

PUBERTY

**Reproduction Block
Physiology Lecture # 4
(Puberty)**

**Department of Physiology
College of Medicine
King Saud University**

PUBERTY

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

- **Accelerated *somatic growth***
- **Maturation of *primary sexual characteristics* (gonads and genitals)**
- **Appearance of *secondary sexual characteristics* (pubic and axillary hair, female breast development, male voice changes,...)**
- ***Menstruation and spermatogenesis* begin**

Puberty – Terms & Events

- Thelarche: development of breast
- Puberache: development of axillary & pubic hair
- Menarche: the first menstrual period
- Adrenarche: the onset of an increase in the secretion of androgens

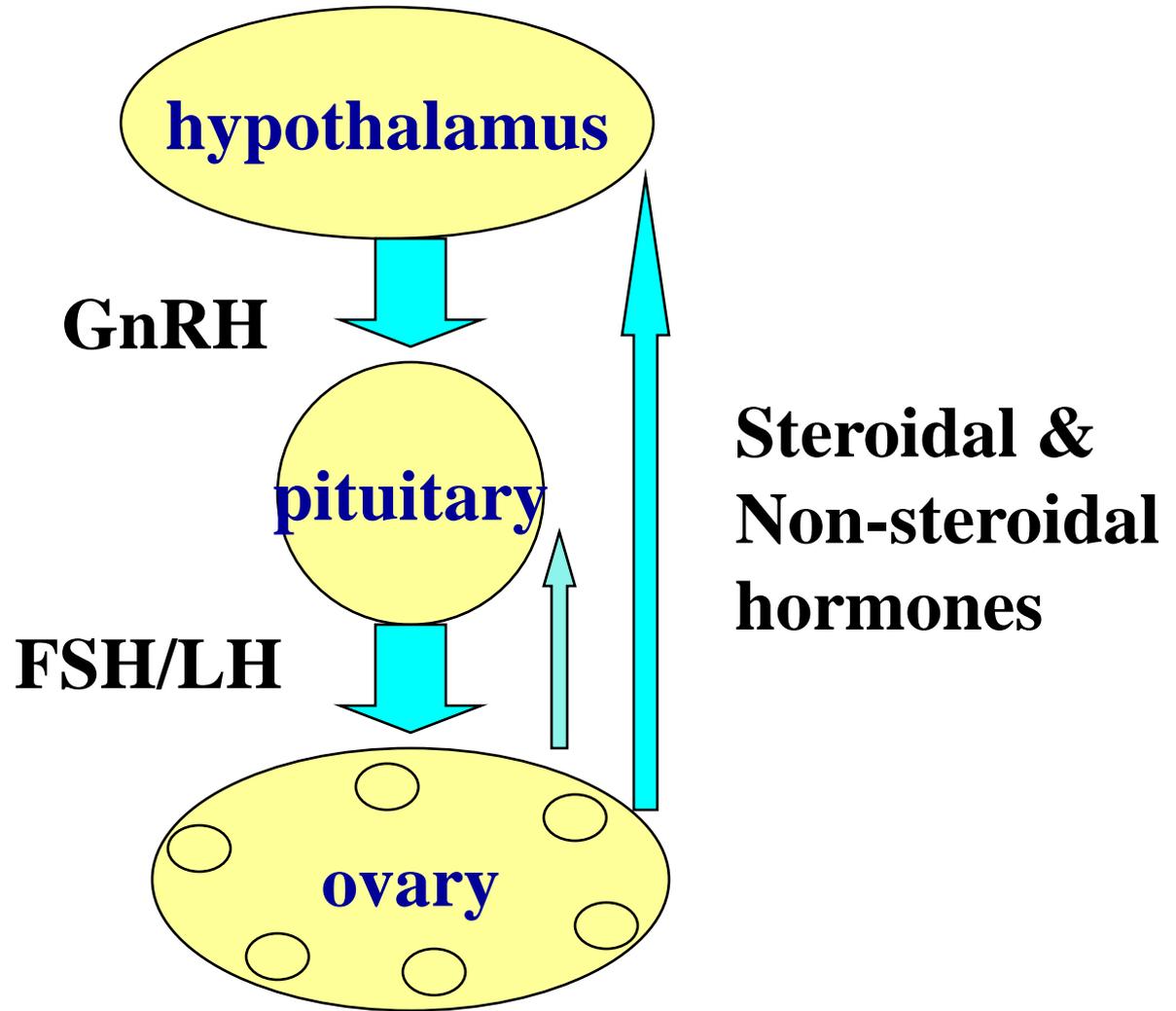
Puberty – hormonal changes

Hormonal changes precede physical changes

Increased stimulation of hypothalamo-pituitary-gonadal axis

- gradual activation of the GnRH (LHRH)**
- increases frequency and amplitude of LH pulses.**
- gonadotropins stimulate secretion of sexual steroids (estrogens and androgens)**
- extragonadal hormonal changes (elevation of IGF-I, and adrenal steroids)**

Hypothalamic-Pituitary-Gonadal Axis



Puberty – hormonal changes

Nocturnal GnRH pulsatility (LH secretion) precedes phenotypic changes by several years

First phenotypic changes:

breast development / testicular enlargement

Puberty – hormonal changes

- in young children, LH and FSH levels insufficient to initiate gonadal function
- between 9-12 yrs., blood levels of LH, FSH increase
- amplitude of pulses increases, especially during sleep
- high levels of LH, FSH initiate gonadal development

Puberty – hormonal changes

- GH secretion from pituitary also increases
- TSH (thyroid stimulating hormone) secretion from pituitary increases in both sexes:
 - 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

Puberty – Female hormonal changes

- estrogen induces secondary sex characteristics:
 - growth of pelvis
 - deposit of subcutaneous fat
 - growth of internal reprod. organs, external genitalia
- androgen release by adrenal glands increases > growth of pubic hair, lowering of voice, growth of bone, increased secretion from sebaceous glands

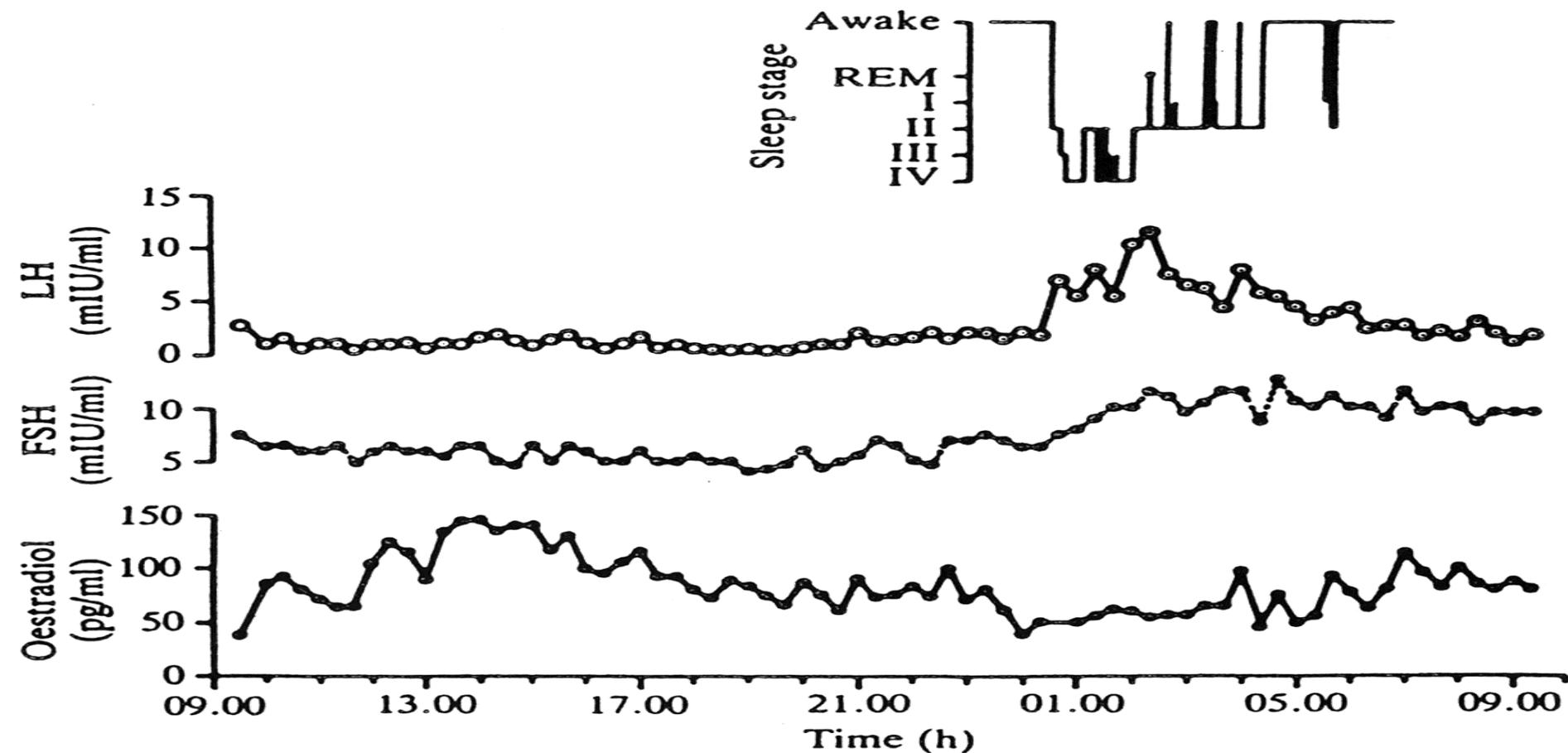
Puberty – Male hormonal changes

- LH and FSH release increases ~10 yrs. of age
- 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)

Puberty –Male hormonal changes

- androgens causes retention of minerals in body to support bone and muscle growth
- Sertoli cells also secrete some estrogen

Sleep dependent nocturnal rise in LH



Staging of pubertal development (Tanner)

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

- **Girls: *breast (B_{1-5}), pubic hair (Pu_{1-5}), axillary hair (A_{1-5}), menarche***
- **Boys: *testicular volume > 4 ml (Te), penis enlargement (G_{1-5}), pubic hair (Pu_{1-5}), axillary hair (A_{1-5}), spermarche***

Monitoring of the pubertal growth acceleration

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

Normal pubertal development

	Boys	Girls
Age of start (yrs)	12,5 (10 - 14)	11,5 (9 - 13)
First sign of puberty	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)

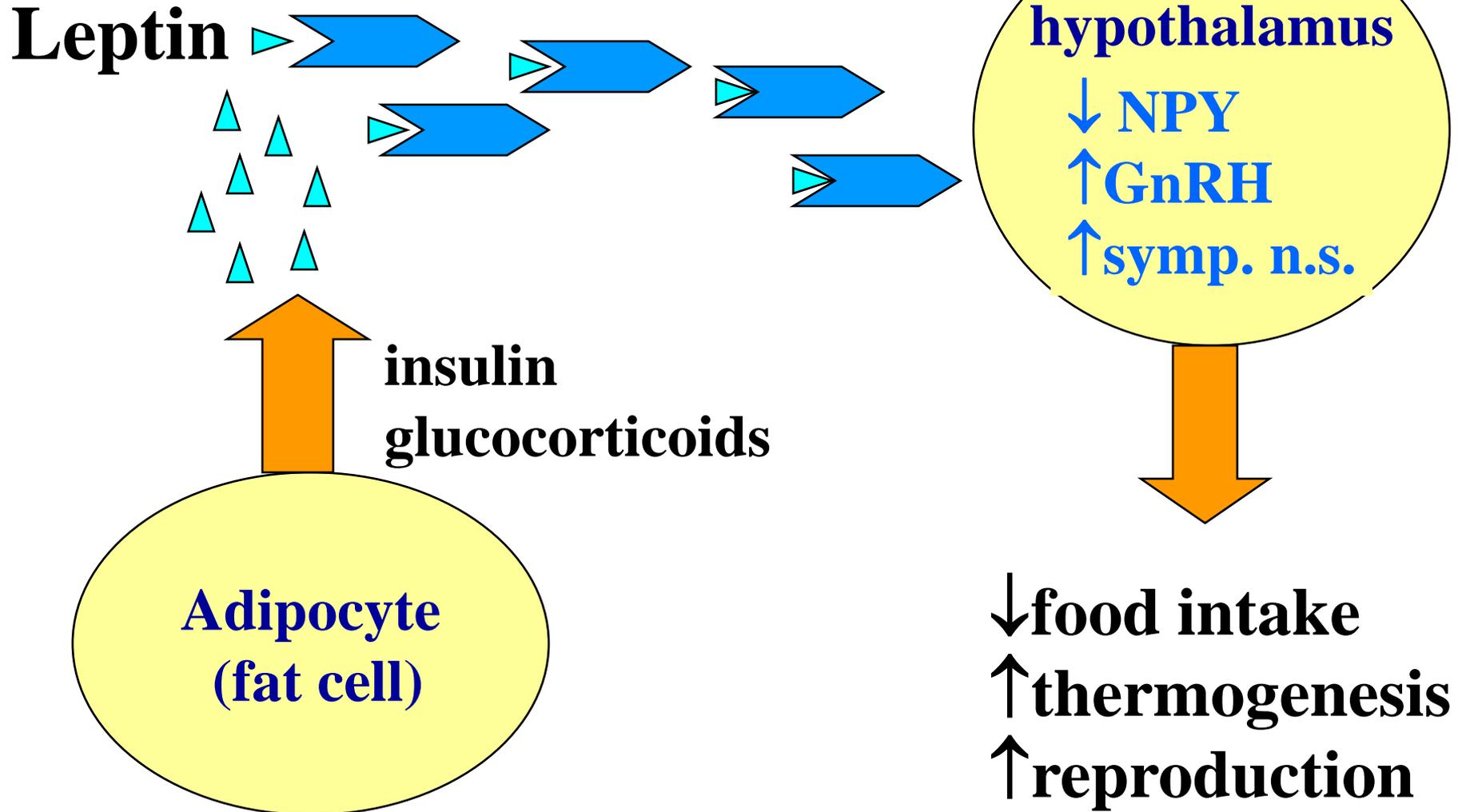
Timing of Puberty

- 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
 - “bodyfat” setpoint very noticeable in girls with fluctuating body weight due to anorexia nervosa

Potential involvement of Leptin:



Pubertal disorders

A. Precocious puberty

B. Delayed puberty

PRECOCIOUS PUBERTY

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

Girls <8 years old

Boys <9 years old

1. Gonadotrophin-dependent (true / central)
2. Gonadotrophin-independent

Gonadotrophin-dependent precocious puberty

- (true / central)
- Intra-cranial lesions
(tumours)
- Gonadotrophin secreting tumours – v. rare

Gonadotrophin-independent precocious puberty

- Precocious pseudopuberty
- No spermatogenesis or ovarian development
- FSH & LH suppressed
- Congenital adrenal hyperplasia (CAH)
- Sex steroid secreting tumours
 - adrenal or ovarian

Delayed puberty - definition

Initial physical changes (secondary sex characteristics) of puberty are not present or incomplete.

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

Pubertal development is inappropriate

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

Causes of delayed puberty

- Hypergonadotrophic hypogonadism (43%)
 - - Gonadal Failure
 - - e.g. Turner's Syndrome
- Hypogonadotrophic hypogonadism (31%)
 - Hypothalamic/pituitary lesions (tumours, post-radiotherapy)
 - Rare gene mutations inactivating FSH/LH or their receptors
- Eugonadism (26%)
 - *Mullerian agenesis*
 - Constitutional delay (*short stature & normal fertility*).

Turner syndrome

Karyotype 45,X (45,X/46,XX, structural abnormalities of X chromosome)

Short stature (final height 144-146 cm)

Gonadal dysgenesis

Skeletal abnormalities

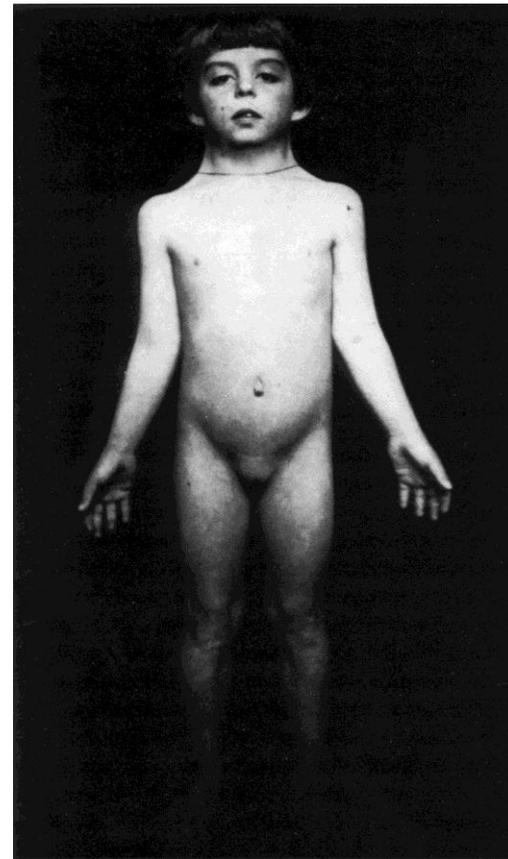
Cardiac and kidney malformation

Dysmorphic face

No mental defect

Impairment of cognitive function)

Therapy: growth hormone, sex hormone substitution



H. Turner, 1938