

PUBERTY

Physiology Lecture # 5 (Puberty)

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OBJECTIVES:

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

PUBERTY

A stage of human development when sexual maturation and growth are completed and result 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, responsible for development of pubic and axillary hair, body odour and acne.

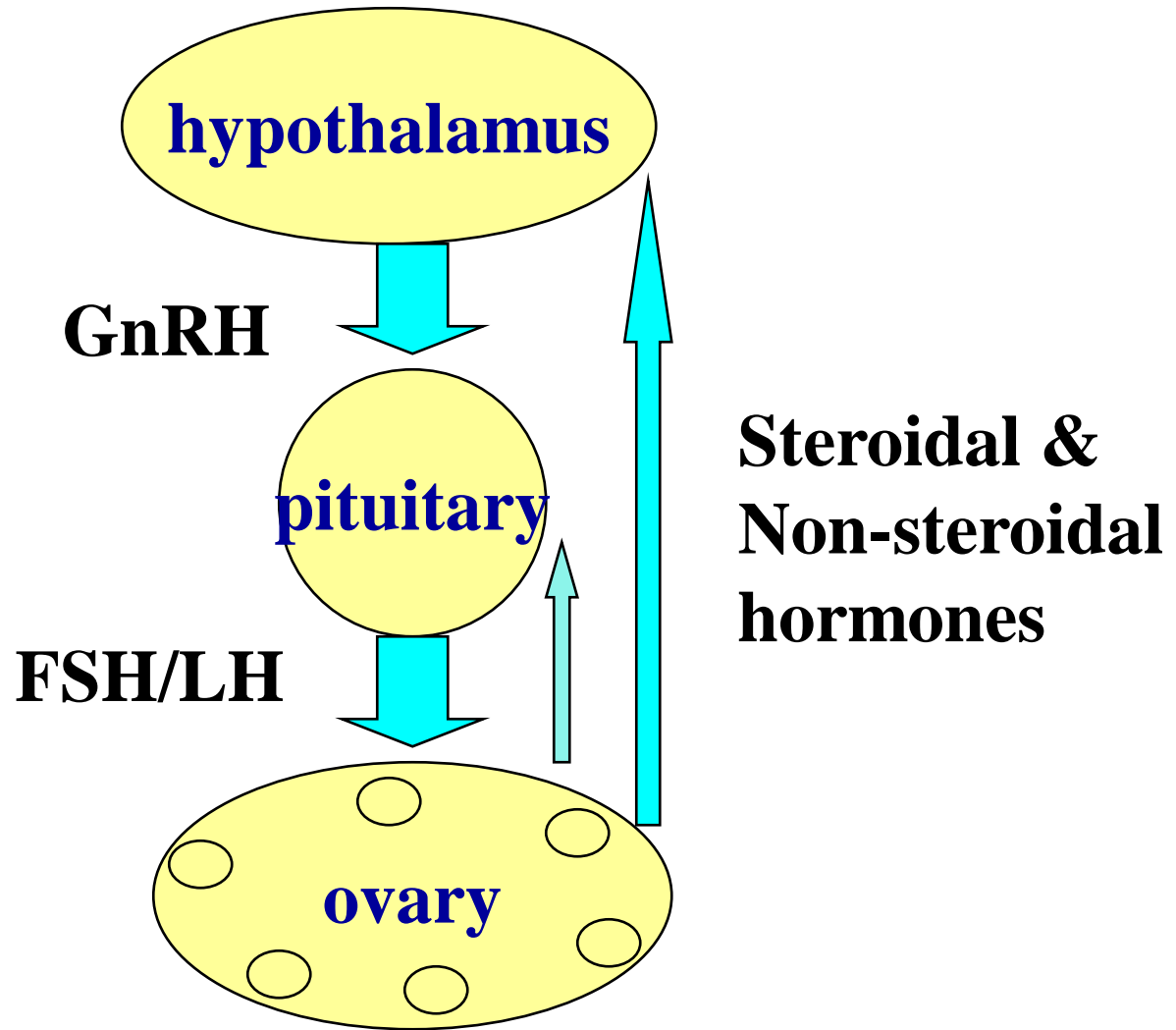
Puberty – hormonal changes

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.
- Hormonal changes precede physical changes.
- 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

Physical Changes

- 5 stages from childhood to full maturity
- Marshall and Tanner (P1 – P5)
- Reflect progression in changes of the external genitalia and of sexual hair
- Secondary sexual characteristics
 - Mean age 10.5yrs in **girls**
 - Mean age 11.5 – 12yrs in **boys**

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 (not as much as in male) → growth of pubic hair, lowering of voice, growth of bone, increased secretion from sebaceous glands.

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

Puberty: Girls

- Breast enlargement usually first sign.
- Thelarche
- Menarche usually 2-3 yrs after breast development
- Growth spurt peaks before menarche
- Pubic and axillary hair growth: sign of adrenal androgen secretion
- Starts at similar stage of apocrine gland sweat production and associated with adult body odour

Pubertal Stages (Tanner) Female

- **P1** Prepubertal
- **P2** Early development of subareolar breast bud +/- small amounts of pubic and axillary hair
- **P3** Increase in size of palpable breast tissue and areolae, increased pubic/axillary hair
- **P4** Breast tissue and areolae protrude above breast level. Further increased pubic/axillary hair growth
- **P5** Mature adult breast. Complete pubic/axillary hair growth

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

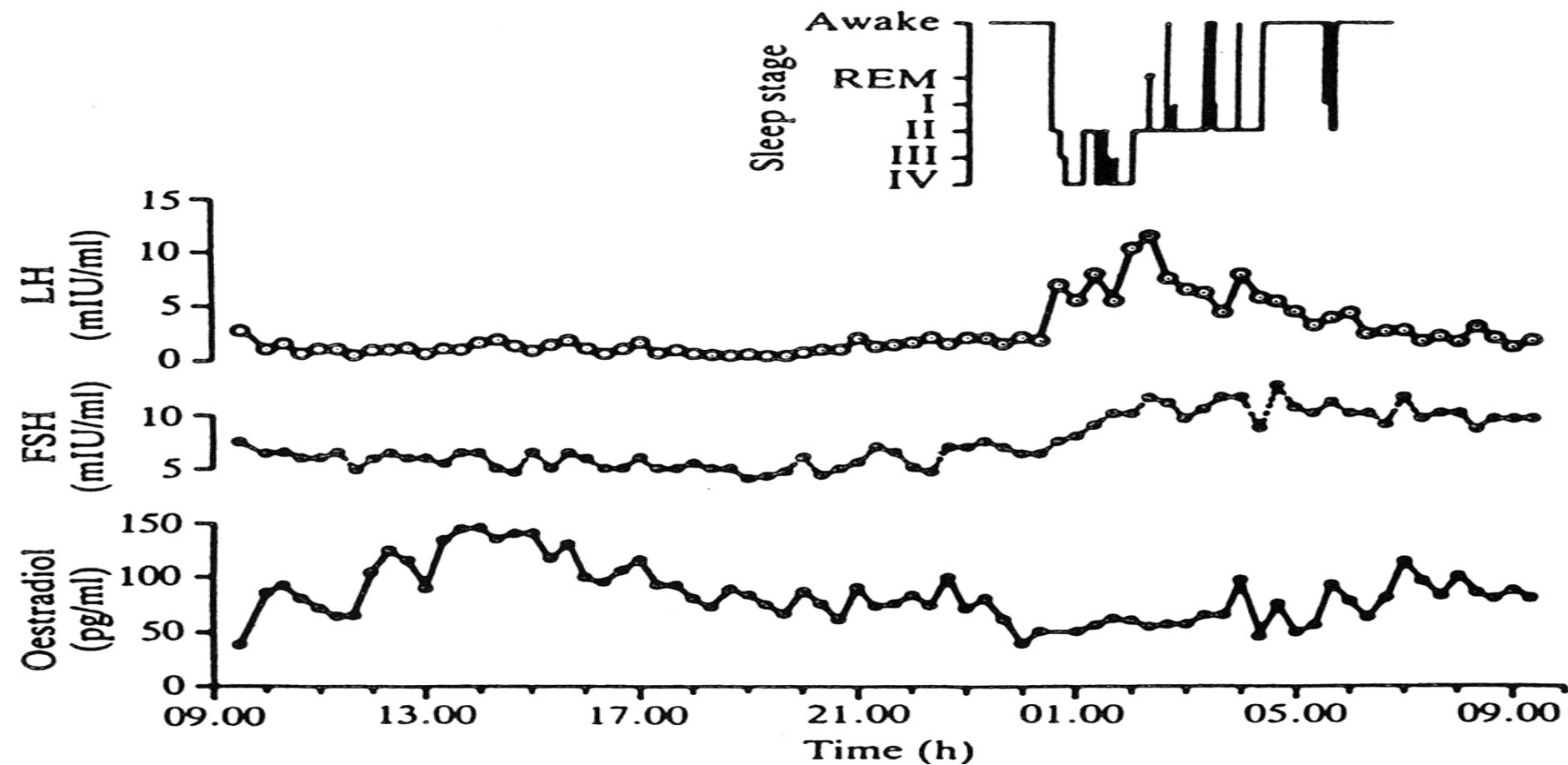
Puberty: Boys

- First signs often go unnoticed
- Testicular enlargement (12-13 yrs)
- Prepubertal testis – 2mls diameter
- Puberty begins when volume reaches 4mls
- Penile and scrotal enlargement occur approx 1 yr after testicular enlargement. Pubic hair appears at same time
- Begins of spermatogenesis; androgen secretion

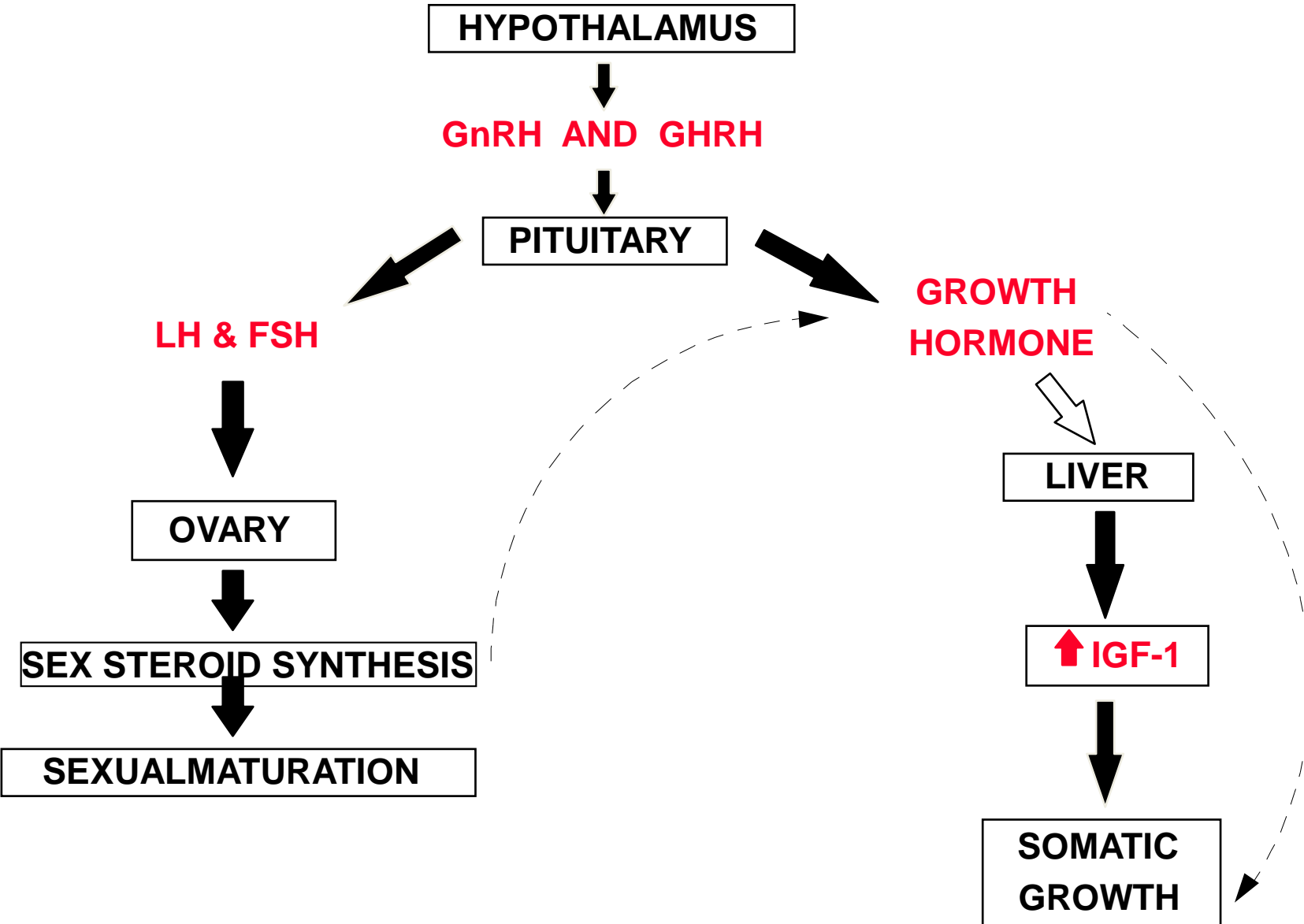
Pubertal Stages (Tanner) Male

- **P1** Prepubertal, testicular volume < 2mls
- **P2** Enlargement of scrotum and penis. Scrotum slightly pigmented. Few pubic hairs
- **P3** Lengthening of penis. Further growth of testes and scrotum. Pubic hair darker
- **P4** Penis increases in length and thickness. Increased pigmentation of scrotum. Increased pubic/ axillary hair
- **P5** Genitalia adult in size and shape. Completed pubic/axillary hair growth

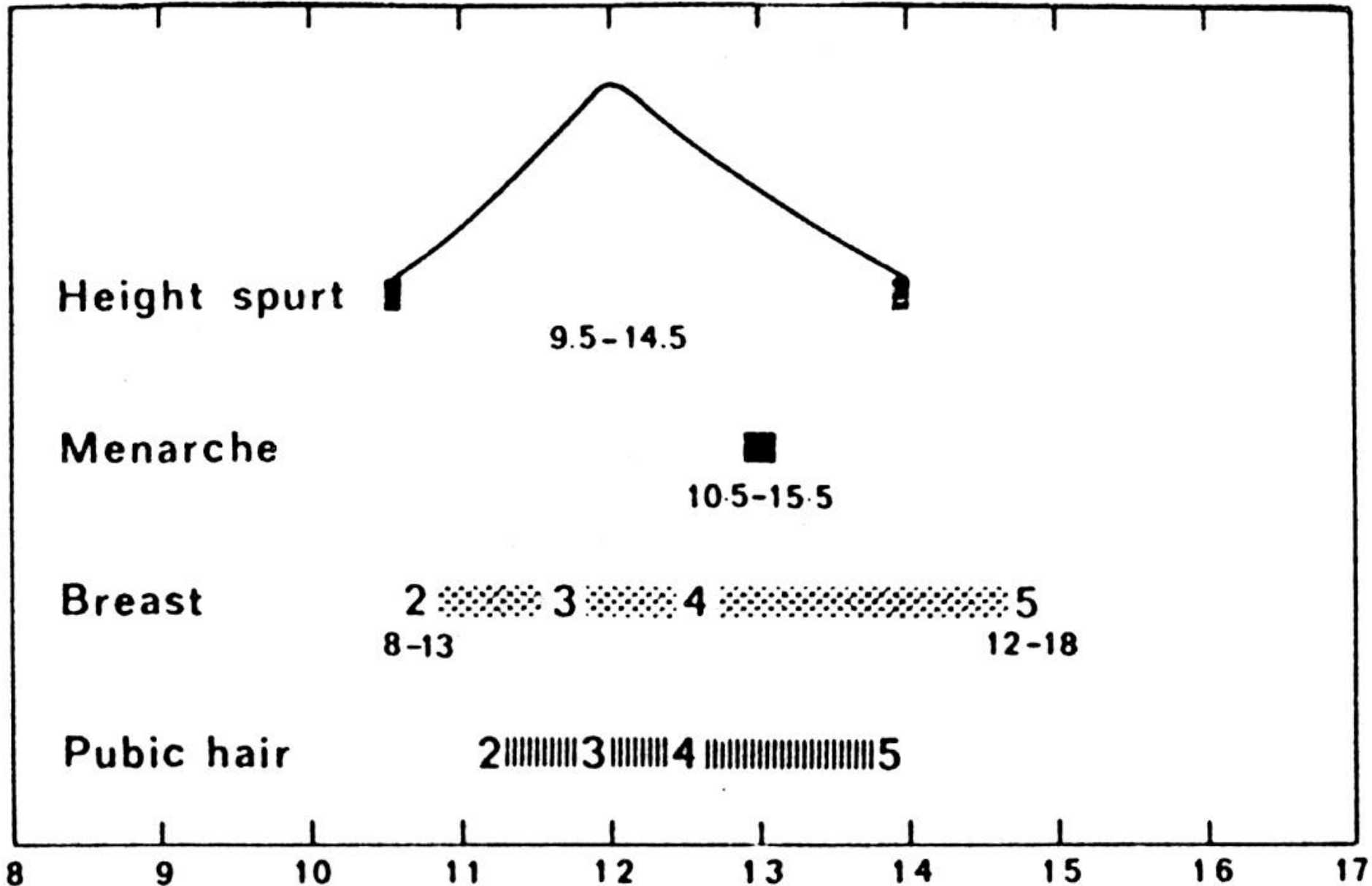
Sleep dependent nocturnal rise in LH



Puberty – hormonal changes



Sequence of normal puberty in girls



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) |

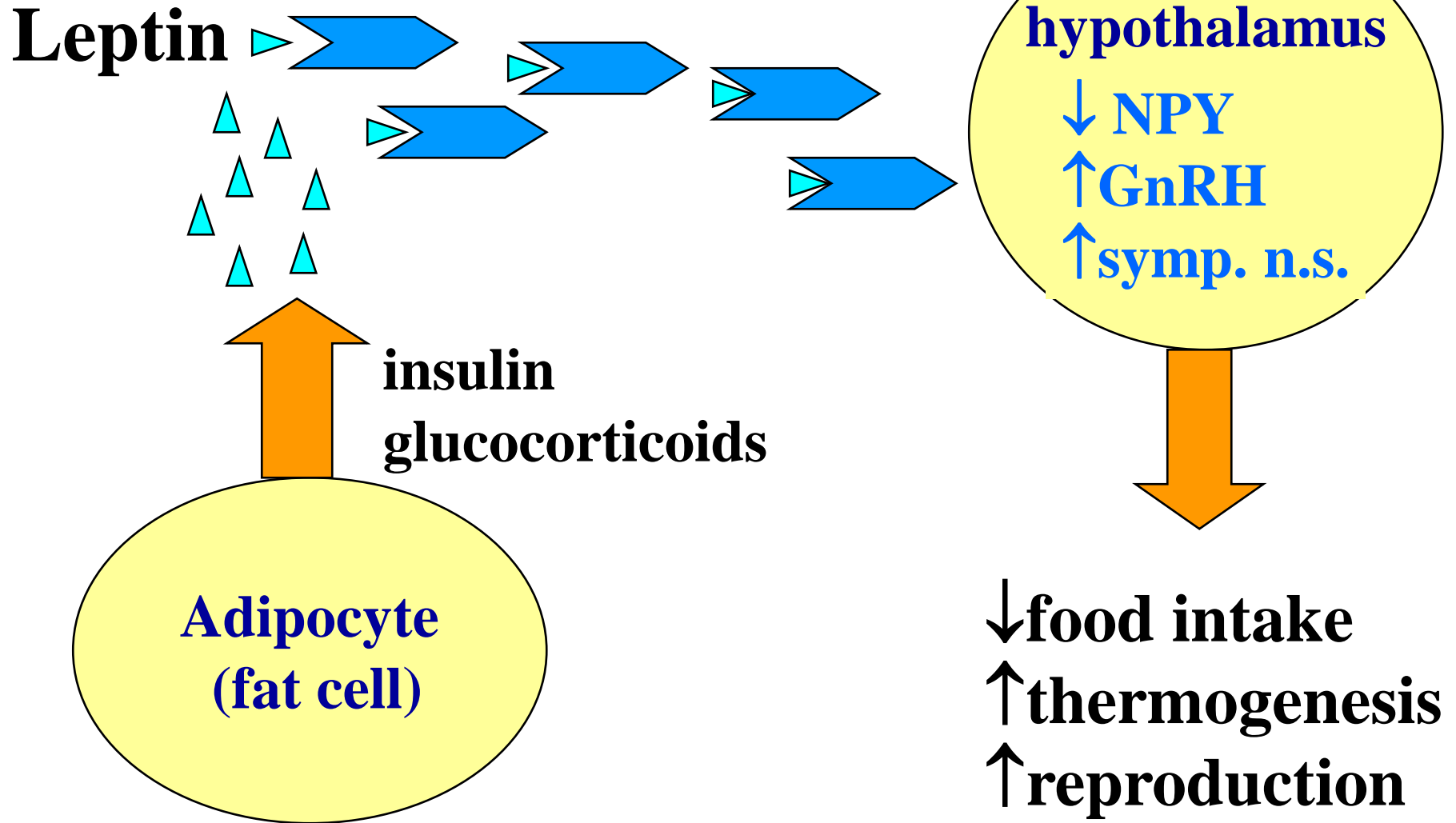
Timing of Puberty

- Genetics: 50-80% variation in pubertal timing.
- 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

- More common in females.
 - Uncommon in males (usually pathological).
 - Maybe associated with a growth spurt.
1. Gonadotrophin-dependent (true / central)
 2. Gonadotrophin-independent

Gonadotrophin-dependent precocious puberty

- (true / central)
- Intra-cranial lesions
(tumours, hydrocephalus, CNS malformations)
- 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 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

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 (Hypergonadotrophic hypogonadism)
 - Turner's Syndrome
 - Post-malignancy chemo / radiotherapy / surgery
 - Polyglandular autoimmune syndromes
- Gonadal deficiency
 - Congenital hypogonadotrophic hypogonadism (+anosmia)
 - 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)

Short stature (final height 144-146 cm)

Gonadal dysgenesis

Skeletal abnormalities

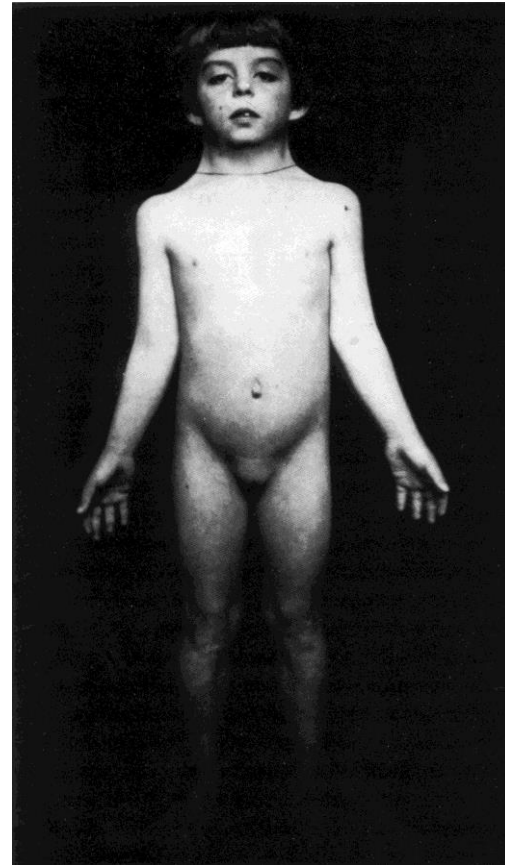
Cardiac and kidney malformation

Dysmorphic face

No mental defect

Impairment of cognitive function)

Therapy: growth hormone, sex hormone substitution



H. Turner, 1938