
First sign of puberty (according to Tanner staging)	G2 (testicular volume up to 4 ml)	B2
Growth velocity (cm/yr)	10,3 (Tanner III-IV)	9,0 (Tanner II-III)

Duration of puberty (yrs)	3,2 ± 1,8 (adult size of testis)	2,4 ± 1,1 (menarché)
----------------------------------	---	--------------------------------

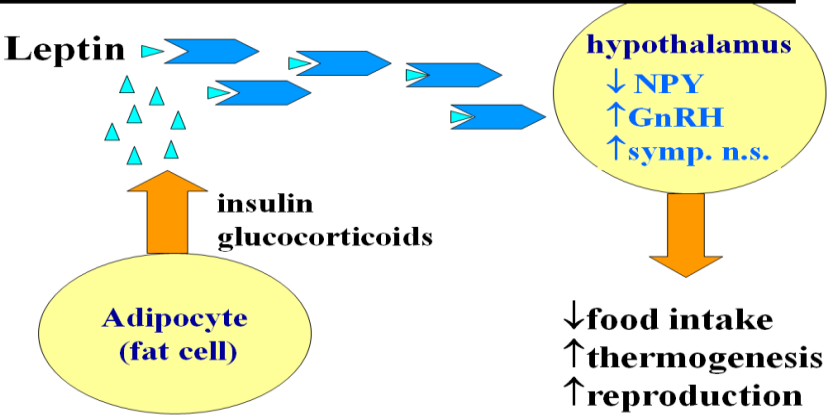
Timing of Puberty

- trend toward **earlier** puberty exists within Western Europe and USA
- examination of lifestyle changes may give clues regarding mechanisms inducing onset
- one of the contributing factors: nutrition

Nutrition

- **Critical body weight** must be attained before activation of the reproductive system.
- **Even though age of menarche is decreasing, the average body weight of menarche remains the same.**
- Earlier puberty due to improvement of nutrition, living conditions, healthcare?
- Evidence supporting hypothesis:
 - Obese girls go through early menarche
 - Malnutrition is associated with delayed menarche
 - Primary amenorrhea common in lean female athletes ← **because they are thin**
 - “body fat” set-point very noticeable in girls with fluctuating body weight due to anorexia nervosa

Potential involvement of Leptin:



EXTRA INFO

Leptin : It's an adipose derived hormone Leptin acts on receptors in the hypothalamus of the brain where it inhibits appetite by counteracting the effects of neuropeptide Y (a potent feeding stimulant secreted by cells in the gut and in the hypothalamus)

- Increase reproduction by increasing GnRH.
- Thrombogenesis by increasing sympathetic activity.

Pubertal disorders

A. Precocious puberty

B. Delayed puberty

A. PRECOCIOUS PUBERTY

Precocious onset of puberty is defined as **occurring younger** than 2 SD standard deviation before the average age:

Girls <8 years old

Boys <9 years old

Precocious puberty has two types:

1. *Gonadotrophin-dependent precocious puberty*

- (true / central), like Intra-cranial lesions (tumours, hydrocephalus, CNS malformations) which will affect the site of gonadotrophic releasing hormone.
 - E.g. Gonadotrophin secreting tumours – very rare.

2. *Gonadotrophin-independent precocious puberty*

- Precocious pseudo puberty.
- **There is no increase in GnRH.** → No spermatogenesis or ovarian development.
- FSH & LH suppressed **lower than normal**.
- E.g. Congenital adrenal hyperplasia (CAH): **secrete large amounts of androgens** → leads to increase pubic and axillary body hair and enlargement of male sexual organs.
- E.g. Sex steroid secreting tumours: either from adrenal or ovarian. If adrenal, it will present with hirsutism, acne, and sexual organs enlargement. If it ovarian, females will present with secondary sexual characters.

B. Delayed puberty

Definition: Initial physical changes of puberty are not present

- by age 13 years in girls (or primary amenorrhea at 15.5-16y).
- by age 14 years in boys.

Pubertal development is **inappropriate** if the interval between first signs of puberty and menarche in girls/completion genital growth in boys is > 5 years

Causes of delayed puberty

- ***Gonadal failure either primary (defect on gonads) or secondary (defect in other place like hypothalamus and pituitary)***
 - ***E.g. Hypergonadotrophic hypogonadism. ← Primary***
 - Turner's Syndrome.
 - Post-malignancy chemo / radiotherapy / surgery.
 - Polyglandular autoimmune syndromes.
 - ***Gonadal deficiency***
 - ***Hypogonadotrophic hypogonadism (+anosmia) ← Secondary***
 - Hypothalamic/pituitary lesions (tumours, post-radiotherapy).
 - Rare gene mutations inactivating FSH/LH or their receptors .

Turner syndrome

Karyotype 45,X (45,X/46,XX, structural abnormalities of X chromosome) **Absent or an abnormal X.**

- * **Characters:**
- * **Short stature (final height 144-146 cm)**
- * **Gonadal dysgenesis**
- * **Skeletal abnormalities**
- * **Cardiac and kidney malformation**
- * **Dysmorphic face**
- * **No mental defect**
- * **Impairment of cognitive function)**

Therapy: growth hormone, sex hormone substitution

Summary

PUBERTY _ Definition:

A stage of human development when sexual maturation and growth are completed and **result in ability to reproduce** .

The signs of reaching puberty: *Menstruation and spermatogenesis* begin

. First phenotypic changes: breast development (**in female**) / testicular enlargement (**in male**)

Terms & Events

- **Thelarche:** development of breast (**first sign of maturation**).
- **Puberache:** development of axillary & pubic hair.
- **Menarche:** the first menstrual period.
- **Adrenarche:** the onset of an increase in the secretion of androgens.

Puberty – hormonal changes

* **Hormonal changes precede physical (body) changes by several years**

* ***Increased stimulation of hypothalamo-pituitary-gonadal axis***

- **Gradual activation of the GnRH (LHRH) → pulsatile, at night and it also stimulates LH release.**
- **Increases frequency and amplitude of LH pulses.**
- **Gonadotropins stimulate secretion of sexual steroids (females → estrogens and androgens, males → different types of androgens)**
- **extragonadal hormonal changes (elevation of IGF-I will stimulate the effect of GH and increases body growth in general, and adrenal steroids)**

Puberty – Female hormonal changes

Estrogen induces secondary sex characteristics:

- **Growth of pelvis. → Deposition of Ca and increase in density will give the female different shape than the male.**
- **Deposit of subcutaneous fat. → In females: beneath the breast, thigh and gluteal region.**

- Growth of internal reprod. organs, external genitalia.

Androgen release by adrenal glands increases, which causes: growth of pubic hair lowering of voice, growth of bone, increased secretion from sebaceous glands → predispose to acne

Puberty – Male hormonal changes

- LH and FSH release increases by 10 yrs. of age → this will eventually cause Spermatogenesis; androgen secretion
- Adrenals also secrete androgens. Androgens initiate growth of sex accessory structures (e.g. Prostate), male secondary sex characteristics (facial hair, growth of larynx)
- Androgens causes retention of minerals in body to support bone and muscle growth the **anabolic effect of androgens (deposition of Ca in bones and Protein in muscles)**
- Sertoli cells also secrete some estrogen .

Pubertal development is classified according to the Tanner standard

Pubertal disorders

Either Precocious puberty or Delayed puberty

Questions :

1) a 7 year old boy was brought to the pediatric clinic as his mother noticed appearance of hair in his face , axillary and pubic area and deepening in his voice. After investigation the physician diagnosed him as precocious puberty due to pituitary tumor. Which one of the following hormone profile confirms the diagnosis ?

- a) Low levels of GnRH, FSH, LH and testosterone
- b) high levels of GnRH, FSH, LH and low levels of testosterone
- c) Low levels of GnRH, high levels of FSH, LH and testosterone
- d) high levels of GnRH, low levels of FSH, LH and high testosterone

2) which one of the following is considered to be the first phenotypic change that occurs in female during puberty?

- a) Menarche
- b) Thelarche
- c) Adrenarche
- d) Pubarche

Answers : Q1 (C) Q2 (B)