

# **SOME CHANGES ASSOCIATED WITH PUBERTY – An Overview**

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# What is Puberty?

- **Puberty:**
  - Period between **childhood** and **adolescence**, when **Hormonal changes** produce **development** of the **Secondary Sexual Characteristics**;
- **From a biological perspective:**
  - Puberty is stage of Physical Maturation when an individual becomes **Physiologically** capable of **Sexual Reproduction**;

- **Some biological changes that occur during puberty:**
- Changes in Neuro-secretary factors & Hormones that
  - Modulate Somatic Growth,
  - Development of Sex Glands,
    - Endocrine as well as Exocrine secretions;
- Resultant increase in Sex Steroid production induces the appearance and maintenance of Sexual characteristics and the capacity for reproduction;

## What changes indicate onset of sexual maturation?

- **Females:** Onset of Menstruation and Development of Breasts
- **Males:** Enlargement of External Genitalia, production of Semen;
- **Both sexes:** development of these Primary Sexual characteristics is accompanied by onset of a variety of Secondary Sexual Characteristics;
  - **In males:** appearance of facial and other body hair, including Pubic area and Armpits, as well as deepening of the Voice Tone;

- **In females:** hair develops in Pubic area and armpits, and the Hips begin to Broaden;
- **Both sexes:** period of Rapid development of Sweat glands;
- Generally, these changes prepare the body for Sexual reproduction, but they also have important social and emotional aspects;
  - Example the need to take care of body odour and general appearance;

# What is adolescence?

- **Adolescence:**
  - Socially defined period of Psychological development that is Socio-cultural;
  - Period of body growth and mental development that takes place between onset of Puberty and attainment of Physical and Emotional Maturity;
- During adolescence entire endocrine system is altered;
- Essentially involves **activation** of the **HPG-axis**,
  - This induces and enhances progressive Ovarian and Testicular Sex Hormone secretion that are responsible for profound Biological, Morphological, Psychological changes to which the Adolescent is subjected;

## Is Puberty the same as Adolescence?

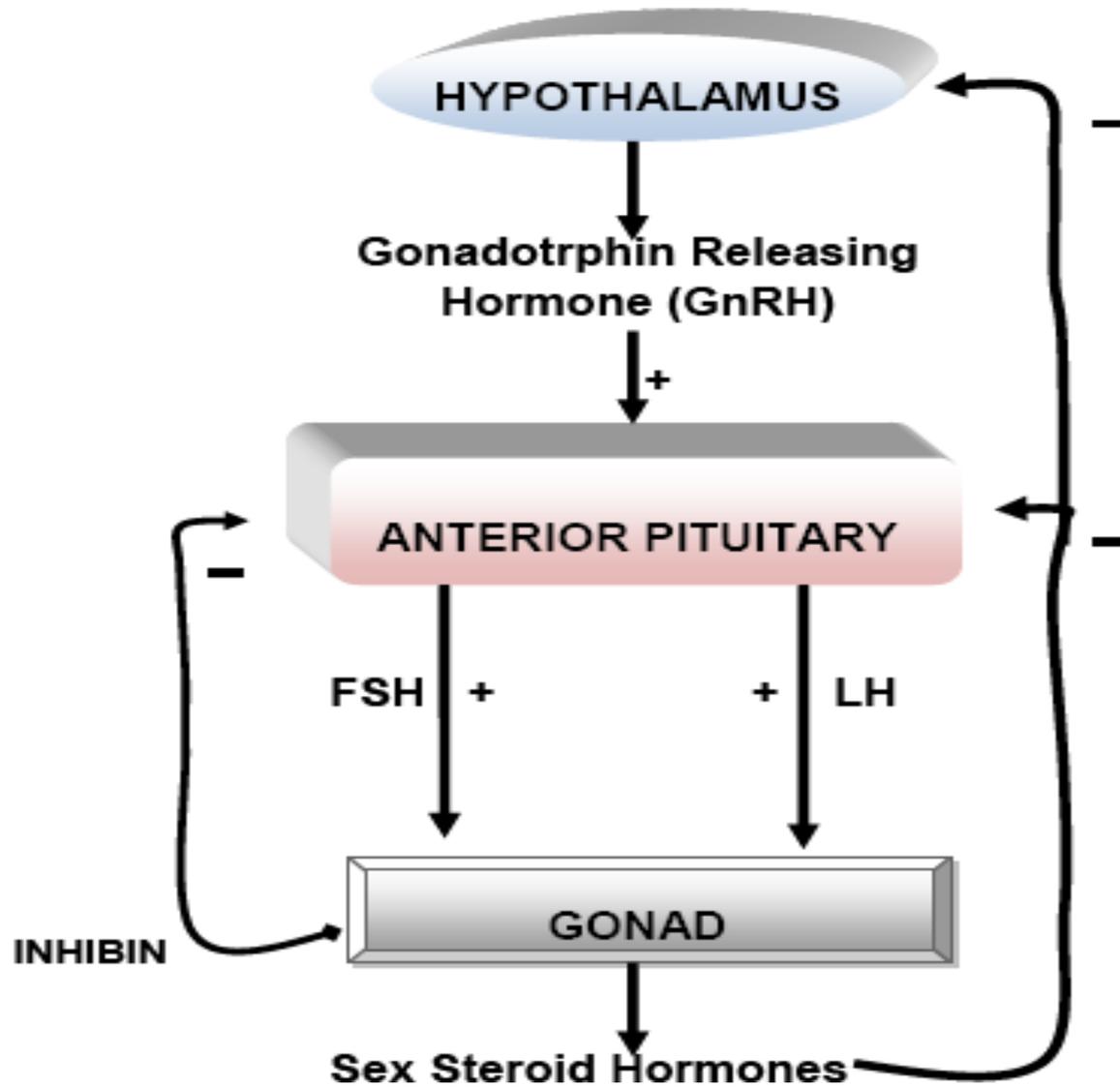
- Puberty is not the same as adolescence;
- Puberty is more of a biological and metabolic phenomenon,
- Adolescence is more socio-cultural phenomenon;
- **Puberty may or may not coincide with adolescence;**

# HORMONAL CHANGES OF PUBERTY

## What is the biochemical concept of Puberty?

- According to Biochemical concept:
  - Puberty is a centrally mediated mechanism controlled by **changes in Feedback Sensitivity to Testosterone and Estrogen;**
  - Major endocrine axis involved is: **Hypothalamus – Anterior Pituitary – Gonadal Axis (HPG-Axis)**

**Fig. 1: Schematic diagram of HPG-Axis**



## How is the HPG-axis activated during onset of Puberty?

- Primary triggering mechanism that initiates activation of HPG-axis at Puberty is still hypothetical;
- Following sequence has been suggested:
  - In childhood (pre-puberty) **level of Sex hormones are low**, but exogenous Gonadotrophins can increase production;
    - Thus, in females the Immature Ovary has capacity to synthesize Estrogen;
  - **Low levels of Sex hormones** inhibit the production of Gonadotrophins in Pre-Pubertal Girls;

- **At Puberty:**
  - Hypothalamic-Pituitary axis becomes **less sensitive to suppression** by the **low levels of sex hormones**,
  - Pulsatile release of Gonadotrophin Releasing Hormone (**GnRH**) starts to stimulate release of Luteinizing hormone (**LH**), resulting in dramatic increase of Ovarian Hormone production,
  - Follicle Stimulating Hormone (**FSH**), the main stimulus for Estrogen secretion, stimulates a Follicle to ripen, and ovulation ensues,

## **Briefly outline the (hypothetical) sequence for activation of HPG axis at onset of Puberty**

- **Just before Puberty:**
  - Sensitivity of Hypothalamus to feedback inhibition by Sex hormones falls dramatically;
- **At Puberty:**
  - Hypothalamus (GnRH release) becomes less susceptible to Feedback Inhibition by sex hormones;
  - Pulses of GnRH stimulate Anterior Pituitary to release FSH and LH;
- FSH then binds to receptors on ovarian follicle stimulating synthesis and secretion of 17-beta-estradiol (female sex hormone) and maturation of Follicle and Ovum;

- Other proteins such as **Inhibin** are also synthesized,
  - Inhibin is a negative feedback regulator of FSH release,
- When Follicle reaches full maturation and Ovum is matured, **LH** binds to cognate receptors and together with other factors such as, Prostaglandin, plays a role in Ovulation;
- Residual Follicle remaining after Ovulation becomes functional Corpus Luteum;

## IMPORTANT TO NOTE

- As central mechanisms become less sensitive to feedback inhibition, Sex hormone levels rise and Puberty is entered;
- Pattern of release of GnRH, which stimulates FSH and LH release from Anterior Pituitary, is highly relevant physiologically; **Why?**
  - Because it is involved in the Control of Sexual Development and Maturation through Puberty, and the subsequent attainment of Fertility;

## What are some Specific Changes that occurs during Puberty?

- **Changes associated with GnRH:**
  - Pre-Pubertal children: no significant LH or FSH response to IV or subcutaneous administration of GnRH is observed;
  - During adolescence, the LH response to GnRH increases progressively in both sexes;
    - Increase of FSH is less marked than LH,
- The important Neuro-Endocrine mechanisms that control onset of puberty is an increase in frequency of GnRH pulse stimulation of the Anterior Pituitary;

- **Changes associated with Gonadotrophins (LH & FSH):**
  - First demonstrable biological change of puberty is the appearance of pulsatile LH release during sleep
  - As puberty progresses, Frequency and Amplitude of secretion of LH during sleep increases, although increase secretions are found during wake period;
  - At the end of puberty, the difference between sleep and wake LH secretory patterns disappears;

- **In Girls:**
  - Plasma [**FSH**] increases progressively from 10 to 11yrs of age, approximately 1 year prior to those of [**LH**];
  - Thereafter, plasma [Gonadotrophins] continues to increase throughout puberty, but fluctuations are observed during the menstrual cycle;
- **In Boys:**
  - Significant increases in plasma [**FSH**] and [**LH**] occur from onset of puberty, closely linked to rapid increase in Testicular size characteristic of the pubertal stage;
  - Further increase in plasma [Gonadotrophins] is also observed at late puberty;

- **Changes associated with Prolactin:**
  - Plasma [Prolactin] increase modestly during female puberty but remain stable in boys;
  - Physiological role of Prolactin in the course of puberty, if any, is not fully known;

- **Changes associated with Adrenal Steroids:**
- Adrenal Androgens vary from infancy to Adolescence:
  - **A phenomenon called Adrenarche;**
- **In Girls:**
  - Dehydroepiandrosterone (**DHEA**) and Dehydroepiandrosterone sulfate (**DHEAS**) increase as early as 6 to 7yrs of age, followed within 1 to 2yrs by a corresponding increase in **Androstenedione**,
- **In Boys:**
  - **DHEA** and **DHEAS** increase as early as 8 to 9yrs of age, followed by **Androstenedione** 1 to 2yrs later;

- Adrenarche begins before rise in Gonadotrophin secretion;
- **Adrenal Androgens** are responsible for appearance of Axillary hair and, in part, for appearance of Pubic hair in Adolescent;
  - They do not play decisive role in determining the initiation of Puberty;

- **Changes associated with the Ovary:**
- Rising levels of plasma [Gonadotrophins] stimulate the ovary to produce increasing amounts of Estradiol;
- Estradiol is responsible for development of Secondary Sexual characteristics, that is:
  - Growth and development of breasts and reproductive organs,
  - Fat redistribution (Hips, Breasts),
  - Bone maturation;
- Maturation of ovary at adolescence correlates well with Estradiol secretion and the stages of Puberty;

- During Puberty plasma [Estradiol] fluctuates widely, probably reflecting successive waves of follicular development that fail to reach ovulatory stage;
- Uterine Endometrium is affected by these changes and undergoes cycles of Proliferation and Regression, until a point is reached when substantial growth occurs so that withdrawal of Estrogen results in the First Menstruation (**Menarche**);
- Plasma [Testosterone] also increase at Puberty although not as markedly as in males;

- Plasma [Progesterone] remains at low levels even if secondary sexual characteristics have appeared;
- A rise in plasma [Progesterone] after Menarche is, in general, indicative that Ovulation has occurred,
- First ovulation does not take place until 6-9 months after Menarche (**Why?**)
  - Because the positive feedback mechanism of Estrogen is not developed;

- **Changes associated with Testis:**
- Increase in Testicular size during Pre-Puberty and Puberty results essentially from development of the Seminiferous Tubules under stimulating effect of FSH;
- Long-standing pulsatile LH secretion induces the differentiation of interstitial cells into Testosterone-secreting Leydig cells, which, in turn, exert a negative feedback control on LH secretion;

- As puberty progresses, Spermatogenesis is initiated and then sustained by FSH and Testosterone produced by Leydig cells under LH control;
- **Dihydrotestosterone** shows a pattern similar to that of Testosterone,
- Proportion of Dihydrotestosterone to Testosterone decreases gradually until adulthood, when Dihydrotestosterone levels are approximately 10% of Testosterone;

## What are the roles of HGH, Insulin-like Growth Factor-I (IGF-I), and Insulin in Puberty?

- Puberty of patients with **HGH** deficiency is frequently delayed, Leydig cell function is diminished, and response to Chorionic Gonadotrophins (**h CG**) is decreased;
- HGH can restore testicular responsiveness to LH and Leydig cell Steroidogenesis;
- [Growth hormone-releasing factor] (**GRF**) and [HGH] secretion increase considerably during puberty,
- Amplitude of HGH peaks increases early in puberty;
- **IGF-I** is an important modulator of growth during childhood and adolescence;

- Adrenal Androgens seem to have no physiological role in normal growth;
- Characteristic pubertal growth spurt results mainly from synergetic effect of Sex steroids, Growth hormone, and IGF-I production, with all showing a significant increase at the time of pubertal growth acceleration;
- Insulin is also important for normal growth;
- Plasma [**Insulin**] increases throughout childhood, but the rise is particularly pronounced during puberty with a strong positive correlation with IGF-I;

## What other Biochemical changes occur during puberty?

- Several Biochemical changes occur in composition of body fluids between infancy and puberty;
- Most of the changes are gradual, and there are rarely abrupt changes to adult concentrations;
- Some of these changes include the following:
  - Plasma activity of most enzymes which are high during childhood decrease to adult values by Puberty or earlier, although activity of ALT may continue to rise, at least in men until middle age;
  - Plasma ALP activity is higher in infancy but decreases during childhood, and rises again with growth before puberty;

- **ALP** activity correlates with skeletal growth and sexual maturity than with chronological age; it is greatest at time of maximum Osteoblast activity with bone growth
- **ALP** decreases rapidly after puberty, especially in girls,
- Plasma [**Creatinine**] increases steadily from infancy to puberty parallel to development of skeletal muscle; until puberty, there is little difference between sexes,
- Plasma [**Uric Acid**] decreases from birth until 7 to 10yrs, then it begins to increase, in boys, until 16yrs,
- Under normal Physiological Conditions, levels of most test constituents remain quite constant between Puberty and Menopause in women and between Puberty and middle age in men;

## REFERENCES

- Textbook of Biochemistry, with clinical correlations, Ed. By T. M. Devlin, 4th Ed.
- Harper's Illustrated Biochemistry 26<sup>th</sup> Edition; 2003; Ed. By R. K. Murray et. al.
- Biochemistry, By V. L. Davidson & D. B. Sittman. 3rd Edition.
- Hames BD, Hooper NM, JD Houghton; Instant Notes in Biochemistry, Bios Scientific Pub, Springer; UK.
- VJ Temple Biochemistry 1001: Review and Viva Voce Questions and Answers Approach; Sterling Publishers Private Limited, 2012, New Delhi-110 – 020.