PHYSICAL GROWTH, MATURATION, AND AGING

PHYSICAL AND MOTOR DEVELOPMENT
DEPARTMENT OF BIOKINETICS AND SPORTS SCIENCE
EPPM02A
C Gouws
CHAPTER OBJECTIVES

• Describe the course of body growth and aging over the life span

• How the genes play a major role in the course of early:
  • physical
  • growth and
  • development

• Review the influence of extrinsic factors on growth and development and the increasing role of extrinsic factors as individuals proceed through the life span;

• Identify typical patterns of growth while recognising individual differences in the timing of growth, and

• Distinguish between growth and maturation.
INTRODUCTION

- Physical growth and aging are fascinating
- Humans are members of a species:
  - Experiencing many common steps
  - Processes in:
    - Growth & aging
PHYSICAL GROWTH, MATURATION, AND AGING

- PRENATAL DEVELOPMENT
  - Embryonic development
  - Fetal development
  - Fetal nourishment
  - Abnormal prenatal development

- POSTNATAL DEVELOPMENT
  - Overall growth
  - Gender
  - Height
  - Weight
  - Physiological maturation
  - Extrinsic influences on postnatal growth
PRENATAL DEVELOPMENT
PRENATAL DEVELOPMENT

- Growth process begins:
  - Ovum & spermatozoon fuse in fertilization
- Genes determine:
  - the normal aspects of development
  - inherited abnormal development.
- Extrinsic factors:
  - environment (amniotic sac in the uterus)
  - nutrients (delivered to the fetus via the placenta)
There is continuous interaction of the genetic factors and extrinsic factors in the fetus’ development.

Examples of other extrinsic factors:
- Abdominal external pressure
- Viruses and drugs
- Nutrients
• Prenatal growth is divided into 2 phase:
  • Embryonic phase:
    • Form conception to 8 weeks
  • Fetal growth:
    • From 8 weeks to birth
EMBRYONIC DEVELOPMENT

- Development begins with the fusion of an ovum and spermatozoan.
- Genetic information
  - hair
  - eye color
  - height,
  - skeletal structure contained in the deoxyribonucleic acid (DNA).
Humans have 23 pairs of chromosomes = 46.

Through a process called meiosis, each sex cell divided into:
- two ‘daughter’ sex cells and
- only one chromosome from each of the 23 pairs migrates to each daughter cell.

When fertilization occurs:
- both parents donates a set of 23 chromosomes
- reestablishing the total of 46 chromosomes
MALE REPRODUCTIVE SYSTEM
FEMALE REPRODUCTIVE SYSTEM

Female Reproductive System

Ovary
Fallopian tube
Uterus
Cervix
Vagina

Copyright © 2002 WebMD Corporation
Fetal Development

- **Fetal stage:**
  - 8 weeks to birth

- **Characterized by:**
  - Further growth
  - Cell differentiation
  - Leading to functional capacity

- **Continued growth of organs & tissue occurs in 2 ways:**
  - Hyperplasia & hypertrophy
Hyperplasia:
• An increase in absolute number of cells

Hypertrophy:

Increase in relative size of individual cell

Growth tends to proceed in 2 directions:
• Cephalocaudal
• Proximodistal
Cephalocaudal:
- head and facial structures grow the fastest
- then the upper body
- followed by the slow growing lower body.

Proximodistal:
- the trunk tends to advance,
- then the nearest parts of the limbs
- finally the distal parts of the limbs.
- Body weight increases
- Body tissues grow steadily
- Rate of growth increasing in about 5 months
- Continuing at that rapid rate until birth
Some cells have an amazing quality:

- **Plasticity:**
  - Modifiability or malleability
  - Capability to take on a new function

In regard to growth

Example:

- Some cells are injured
- Remaining cells stimulate to perform role of damaged cell
Many characteristics of fetal environment have potential to affect growth

- Negatively or Positively

Nourishment is the extrinsic factor that has the most impact on feta development.

Fetus is nourished by:

- the diffusion of oxygen
- nutrients between fetal blood
- maternal blood in the placenta.
Carbon dioxide and excretory by products are exchanged and carried away in the mother’s blood.

Fetus needs:
- energy
- nutrients
- oxygen.

Good conditions very important in meeting the need of the fetus.

Less risk of illnesses and infections!
Abnormal prenatal development can result from either genetic or extrinsic factors. Genetic abnormalities are inherited. May be immediately apparent. May remain. Congenital defects: anomalies present at birth, regardless of whether their causes are genetic or extrinsic.
CELL GROWTH AND DIFFERENTIATION

- Through mitosis the embryo divides into 2, 4, 8, and so on.
- After 4 days, the cell mass is transformed to blastocyst.
- It implants itself in the uterus.
- As the number of cells continues to grow, differentiation occurs to form specific tissues and organs.
GENETIC CAUSES OF ABNORMAL PRESHAL DEVELOPMENT

- An individual may inherit genetic abnormalities:
  - Dominant disorders: one parent passes on a defective gene.
  - Recessive disorders: a defective gene(s) from each parent.

- Abnormalities may result from:
  - new mutation
  - the alteration
  - deletion of a gene during formation of the egg or sperm.
Mutations result from:

- unrepaired damage to DNA or to RNA genomes (typically caused by radiation or chemical mutagens)
- from errors in the process of replication, or from the insertion
- deletion of segments of DNA by mobile genetic elements.
MUTATION

Point Mutation

Sugar
Phosphate
Backbone

Base pair

Adenine
Thymine
Cytosine
Guanine

Mutation

Cytosine
Guanine
Cytosine
Guanine
Radiation exposure

As fears of a meltdown in Japan rise, so do the fears of radiation exposure. What does radiation do to the human body?

Background radiation

Everybody is exposed to both naturally-occurring and artificial background radiation; levels typically range from 0.0015 – 0.0035 Sv/year.

Comparing exposures

- **10 Sv**: Fatal within weeks
- **6**: Typical levels in Chernobyl workers who died within a month
- **5**: A single dose would kill half of those exposed within a month
- **1**: A single dose could cause radiation sickness and nausea
- **0.4**: Detected level at Fukushima (as of Tuesday morning in Japan)
- **0.35**: Exposure of relocated Chernobyl residents
- **0.10**: Recommended limit for people working with radiation every 5 years
- **0.01**: Full-body CT scan
- **0.002**: Typical natural radiation per year
- **0.0004**: Mammogram x-ray
- **0.0001**: Chest x-ray
- **0.00001**: Dental x-ray
- **0.000001**: Radon gas from the ground

Symptoms of radiation exposure

Generally speaking, radiation sickness is brought on by a large dosage of radiation in a short period of time, but it has also occurred with long term exposure.

Early symptoms, exposure levels and time to symptom onset:

- **1–2 Sv**: Nausea, vomiting (6 hrs.)
- **2–6 Sv**: Diarrhea (8 hrs.), Headache (24 hrs.), Fever (3 hrs.)
- **6–8 Sv**: Lungs: Inflammation and scarring, Red blood cells: Low platelet count, spontaneous bleeding
- **8–10 Sv**: Thyroid gland: High cancer risk as the thyroid absorbs radioactive iodine-131, Lungs: Inflammation and scarring

Later symptoms:

- **Dizziness, disorientation**
- **Weakness, fatigue**
- **Hair loss, bloody vomit and stools, infections, poor wound healing, low blood pressure**

Chances of death based on exposure level:

Without medical care: 5–100%
With medical care: 95–100% (50–100%)

Radiation exposure can also increase the chances of developing cancer, tumours, and genetic damage.
Both new mutations and inherited disorders can result in single or multiple formations of:

- organ, limb or body region
- deformation of a body part
- disruptions in development resulting from breakdown of normal tissue.
EXTRINSIC CAUSES OF ABNORMAL PRENATAL DEVELOPMENT

Teratogens

- any drug or chemical agent that causes abnormal development in fetus upon
Malformation, retarded growth or life-threatening conditions can also result from other external factors:

- External or internal pressure on the infant, including pressure from another fetus in utero
- Extreme internal environmental temperature, as when the mother suffers from high fever or hypothermia;
- Exposure to X-rays or gamma rays
- Gamma rays are given off by stars, and by some radioactive substances.
- They are extremely high frequency waves, and carry a large amount of energy.
OTHER PRENATAL EXTRINSIC FACTORS

- Changes in the atmospheric pressure:
  - especially those leading to hypoxia (oxygen deficiency) in the fetus
- Environmental pollutants.
POSTNATAL DEVELOPMENT

- Educators and therapists must know how various tissues and systems advance, then age, as well as the body as a whole.
- Various body tissues and organs do not necessarily grow
  - develop and age in the same pattern as overall body size.
- We must be able to compare an individual with the average and adjust for performance expectations accordingly.
POSTNATAL DEVELOPMENT

Some of the answers to questions we might be interested in:

1. **Does one system advance more slowly than the other and delay the onset of a behaviour?**
2. **Does muscle growth keep pace with whole-body growth?**
3. **Do the muscles and skeletal framework maintain their young-adult levels of strength with aging?**
4. **Does the musculoskeletal system weaken and cause a decline in performance?**
5. **Are declines inevitable or can we do something about them?**
POSTNATAL DEVELOPMENT

- Body growth after birth is continuation of prenatal growth.
- The growth pattern is predictable and consistent but not linear (Figure 3.5a, b & Figure 3.6a, b).
- There is a rapid growth after birth followed by gradual but steady growth during childhood, rapid growth during adolescence and then leveling off.
- The growth patterns follow an S-shaped curve.
- Sigmoid curve after the Greek letter $S$. 
SIGMOID CURVE
The timing of individual’s spurts and steady growth periods is likely to vary from average.

This is called the universality and specificity principles.
Gender differences are minimal in childhood.

Boys slightly taller than girls.

Girls tend to mature at a faster pace than boys throughout childhood.

Girls begin their growth spurts when they are about 9 years old.

Age at takeoff.

Boys begin their growth spurt at about 11 years.

One third will initiate it even earlier or later.
Follows sigmoid pattern of growth.

We can approximate within what percentile an individual falls for height at a specific age, over time as well as whether the person maintains position in the group or changes.

Children tend to maintain relative percentile position in comparison to group norms after they are 2-3 years old.

On average, girls reach peak height velocity at 11.5-12.0.

Boys reach their peak height velocity at 13-5-14.0.

Height velocity faster and consequently, boys taller than girls.
WEIGHT

- Follows sigmoid pattern of growth.
- Susceptible to extrinsic factors.
- Reflects variations in the amount of muscle with exercise as well as variations in the amount of fat tissue with diet and exercise (Body Composition).
- Peak weight velocity during adolescence follows peak height velocity.
- Growth of various segments lengths and breadths reaches peak velocity before the individual reaches peak height velocity.
- Growing ‘up’ first and then filling ‘out’.
RELATIVE GROWTH

- Follows sigmoid pattern of growth.
- Specific body parts, tissues and organs have differential rates of growth.
- Refer to Figure 3.8.
- Proportions changes throughout life.
- Body proportions at birth reflect the cephalocaudal and proximodistal direction of prenatal growth.
- Newborn has a form quite different from that of an adult.
- Boys and girls have similar proportions in childhood.
In girls, shoulder and hip breadth increase at about the same rate.

Boys increase shoulder breadth in relation to hip.

This has implications for skill performance: balance.

Tissues and organs grow differently.

Refer to Figure 3.3.

80% of the brain weight is achieved by 4 yrs.

Suprarenal (adrenal glands) increase only in teenage years.

Thymus grows rapidly during childhood then decreases in relative size during late adolescence.
Tissues grow without an increase in size.

**Physiological maturation**: developmental process leading to a state of full function.

Chronological age, growth in body size and physiological maturation are related.

However, they can proceed with their own timing.

**Secondary sex characteristics**: aspects of form or structure appropriate to male or females, often used to assess physiological maturity in adolescents.

Refer to Figure 3.9.
SECONDARY SEX CHARACTERISTICS

Male
- Facial hair
- Broad shoulders
- Increased body hair
- Pubic hair
- Mature genital organs
- Body more muscular

Female
- Mature breasts
- Broader hips
- Pubic hair

beard grows
voice breaks
increased body hair
on limbs and torso
pubic hair
 grows and
genital develop

growth spurt
breasts form
hips broader
periods start
Secondary sex characteristics appear at a younger age in girls and boys who are early maturers.

Girls mature earlier than boys.

The breasts enlarge, pubic hair appears, menarche and a first menstrual cycle appear.

Average age of menarche is 12.5-13.0.

In boys, testes and scrotum grow in size, and pubic hair appears.

More mature individuals likely to be stronger and more coordinated than those who are less mature at the same chronological age.
Maturation status to be considered when designing activities and setting performance goals.
EXTRINSIC INFLUENCES ON POSTNATAL GROWTH

- Can have influence in the mother’s womb.
- Extrinsic factors have an increased influence after birth.
- Growth and maturation controlled by genes but can be sensitive to alteration by environmental factors.
- **Catch-up growth**: rapid physical growth of the body to recover some or all of retarded growth during a period of negative extrinsic influence once the negative influence is removed.
- Malnutrition.
ADULTHOOD AND AGING

- Growth ends in the late teens or early twenties.
- Some measure of body size can change in adulthood = AGING.
- Largely spearheaded by extrinsic factors.
- Height might decrease = compression and flattening of the intervertebral discs of the spinal column.
INTERVERTEBRAL DISCS

- Superior Vertebral Notch
- Facet Joint
- Ligamentum Flavum
- Intervertebral Disc
- Intervertebral Foramen
- Inferior Vertebral Notch
- Annulus Fibrosus
- Nucleus Pulposus
- Lamellae
ADULTHOOD AND AGING

- Bones also lose density as a result of progressive matrix of the skeleton.
- Loss in bone density severe in individuals with osteoporosis.
- Weight gain a problem in the early 20’s.
- Less time to exercise and prepare healthy meals as the person starts a career.
- Exercising regularly leads to gains in weight and muscle and shedding of fat.
- Older adults lose muscle tissue as a result of inactivity and to some extent lost appetite.
OSTEOPOROSIS

Normal bone matrix

Osteoporosis