The Second Decade: Physiology and Health Related Issues

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Disclosure

• No conflicts to disclose
Outline

- Stages of adolescence
- Growth and development
- Sexual maturation in males and females
- Changes in body systems
- Physical health related issues
- Approach to health care for adolescents
Adolescents

• Adolescents - 10-19 years of age
• Youth - 15-24 years of age
• Young people - 10-24 years of age

Period of major changes:

• physical
• physiological
• sexual
• emotional
• behavioral

• cognitive
• psychological
• financial
• social
• cultural
Common descriptions

• *Time of physical growth and personality development*
• *Series of predictable events*
• *Confusing and ambiguous period for all*
• *Time of change*
# Stages in Adolescence

<table>
<thead>
<tr>
<th>Early Adolescence</th>
<th>Middle Adolescence</th>
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<tbody>
<tr>
<td>10-13 years</td>
<td>14-16 years</td>
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<tr>
<td>• Puberty</td>
<td>• Peer network</td>
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<tr>
<td>• Privacy</td>
<td>• Cognitive development</td>
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<tr>
<td>• Independence</td>
<td>• Control over life</td>
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<tr>
<td>• Peers as confidents</td>
<td>• Bundles of energy</td>
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<td>• Adult role models</td>
<td>• Developing adult identity</td>
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Late adolescence 17-19 years

| • Separation      |
| • Decision making |
| • Continue developing adult identity |
Puberty

- **Gonadarche** - activation of the gonads by the pituitary hormones follicle-stimulating hormone (FSH) and luteinizing hormone (LH)

- **Adrenarche** - increase in production of androgens dehydroepiandrosterone (DHEA) and androstenedione by the adrenal cortex
Hormonal changes in males

- LH stimulates the Leydig cells in the testes to produce testosterone
- Testosterone and FSH lead to an increase in testicular volume
- Testosterone induces growth of the penis, deepening of the voice, growth of hair, and increase in muscular mass
Hormonal changes in females

- FSH stimulates the growth of ovarian follicles
- FSH and LH stimulate production of estradiol by the ovaries
- Estradiol stimulates breast development and growth of the skeleton
- FSH, LH and estradiol lead to ovulation and menstrual cycles
Puberty

- In addition to sex hormones, androgenic hormones induce growth of maturation of the apocrine sweat glands and development of acne.
- Other hormones involved along the hypothalamic-pituitary axis include growth hormone-insulin like growth factor, thyroid axes, oxytocin and vasopressin.
- Chronic health issues such as HIV, malnutrition and others can delay puberty.
Severe growth and puberty delay with HIV

Weight = 17.2 kg (37.9 lbs)

Age = 17 years
### Sexual maturation stages

| Stage | Female | | Male |
|-------|--------|-----------------|-----------------|-----------------|-----------------|-----------------|
|       | Age range (years) | Breast growth | Pubic hair growth | Other changes | Age range (years) | Testes growth | Penis growth | Pubic hair growth | Other changes |
| I     | 0–15 | Pre-adolescent | None | Pre-adolescent | 0–15 | Pre-adolescent testes (≤2.5 cm) | Pre-adolescent | None | Pre-adolescent |
| II    | 8–15 | Breast budding (thelarche); areolar hyperplasia with small amount of breast tissue | Long downy pubic hair near the labia, often appearing with breast budding or several weeks or months later | Peak growth velocity often occurs soon after stage II | 10–15 | Enlargement of testes; pigmentation of scrotal sac | Minimal or no enlargement | Long downy hair, often appearing several months after testicular growth; variable pattern noted with pubarche | Not applicable |
| III   | 10–15 | Further enlargement of breast tissue and areola, with no separation of their contours | Increase in amount and pigmentation of hair | Menarche occurs in 2% of girls late in stage III | 1½–16.5 | Further enlargement | Significant enlargement, especially in diameter | Increase in amount; curling | Not applicable |

Females - breasts precede hair development and menstrual period.
Males - testicular enlargement precede hair development and penile growth.
## Sexual maturation stages

<table>
<thead>
<tr>
<th>Stage</th>
<th>Female</th>
<th>Male</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Age range (years)</td>
<td>Breast growth</td>
</tr>
<tr>
<td>IV</td>
<td>10–17</td>
<td>Separation of contours; areola and nipple form secondary mound above breasts tissue</td>
</tr>
<tr>
<td>V</td>
<td>12.5–18</td>
<td>Large breast with single contour</td>
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</table>
Factors affecting puberty

**Genetics vs. Environment Matter**

Modest acceleration of puberty in recent years:

- Increased BMI possibly the cause through peripheral aromatization of adrenal androgens in adipose tissue
- Environmental exposures with estrogenic and/or anti-androgenic effects
- Social/family stress
- Presence of an adult non-biologically-related male in the household
Sexual maturation related symptoms

- Male genital system: urethral discharge, scrotal masses, inguinal adenopathy, inguinal hernia, uncircumcised hygiene
- Female genital system - vulvar itching, vaginal discharge, dysmenorrhea, menstrual dysfunction, STDs, contraception, hygiene
- Breast- tenderness, erythema, dimpling, asymmetric masses or size, discharge, axillary adenopathy, gynecomastia in males
Growth velocity

Gaining up to 25% of adult height and 50% of adult weight
Muscle growth in boy and fat deposition in girls
Growth spurt

- Limbs accelerate before the trunk, with the distal portions of the limbs accelerating before the proximal portions.
- Growth spurt is primarily truncal.
- Peak female growth velocity - 0.5 years prior to menarche.
- The growth spurt typically lasts for about two years in both sexes.
- Modest seasonal variations in growth with greater growth occurring in the spring.
Timing of hormonal changes and growth

Patton GC, Viner R. The Lancet 2007 369, 1130-1139
Body mass

Males

Females
Body systems

- **Skin** - acne, facial and axillary hair development
- **Eyes** - frequent onset of miopia
- **Dentition** - eruption of the third set of molar teeth
- **Heart** - accentuated heart sounds, functional murmurs becoming more apparent
- **Hematology** - anemia and iron deficiency common among females
- **Musculoskeletal** - scoliosis, joint issues, Osgood-Schlatter disease (inflammation of the tibial tubercle apophysis), sport and accidental injuries, damage to epiphyseal growth plates
Bone health

- Bone growth occurs in length, followed by width, then mineral content, and then bone density
- ~50% of total body calcium is accumulated during puberty in females and 50-65% in males
- By the end of puberty males have ~50% more total body calcium compared to females
- Increase in bone density is greater in African-American than in Caucasian females
- Risk for osteoporosis during adulthood may be related to the bone calcium deposition in puberty
Drug metabolism

Figure 2. Age Dependence of the Clearance of Unbound Oral S-Warfarin after Adjustment for Total Body Weight, Body-Surface Area, or Estimated Liver Weight.

Asterisks indicate a significant difference (P<0.05) between the prepubertal group and the other groups. T bars are standard deviations. Data were adapted from Takahashi et al.76

Frequent onset in adolescence

- Polycystic ovarian syndrome
- Eating disorders (anorexia, bulimia)
- Depression, anxiety and other mental health issues
- Adulthood asthma
- Epilepsy
- Type 1 diabetes
- Autoimmune diseases (lupus, juvenile rheumatoid arthritis, thyroiditis)
- Earlier onset of puberty has been associated with shorter height and increased BMI
Infectious diseases in adolescence

Risk factors for *P. falciparum* infection in Eastern Uganda

- **Percentage sleeping under a net**
- **Prevalence of malaria parasitaemia**

Association with the long-term outcome

- 50\textsuperscript{th}-74\textsuperscript{th} percentiles accepted BMI during adolescence was associated with increased cardiovascular and all-cause mortality during 40 years of follow-up

- Overweight and obesity were strongly associated with increased cardiovascular mortality in adulthood

Mortality in adolescence

**Females**
- Lower respiratory infections: 7.3
- Diarrhoal diseases: 5.2
- Meningitis: 5.0
- HIV/AIDS: 3.9
- Congenital anomalies: 3.6
- Maternal conditions: 10.1
- Self-harm: 9.6
- Road injury: 6.1
- Diarrhoal diseases: 5.9
- Lower respiratory infections: 5.4

**Death rates (‘000)**

**Males**
- Road injury: 6.8
- Drowning: 6.8
- Lower respiratory infections: 6.1
- Diarrhoal diseases: 4.8
- Meningitis: 4.1
- Road injury: 22.0
- Interpersonal violence: 12.4
- Self-harm: 9.1
- Drowning: 6.4
- Lower respiratory infections: 5.5

**Death rates (‘000)**

WHO/UNAIDS 2016
Physical and psychological maturation

Patton GC, Viner R. The Lancet 2007 369, 1130-1139 DOI: (10.1016/S0140-6736(07)60366-3)
We do not know about second decade.....

- Triggers of puberty
- Relationship between puberty and central nervous system development
- Relationship between puberty with the health issues of adulthood
- Triggers of diseases with onset during adolescence
- Role of puberty in the formation of gender identity
- Impact of growing mismatch between biological and social maturity
Approach to health care services

• Comprehensive multidisciplinary health care including general medical care and specialized care in high-risk areas (e.g. mental health, reproductive health and substance abuse)
• Education of adolescents on health and health care services
• Encouragement of health care seeking behaviors, including independent health care
• Education and support to parents, caregivers and communities on adolescents and their needs
Second Decade continued.....