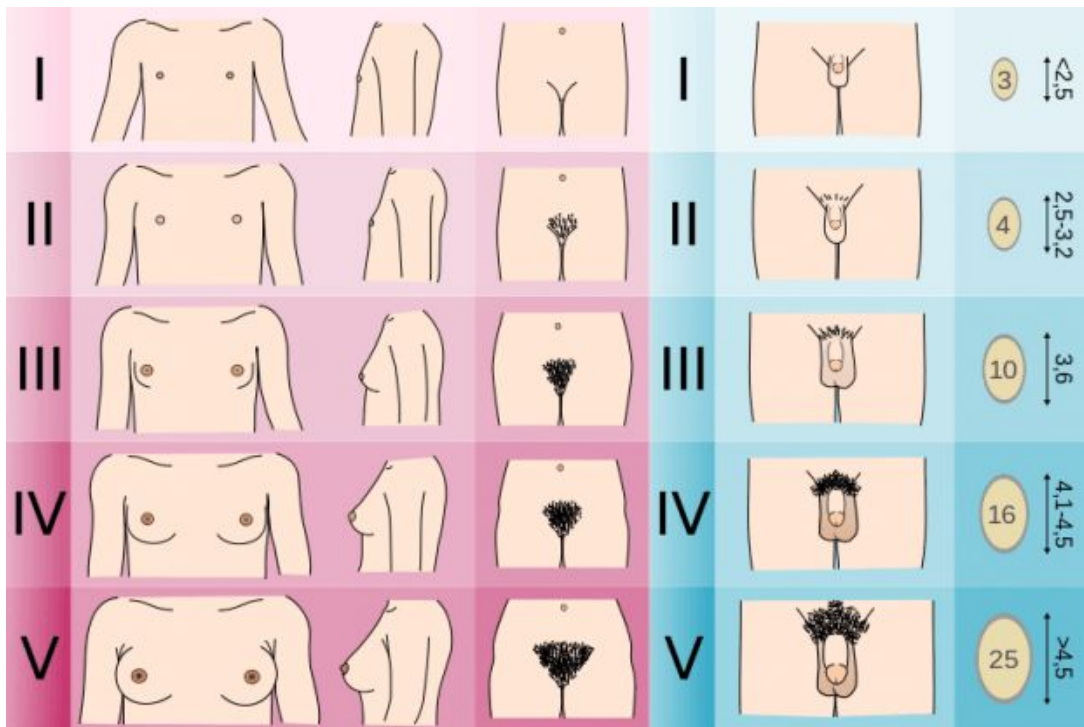


# Puberty, Precocious Puberty and Delayed Puberty

[See online here](#)

During puberty, a child's body matures into the body of an adult. During this process, pathological problems can occur. Early-onset of puberty might, for example, cause dwarfism. Psychological stress on the patient can be significant and should be taken into consideration during medical consultation. The following article provides soon-to-be physicians with a summary of puberty and its malfunctions so that a correct diagnosis and treatment can occur.



## Puberty

### Definition of puberty

The word puberty derives from the Latin word *pubertas* and means sexual maturity. It covers the period of time from the first appearance of secondary sexual characteristics until achieving full fertility.

### Onset of puberty

Over the years, the median age at the onset of puberty has decreased. The average age of a girl's menarche is 12.8 years, and the average onset of boy's voice change is 13.5 years. In general, the point in time varies from individual to individual and depends on

various factors (e.g., nutrition, environment, and climate).

## Physical change during puberty

Puberty can be divided into four different consecutive stages: thelarche, pubarche, growth spurt, and menarche.

### Thelarche

- Breast development with the formation of the breast bud and proliferation of duct and gland epithelium
- Normally occurs first
- Participating hormones: estrogen, estradiol, prolactin
- Onset: between ages 7 and 14
- Classification: Tanner



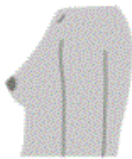
**Tanner 1**  
Prepubertal



**Tanner 2**  
Breast bud



**Tanner 3**  
Breast elevation



**Tanner 4**  
Areolar mound

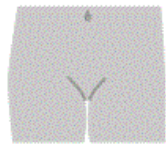


**Tanner 5**  
Adult contour

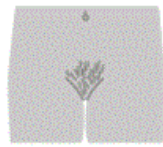
Image: 1st Signs of puberty: thelarche, by Lecturio

### Pubarche

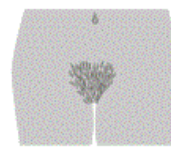
- Growth of pubic and armpit hair
- Participating hormones: testosterone, 5 $\alpha$ -dihydrotestosterone
- Onset: between ages 8 and 15
- Classification: Tanner



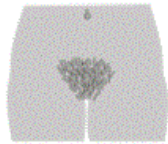
**Tanner 1**  
Prepubertal



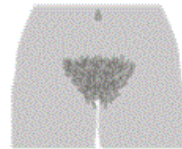
**Tanner 2**  
Presexual hair



**Tanner 3**  
Sexual hair



**Tanner 4**  
Mid-escutcheon



**Tanner 5**  
Female escutcheon

Image: 1st Signs of puberty: pubarche, by Lecturio

### Growth spurt

- Occurs in girls two years earlier than in boys about one year after first indicators of puberty
- Three to ten centimeters of growth per year
- Participating hormones: The release of sex steroids leads to the production of growth hormones, which leads to the production of IGF1 in the liver.

### Menarche

- First menstrual bleeding
- Bleeding due to estrogen withdrawal without preceding ovulation
- Onset: between ages 9 and 16
- About one year after a growth spurt
- Normally occurs later than other signs of puberty

A shift in the composition of body tissue also takes place. Girls develop more fat tissue, and boys develop more muscle tissue. Sex hormones furthermore have an impact on the skeleton, which makes it possible to link sexual maturity and bone age. These can be evaluated by an X-ray of the core of the bone of the wrist, elbow joint, or knee.

## Stages of development of breast, pubic hair and genitals during puberty

According to Tanner, the development of the female breast, as well as pubic hair growth and development of male genitals, can be organized in the following way:

<b>Tanner stage</b>	<b>Breasts (female)</b>	<b>Pubic hair</b>	<b>Genitals (male)</b>
<b>I</b>	B1: no breast development; no palpable glandular tissue	P1: no pubic hair	G1: pre-pubertal, testicular volume less than 1.5 mL, small penis.
<b>II</b>	B2: breast bud; areola begins to widen; small area of glandular tissue	P2: labia majora or mons pubis: small amount of long, downy hair	G2: testicular volume 1.6–6 mL, skin on scrotum thins, reddens and enlarges, penis unchanged.

<b>III</b>	B3: breast tissue enlarges; glandular tissue extends beyond the borders of the areola	P3: hair becomes darker and coarser, extends laterally over symphysis	G3: testicular volume 6–12 mL, scrotum enlarges further, penis begins to grow.
<b>IV</b>	B4: breast bud: elevation of glandular tissue in areola area from other breast tissue	P4: coarse hair (adult-like), less extended.	G4: testicular volume 12–20 mL, scrotum enlarges further and darkens, penis increases in length and circumference.
<b>V</b>	B5: fully developed breast; areola returns to contour of the surrounding breast.	P5: coarse hair (adult-like), extended to groin and medial thighs	G5: adult: testicular volume of more than 20 mL, adult scrotum, and penis.

## Precocious Puberty

### Definition

Precocious puberty is the onset of puberty with the development of external sexual characteristics before reaching 8 years old. Precocious puberty can create some problems. For instance, because of the early maturation of bones, an early growth spurt can end linear growth early and cause short stature.

### Epidemiology

Race may, in part, determine the onset of puberty. For example, in the United States, African American girls have an earlier onset of puberty. Some experts suggest redefining precocious puberty as onset before age 6 in African American girls and before age 7 in all other girls.

### Etiology

Factors that are correlated with the earlier onset of puberty in females are **low birth weight, obesity, international adoption**, and an absent father. While the age of onset is getting younger, the onset of menarche has not changed significantly. Precocious puberty is important to diagnose and treat because children with untreated precocious puberty tend to be much shorter in adulthood and have poor psychosocial well-being. If precocious puberty starts before the age of 6, then there is abnormal brain imaging in 20% of girls. If it starts between ages 6–8, then abnormal imaging of the brain is only 2%.

## Classification of Precocious Puberty

True [precocious puberty](#) has to be distinguished from precocious pseudopuberty. The cause of the former is either premature or excessive gonadotropin secretion by the pituitary gland or hypothalamus, which can have idiopathic reasons or can be caused by other factors, such as tumors in the central nervous system (CNS), traumas, or primary hypothyroidism. In the case of precocious pseudopuberty, sex hormones are pathologically increased without a rise in gonadotropin. Reasons for this may include tumors in the ovaries or adrenal cortex, as well as an iatrogenic influx of estrogens. Another example of precocious puberty is congenital adrenal hyperplasia.

<b>Gonadotropin-dependent</b>	<b>Gonadotropin-independent</b>
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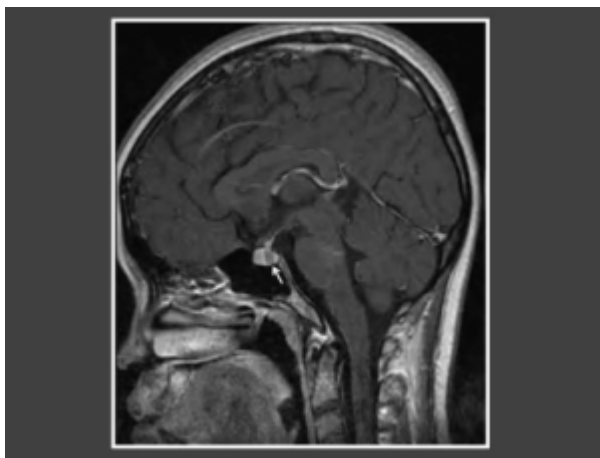
- Early activation of hypothalamic-pituitary-ovarian (HPO) axis
  - Isosexual development
  - 90% of cases are idiopathic
- Associated with CNS lesions, irradiation, and trauma

- Results from excess secretion of sex steroids from ovaries or exogenous sources
- Most common cause: autonomously functioning ovarian cysts
- Rare causes: ovarian tumors (i.e. granulosa), Leydig

## Clinical Features

The breast development starts prematurely, the onset of growth of pubic and armpit hair starts and menarche comes early. Another sign is rapid growth during early stages with the early lock of the epiphysis and therefore reduced final height.

## Diagnosis of Precocious Puberty



**Image:** A girl with global developmental delay who presented with bilateral breast enlargement. T1WI Sagittal MRI of the brain (post-gadolinium dynamic protocol) shows an intrasellar lesion representing pituitary microadenoma (arrow), by openi. License: [CC BY 2.5](https://creativecommons.org/licenses/by/2.5/)

A detailed anamnesis should be taken, and patients must be examined clinically. This should include sonography in order to evaluate inner sexual characteristics and classification of the external sexual characteristics according to Tanner stages. Furthermore, endocrinological diagnostics should be performed to distinguish central genesis from peripheral genesis. Precocious pseudo-puberty, unlike true precocious puberty, is associated with high levels of sex hormones, while the level of gonadotropin is low. In addition, a neurological examination should be carried out, followed by a magnetic resonance (MR) or computerized tomography (CT) scan to show central genesis.

## Treatment of Precocious Puberty

Primary treatment includes treating the underlying genesis of the disease. Administering gonadotropin-releasing hormone (GnRH) analogs suppresses the endogenous forming of gonadotropins due to receptor-down-regulation, which results in less secretion of sex hormones.

## Prognosis

If gonadal suppression treatment starts before bone maturation, then normal height can be achieved.

# Definition of Delayed Puberty

## Delayed puberty-related sexual maturity

The counterpart to precocious puberty is delayed puberty, in which the onset of puberty is later than usual. This means that there is either no onset of the development of secondary sexual characteristics until the 14th year of life or no menarche until the 16th year of life.

## Etiology of Delayed Puberty

### Genesis of delayed puberty

The most common reason for delayed puberty is hypogonadotropic hypogonadism with primary ovarian insufficiency. Due to the lack of sex hormone secretion, sexual maturation fails to occur. If hypogonadotropic hypogonadism causes delayed puberty, the pituitary gland does not form and release enough GnRH, which leads to a lack of luteinizing hormone (LH) and follicle-stimulating hormone (FSH). One possible reason for this might be Ulrich-Turner syndrome. With [Kallmann syndrome](#), in addition to hypogonadotropic hypogonadism, an aplastic or hypoplastic olfactory bulb is present, resulting in anosmia. Early-onset of [anorexia nervosa](#) should be considered as a psychological genesis. In rare cases, tumors in the pituitary gland or hypothalamus (e.g., hamartoma, dermoid cyst) can cause delayed puberty.

## Diagnosis of Delayed Puberty

In cases of delayed puberty, anamnesis and clinical examination should be performed in a timely manner. In addition, a chromosomal analysis should be performed to exclude Ulrich-Turner syndrome. Furthermore, determining bone age might indicate sexual maturity. Hormone levels need to be determined endocrinologically, and radiological inspection of the CNS can be useful.

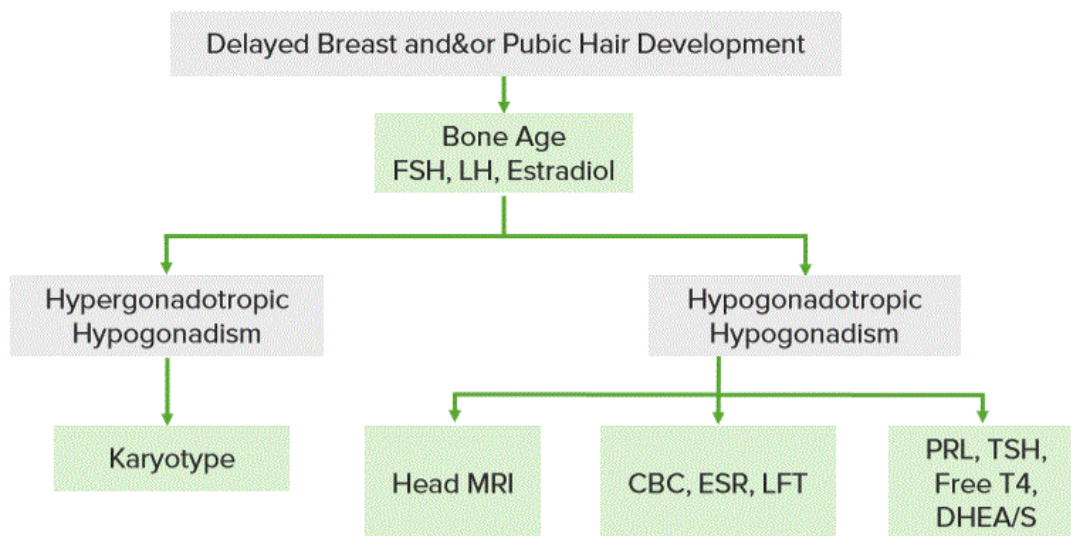


Image: Delayed puberty diagnosis, by Lecturio

# Treatment of Delayed Puberty

## Therapy of delayed puberty

The first priority is excluding possible causes of the disease. Furthermore, estrogens and gestagens should be administered.

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Notes