Puberty, Precocious Puberty and Delayed Puberty

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During puberty a child’s body matures into the body of an adult. During this process pathological faults can occur. An early onset of puberty might, for example, cause dwarfism. Psychological stress of the patients is not negligible and should be taken into consideration in 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 be conducted.

Puberty

Definition of puberty

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

Over the years, the median age at onset of puberty has decreased further and further. The average age of a girl’s menarche is 12.8 years and onset of boy’s voice change is 13.5 years. In general, it is worth stating that the point in time varies from individual to individual and depends on various factors (e.g. nutrition, environment, climate).

Physical change during puberty

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

- **Thelarche**
  - Breast development with formation of breast bud, proliferation of duct- and gland-epithelium
  - Normally occurring first
  - Participating hormones: oestrogen, estradiol, prolactin-Onset: between 7th/8th and 14th year of life
  - Classification: Tanner (see below)

- **Pubarche**
  - Growth of pubic- and armpit hair
  - Participating hormones: testosterone, 5α-dihydrotestosterone
  - Onset: between 8th/9th and 15th year of life
  - Classification: Tanner (see below)

- **Growth spurt**
  - Girls two years earlier than boys, three to ten centimeters of growth per year
  - Participating hormones: sexual steroids lead to liberation of growth hormones, which leads to liberation of IGF1 out of the liver
  - About one year after first indicators of puberty

- **Menarche**
  - First menstrual bleeding
  - Bleeding due to oestrogen withdrawal, without preceding ovulation
  - Onset: between 9th and 16th life of year
  - About one year after growth spurt
  - Normally occurring last

Furthermore, a shift in composition of body tissues takes place. Girls develop more fat tissue and boys more muscle tissue.

Sexual hormones have an impact on the skeleton, which makes it possible to link sexual maturity and bone age, which can be recorded by 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:

<table>
<thead>
<tr>
<th>Tanner stage</th>
<th>Breasts (female)</th>
<th>Pubic hair</th>
<th>Genitals (male)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>B1: no breast development, no palpable glandular tissue</td>
<td>P1: no pubic hair</td>
<td>G1: pre-pubertal, testicular volume less than 1.5 ml, small penis</td>
</tr>
<tr>
<td>II</td>
<td>B2: breast bud, areola begins to widen, small area of glandular tissue</td>
<td>P2: Labia majora or mons pubis: small amount of long downy hair</td>
<td>G2: testicular volume 1.6 – 6 ml, skin on scrotum thins, reddens and enlarges, penis unchanged</td>
</tr>
<tr>
<td>III</td>
<td>B3: breast tissue enlarges, glandular tissue extends beyond the borders of areola</td>
<td>P3: hair becomes darker and coarser, extends laterally over symphysis</td>
<td>G3: testicular volume 6 – 12 ml, scrotum enlarges further, penis begins to grow</td>
</tr>
<tr>
<td>IV</td>
<td>B4: Bud breast: elevation of glandular tissue in areola area from other breast tissue</td>
<td>P4: Coarse hair (adult-like), less extended</td>
<td>G4: testicular volume 12 – 20 ml, scrotum enlarges further and darkens, penis increases in length and circumference</td>
</tr>
<tr>
<td>V</td>
<td>B5: fully developed breast, areola returns to contour of surrounding breast</td>
<td>P5: Coarse hair (adult like), extended till groins and medial thighs</td>
<td>G5: Adult: testicular volume of more than 20 ml, adult scrotum and penis</td>
</tr>
</tbody>
</table>
Precocious Puberty

Definition

Precocious puberty – premature sexual maturity

**Precocious puberty** means onset of **puberty** with development of external sexual characteristics before turning eight years old.

Etiology and Classification of Precocious Puberty

Genesis and division of precocious puberty

**True precocious puberty** has to be distinguished from **precocious pseudopuberty**. Genesis of the first one is either premature or excessive **gonadotropin secretion** of **pituitary gland** or **hypothalamus**, which can have **idiopathic** reasons or can be explained by different reasons, like **tumors** in CNS, **traumas** or **primary hypothyroidism**. In case of precocious pseudopuberty, sex hormones are pathologically increased without rise in gonadotropin. Reasons for this might be **tumors** in **ovaries** or **adrenal cortex**, as well as **iatrogenic** influx of oestrogens. Another example for precocious puberty is **congenital adrenal hyperplasia**.

Symptoms and Clinic of Precocious Puberty

Signs for precocious puberty

**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 **early lock of epiphysis** and therefore **reduced final height**.

**Diagnosis of Precocious Puberty**

First of all, a detailed **anamnesis** has to be held and patients have to be inspected **clinically**. This should include **sonography** in order to evaluate **inner sexual characteristics** and classification of the **external sexual characteristics** according to **Tanner** (see before). Furthermore, **endocrinological diagnostics** have to be carried out in order to be able to distinguish **central** genesis from **peripheral** genesis. Precocious pseudo-puberty, unlike true precocious puberty, is associated with high levels of **sex hormones**, while **level of gonadotropin** is low. In addition to that, a **neurological examination** should be carried out, followed by **MR** or **CT** to show central genesis.

[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]

**Treatment of Precocious Puberty**

**Therapy of precocious puberty**

First of all, the underlying genesis of the disease should be treated. By administering **GnRH analogues**, the endogenous forming of gonadotropins is suppressed due to **receptor-down-regulation**, which results in less secretion of sex hormones.

**Definition of Delayed Puberty**

**Delayed puberty - belated sexual maturity**

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

Genesis of delayed puberty

The most common reason for delayed puberty is hypergonadotropic hypogonadism with primary ovarian insufficiency. Due to lacking secretion of sex hormones, sexual maturing fails to appear. One possible reason for this might be Ulrich-Turner syndrome. Furthermore, hypogonadotropic hypogonadism might be a cause of delayed puberty. In this case, the pituitary gland does not form and release enough GnRH, which leads to a lack of LH and FSH. In case of Kallmann syndrome, in addition to hypogonadotropic hypogonadism, an aplastic or hypoplastic olfactory bulb is present, resulting in anosmia.

An early onset of Anorexia nervosa might be worth considering as a psychological genesis. In rare cases, tumors in pituitary gland or hypothalamus (e.g. hamartoma, dermoid cyst) might be a cause of the disease.

Diagnosis of Delayed Puberty

In this case, anamnesis and clinical examination are expedient. In addition to that, a chromosomal analysis should be carried out in order to determine or exclude Ulrich-Turner-syndrome. Furthermore, determination of bone age might be an indicator for sexual maturity. Hormone levels need to be defined endocrinologically and radiological inspection of CNS is useful.

Treatment of Delayed Puberty

Therapy of delayed puberty

First priority is the elimination of possible reasons for the disease. Furthermore, oestrogens and gestagens need to be substituted.

Popular Exam Questions Regarding Malfunctions of Puberty

You can find the correct answers below the references.

1. Which statement about puberty is not true?
   A. The order of stages of puberty is the following: thelarche – pubarche – growth spurt – menarche
   B. Tanner stadium B3 describes an enlargment of breast tissue with glandular tissue that is bigger than the areola
   C. Tanner classification includes the development of breast, pubis hair and genitals
   D. Normally, girls experience the period of growth spurt about two years later than boys
   E. Median age of onset of puberty is decreasing

2. Following hormones do not have a direct or indirect influence on puberty or its course
A. Testosterone  
B. Prolactin  
C. Oestrogen  
D. Growth hormones (somatotrophin)  
E. Insulin

3. Which statement regarding puberty and its malfunctions is true?

A. Precocious puberty can be divided into true precocious puberty and false precocious puberty  
B. Precocious puberty results in an increased final height of the patients  
C. The most common reason for delayed puberty is hypogonadotropic hypogonadism  
D. Precocious puberty can be treated by administering GnRH analogues  
E. Congenital adrenal hyperplasia is a form of delayed puberty

References

Störungen der Pubertätsentwicklung via österreichische Gesellschaft für Kinder- und Jugendheilkunde

Correct answers: 1D, 2E, 3D

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