Chapter 4: Prenatal Development

Objectives

- Describe the three major phases of prenatal development.
- Describe the possible effects of drugs and medications on both the mother and the developing fetus.
- Identify the possible effects of maternal diseases on the developing fetus.
- Describe the most common genetic factors known to affect prenatal growth and development.
- Identify prenatal diagnostic procedures and describe the advantages and disadvantages of each.
- Describe adequate prenatal nutrition.
- Define the major birth weight categories.
- Discuss SOGC and CSEP guidelines concerning exercise during pregnancy and the postpartum period.

Stages of Prenatal Growth

- Germinal Period
  - Conception - 2 weeks

- Embryonic Period
  - 3 – 8 weeks

- Fetal Period
  - Early - 3 to 6 months
  - Later 7-9 months

Stages of Prenatal Growth

- Germinal Period (conception - 2 weeks)
  - Oocyte (female germ cell) released from ovary and travels to uterine tube.
  - Sperm fertilizes oocyte in uterine tube.
  - Zygote travels up uterine tube, dividing continuously, creating blastomeres (group of cells).
  - Morula (minimum 12-15 cells) attaches to endometrium (posterior wall of uterus) after approximately 6 days.
  - Blastocyst (attached morula) sinks into endometrium for approximately 7 days, completing implantation.
  - Zygote is largely unchanged in size during this period - 2.5mm in size.
  - Precarious period.

Stages of Prenatal Growth

- Embryonic Period (3 – 8 weeks)
  - Embryo forms different layers of cells
    - Ectoderm – outside layer; becomes nervous system, sensory receptors, and skin
    - Mesoderm – middle layer; becomes circulatory system (heart begins to beat at 4 weeks), muscles, bones, excretory system, and reproductive system
    - Endoderm – inner layer; becomes digestive system and respiratory system.
  - Development of other pre-natal essentials
    - Placenta: Where blood vessels of mother and child intertwine
    - Umbilical cord: Connects embryo to placenta
    - Amnion: Clear fluid sack that protects embryo
  - Growth: 6mm long at 4 weeks, 4cm in size at 8 weeks
  - High risk of congenital malformation
Thalidomide – A Case Study

• **Myth:** Maternal environment is a protective shelter for the developing embryo.
• **Thalidomide:** Tranquilizing drug responsible for over 5000 malformed births in West Germany in 1950s.
• **Timing** of teratogen exposure critical.
  – Drug caused diverse deformities (e.g. malformed arms, outer ear, missing bone in hand).
  – Drug affected tissue/system that was going through greatest development at the time of exposure.

Stages of Prenatal Growth

• **Early Fetal Period (3 to 6 months)**
  – First reflex actions are felt by mother (“quickening”)
  – Fetus opens mouth and eyelids
  – Skeleton forms and hands are fully shaped
  – Structurally complete but systems need time to mature.
  – Survival of fetuses during this period?
  – Growth: 3 inches and 25 grams at 3 months, 14 inches and 2 pounds at 6 months.
• **Later Fetal Period (7 to 9 months)**
  – Adipose tissue forms
  – Brain becomes very active
  – Kicking and frequent changes in position due to cramped quarters.
  – Growth: 16 inches and 2.5 pounds at 7 months, 20 inches and 7 pounds at birth (weight triples!)

Drugs and Medications

• **Recreational drugs**
  – Alcohol
  – Cocaine
  – Tobacco
  – Marijuana (Cannabis)
**Alcohol**

- **Prevalence** (Centre for Disease Control, 2003)
  - 130,000 women in US consume alcohol during pregnancy at levels known to increase birth defects
  - 12.9% use alcohol during pregnancy
  - 2.2% binge drink
  - 3.3% drink frequently

- **Risk** (American Academy of Pediatrics)
  - There is no safe dose of alcohol for pregnant women
  - Growth retardation found with one drink per day
  - Infant symptoms related to maternal alcohol use: 1 in 300 births

**Fetal Alcohol Syndrome (FAS)**
- Cluster of birth defects resulting from prenatal alcohol exposure

**Alcohol-Related Neurodevelopmental Disorders (ARND)**
- Less severe symptoms

**Neonatal Abstinence Syndrome (NAS)**
- Withdrawal symptoms

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**Alcohol - Birth Abnormalities**

<table>
<thead>
<tr>
<th>FAS</th>
<th>ARND</th>
<th>NAS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Characteristic facial features</td>
<td>Fine motor dysfunctions, clumsiness</td>
<td>Withdrawal symptoms from minutes, hours, days after birth</td>
</tr>
<tr>
<td>Mental retardation</td>
<td>Delays in motor performance</td>
<td>Tremulousness</td>
</tr>
<tr>
<td>Attention deficit hyperactivity disorder</td>
<td>Speech disorders</td>
<td>Hyperactivity</td>
</tr>
<tr>
<td>Retarded physical growth in stature, weight, head circumference</td>
<td></td>
<td>Irritability</td>
</tr>
<tr>
<td>IQ =67</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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**Cocaine**

- **Prevalence & Risk**
  - 1 in 10 newborns affected in some major urban areas (ACOG, 2002)
  - Like alcohol, just a single use can cause severe problems

- **Prenatal Complications**
  - Constricted blood vessels in uterus
  - Heart rate and blood pressure fluctuations of mother and fetus
  - Fetal brain damage
  - Miscarriage

- **Postnatal Complications**
  - Preterm birth (25% higher incidence among cocaine users)
  - Low responsiveness / Irritability
  - SIDS (Sudden Infant Death Syndrome)
  - Mental retardation (5x greater prevalence)
  - Fine and gross motor deficiencies (even after age 2)

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**Tobacco**

- **Prevalence**
  - 12%-22% of women smoke during pregnancy

- **Concerns**
  - 2200 ingredients in tobacco leaves and smoke
    - Carbon monoxide reduces hemoglobin’s oxygen carrying/releasing capacity
    - Nicotine affects placental blood vessels
  - Fetal hypoxia (lack of oxygen to body tissues)

- **Prenatal complications**
  - Growth retardation
  - Premature rupture of membranes (birth)
  - Miscarriage
  - Stillbirth

- **Postnatal complications**
  - Low birth weight
  - Mental alertness
  - Visual alertness
  - Breastfeeding
  - Sudden infant death syndrome (SIDS)
  - Growth retardation (weight, stature, head circumference)
  - Respiratory disorders (pneumonia, bronchitis)
Tobacco

- Smoking during breastfeeding
  - "A nursing mother is in effect giving her baby a cigarette if she smokes while nursing" (Gold, 1995)

- Second hand smoke
  - Children in homes where there is second hand smoke have more respiratory problems (bronchiolitis, pneumonia, asthma)

Cannabis (Marijuana)

- Prevalence
  - 44% of women have smoked marijuana during reproductive years

- Concerns
  - Contains 400 different chemicals
  - THC – most active chemical
  - THC can cross placenta and accumulate in the fetus

- Prenatal Complications
  - Mixed findings on the effects of marijuana on embryo or fetus
  - Currently not associated with any known obstetric complications

Prescriptive Drugs

- Some mothers have chronic disease and must continue medications during pregnancy.

  - Does the drug or the mother’s poor health cause complications?

  - Some drugs may damage a body part that is growing and developing during the drug use
    - E.g. Thalidomide

  - Some drugs prescribed for mother may adversely affect the fetus in way their meant to positively affect mother
    - E.g. Medication for seizures

Nonprescriptive / Over the Counter (OTC) Drugs

- Public generally consider OTC drugs “safe”

  - BUT OTC drugs contain many chemicals to treat a wide variety of problems (e.g. cold medications often contain alcohol)

  - Can have teratogenic effect upon fetus

  - Caution is warranted during pregnancy

### Medication Table

<table>
<thead>
<tr>
<th>Medication</th>
<th>Designed to Treat</th>
<th>Teratogenic Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anticoagulants: Warfarin</td>
<td>Blood clots</td>
<td>CNS defects, Miscarriage, Eye defects</td>
</tr>
<tr>
<td>Antidepressants: Lithium</td>
<td>Bipolar Disorder</td>
<td>Congenital heart defects</td>
</tr>
<tr>
<td>Antibiotics: Tetracycline</td>
<td>Infections</td>
<td>Underdevelopment of tooth enamel and tooth yellowing</td>
</tr>
<tr>
<td>Antibiotics: Streptomycin</td>
<td>Tuberculosis</td>
<td>Hearing loss</td>
</tr>
<tr>
<td>Anticonvulsants: Dilantin</td>
<td>Seizure disorders</td>
<td>Mental retardation, Neural tube defects, Hand and face defects</td>
</tr>
<tr>
<td>Antithyroid: Propylthiouracil; Iodide; Methimazole</td>
<td>Ovareactive thyroid</td>
<td>Thyroid gland defects</td>
</tr>
</tbody>
</table>

Monday, June 16, 2008
Ontario Passes Ban on Smoking in Cars with Kids


  - $250 fine
  - Children under 16
  - 23 times the toxins when in enclosed space size of car
  - In effect in NS and BC
OTC Medications

<table>
<thead>
<tr>
<th>Generally Safe</th>
<th>Potentially Dangerous</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acetaminophen (Tylenol)</td>
<td>Aspirin: postterm pregnancy and prolonged labor; bleeding in skull of baby; maternal bleeding during delivery</td>
</tr>
<tr>
<td>Ibuprofen (Advil, Motrin)</td>
<td>Cold medications containing alcohol: FAS and ARND</td>
</tr>
<tr>
<td>Naproxen Sodium (Aleve)</td>
<td>OTC drugs designed to treat a variety of problems</td>
</tr>
</tbody>
</table>

Long term use of any OTC is not recommended.

Obstetrical Medications

- **Prevalence**
  - Millions of doses of narcotics, non narcotics, sedatives, and tranquilizers given each year
  - Average of 7 drugs per vaginal delivery
  - Average of 15.2 drugs per cesarean section delivery

- **Most Common**
  - Oxytocin – aid labor
  - Meperidine – relieve pain
  - Phenergan – relieve anxiety
  - General Anesthetic Drugs – loss of sensation / sleep
  - Regional Anesthetic Drugs – loss of sensation in 1 area

- **Concerns**
  - Enter fetal circulation and exert effects on the child within minutes of administration to the mother

Maternal Diseases

- **Viral diseases**
  - Rubella
  - Congenital rubella syndrome (CRS)
  - HIV

- **Parasitic diseases**
  - Toxoplasmosis

- **Hematologic diseases**
  - Rh incompatibility

- **Endocrine diseases**
  - Diabetes mellitus

Rubella

- **Common Name**
  - German measles

- **Prevalence**
  - Once epidemic (e.g. 15 million cases in US in 1965)

- **Symptoms**
  - Highly contagious
  - Swollen lymph nodes, mild fever, headache, aching joints, pink rash on face, body, arms, and legs
  - 20%-50% of infected may not notice symptoms

Congenital Rubella Syndrome (CRS)

- **Prevalence**
  - 20,000 newborns / year have CRS in US

- **Concerns**
  - Maternal infection leads to fetal damage (i.e., CRS)
  - Symptoms more severe in fetus than adult (rubella)
  - Severity depends on when pregnant woman incurs virus
  - Often masked during infancy – and evident only in later months/years

- **Associated defects**
  - Growth retardation
  - Mental retardation
  - Congenital glaucoma, cataracts
  - Bony lesions
  - Pneumonia
  - Hepatitis
  - Cardiac anomalies
  - Death (80%)

Incidence of rubella and congenital rubella syndrome have decreased since introduction of vaccines. (Above US trends)
HIV

- **Prevalence**
  - 7000 HIV babies born each year in US

- **Concern**
  - Easily passed on to offspring
    - In utero from the mother to the fetus
    - During delivery when the fetus comes in contact with infected blood or infected vaginal secretions
    - Through breast milk

- **Zidovudine has decreased number of HIV babies**
  - 1994: 25% of HIV infected mothers passed on to offspring
  - 2000: 4.8% of HIV infected mothers passed on to offspring
  - Given: a) during pregnancy, b) during delivery, c) 6 weeks after delivery

- **Poor prognosis for infected children**
  - Median age of survival time from onset is 2 years
  - 90% manifest symptoms by 4 years of age
  - Few live past 13 years of age

**Neurological Deterioration in HIV-Infected Children**

- Loss of previously acquired milestones
- Failure to attain developmental milestones at the expected age
- Impaired brain growth
- Spasticity or rigidity
- Muscle weakness
- Ataxia – impaired ability to control movement
- Seizures, tremor, athetosis

Toxoplasmosis

- **Prevalence**
  - 1 in 900 pregnancies in US

- **Toxoplasma gondii parasite**
  - Feline (cat) family are primary hosts of organism
  - In soil contaminated by cat’s feces (i.e. cleaning cat litter box)
  - In undercooked meats (i.e. ingested when eat red meat)
  - Called “silent infection”

- **Effects**
  - 85% of newborns will experience convulsions and mental retardation
  - 75% of newborns will have motor problems
  - 13% - deafness
  - 50% - visual problems

Rh Factor

- 4 blood types in humans
  - A, B, AB, O

- **Rh factor – rhesus factor**
  - A protein found on the blood cells of most people
  - Positive (+) indicates you have the factor (85%)
  - Negative (-) indicates you do not have the factors (15%)

- **Transfusion**
  - Across blood types stimulates recipient’s immune system to produce antibodies to destroy donor’s blood cells.

Rh Incompatibility

- Potential problem during gestation:
  - Fetus’ Rh+ blood cells escape and enter mother’s Rh- circulation
  - Mother’s body produces antibodies to fight fetal Rh+ blood cells
  - Mother’s antibodies enter fetal circulation and fight fetus’ Rh+ blood cells.
Rh Incompatibility

• In first offspring…
  – Fetal and maternal circulation do not usually mix under normal circumstances
  – Fetal blood cells may enter mother’s circulation by escaping from broken vessels in placental villi just before delivery.
  – Mother doesn’t usually develop antibodies until after baby is born – sparing 1st offspring.

• In subsequent offspring…
  – Mother will illicit antibody reaction
  – To prevent this, mother is given anti-D IgG immunoglobulin immediately after first delivery (within 72 hours).
  – Deaths from Rh incompatibility: 3.9% in 1969 to 0.5% in 1986.

Rh Incompatibility

• Erythroblastosis fetalis
  – Disease of Rh+ newborn exposed to antibodies of Rh-mother
  – Characteristics
    • Anemia
    • Immature red blood cells
    • Edema
    • Jaundice

Diabetes Mellitus

• Infants of diabetic mothers high risk population

• Fetus’ metabolic environment constantly changing
  – Normoglycemia (maternal normal blood sugar)
  – Hypoglycemia (maternal low blood sugar)
  – Hyperglycemia (maternal high blood sugar)

• Concern in 3rd trimester - Maternal hyperglycemia
  – Leads to increases in fetal glucose
  – Leads to increases in fetal insulin production in pancreas
    – Called fetal hyperinsulinemia
  – Leads to increased glycogen in fetal liver

Diabetes Mellitus - Hyperinsulinemia

• Macrosomia
  – Increased fetal insulin production leads to increased glycogen in liver
  – Increased glycogen leads to increased triglyceride synthesis in fat cells
  – Birth weight above 90th tile
  – May be responsible for adult obesity

• Inhibition of maturation of lung surfactant
• Muscle weakness
• Cardiac arrhythmias
• Permanent neurological damage

Abnormalities of Infants Born to Diabetic Mothers

• Central Nervous System
  – Spina Bifida
  – Hydrocephalus

• Congenital Abnormalities
  – Heart Defects
  – Skeletal and CNS Defects

• Macrosomia
• Musculoskeletal Deformities
• Respiratory Distress Syndrome
• Traumatic Birth Injury
  – Asphyxia
  – Facial Nerve Injury
  – Brachial Plexus Injury
  – Cesarean Section (Cephalopelvic Disproportion)
Chromosomal and Genetic Disorders

- Chromosomal Disorders
  - Down Syndrome
  - Edwards Syndrome

- Genetic Disorders
  - Phenylketonuria (PKU)
  - Cystic Fibrosis (CF)
  - Sickle Cell trait (SCT)
  - Sickle Cell Disease (SCD)
  - Fragile X Syndrome (FXS)

Chromosome Disorders

- All Body Cells
  - 23 pairs of chromosomes (i.e. 46 chromosomes)

- Reproductive Cells an Exception
  - Sperm and ovum: Only 23 chromosomes each

- At Conception
  - 23 sperm chromosomes
    + 23 ovum chromosomes
    = new individual

- Meiotic Nondisjunction:
  - During meiosis (cell division), pair of chromosomes does not separate properly
  - One sperm or ovum cell contains two members of a particular chromosome while the other member contains none
  - A cell with two chromosomes combines with a normal chromosome
  - Result is 3 chromosomes of one type (47 total)

Down Syndrome (Trisome 21)

- Prevalence
  - 1 in 700 births (greater in mothers over 35)

- Mental retardation
  - IQ between 20 and 60
  - Mental age of 8 years

- Motor delays
  - Walking delayed from age 1 to 2
  - Infant treadmill walking helps develop walking pattern
  - Emphasizes neural connections
  - Trains multiple subsystems

Edwards Syndrome (Trisome 18)

- Prevalence
  - 1 in 3000 pregnancies and 1 in 6000 births (>35)

- Fetal Complications
  - Cardiac anomalies
  - Central nervous system anomalies
  - Hydrocephalus
  - Kidney and other organ malformations

- Infant Complications
  - Low rate of survival: Median lifespan 5 – 15 days
  - Mental retardation
  - Growth deficiency
  - Respiratory and digestive malfunctions
  - Other developmental delays

Symptoms and Signs of Trisomy 21 (Down Syndrome)

- Birth weight lower than normal
- Walking delayed 1 or more years
- Speech development slow
- Fine motor control development slow
- Toilet training delayed
- Hypotonia
- Short stature
- Puberty delayed
- Respiratory infections common
- Heart disease common
- Anatomical features (i.e. close set eyes, short thick neck)
Genetic Disorders

- Phenylketonuria (PKU)
  - Prevalence
    - 1 in 14,000 births
  - Cause
    - Fetus inherits gene that suppresses the activity of a liver enzyme (i.e., phenylalanine hydroxylase)
  - Concern
    - Normally the enzyme converts L-phenylalanine to amino acid tyrosine
    - Accumulated L-phenylalanine causes disturbance in amino acid metabolism
    - This disturbance can affect the CNS (neurological, motor)
  - Detection
    - Through blood test approximately 1 week after birth
  - Treatment
    - Low phenylalanine diet

- Cystic Fibrosis (CF)
  - Prevalence
    - 1 in 2500 births
  - Concerns
    - Thick, sticky mucus secreted in the lungs
    - Repeated respiratory infections
    - Scar tissue develops on the lungs
    - Movement: Shortness of breath, easily fatigued
  - Prognosis
    - No cure
    - Due to new drugs (i.e., thins mucus) children live longer (30ish)

Cystic Fibrosis and Exercise

Benefits
- Loosen mucus in the lungs.
- Stimulates coughing.
- Cardiovascular health.
- Psychological health.

Precautions
- Build up slowly.
- Stay hydrated.
- Proper nutrition (extra calories).

Genetic Disorders

- Sickle Cell Trait (SCT)
  - Prevalence
    - 1 in 12 African Americans
  - Cause
    - Child inherits 1 normal gene for hemoglobin (Hb-A) and 1 abnormal gene for hemoglobin (Hb-S)
  - Concerns
    - Asymptomatic, live normal lives
    - No problems with physical activity
    - Can pass the SCT gene to offspring

- Sickle Cell Disease (SCD)
  - Prevalence
    - 1 in 500 African Americans, 1 in 1000-1400 Hispanic Americans
  - Cause
    - Child inherits two abnormal Hb genes (Hb-SS)
  - Concerns
    - Red blood cells are sickle-shaped (vs. donut shaped)
    - Red blood cells unable to travel through blood vessels; clump together and block blood flow
  - Treatment
    - Transfusions of red blood cells
    - New drug (hydroxyurea) turns on production of health Hb
Genetic Disorders

- **Fragile-X Syndrome (FXS)**
  - **Cause**
    - Gene mutation in FMR1 gene
  - **Effects**
    - Autism
    - Delay in early motor skills
    - Crawling, sitting, walking (i.e., age 2)
    - Poor balance, flat feet, hyperextensibility of joints
    - Difficulty playing games with other children
  - **Treatment**
    - Physical therapy
    - Adapted physical education

Prenatal Diagnostic Procedures

- **Most babies (96%) born healthy.**
  - Fewer babies born with abnormalities than ever before.

- **Woman high risk candidate if:**
  - 35 years of age at time of delivery
  - has already given birth (or has a partner who has already given birth) to child with genetic disease or birth defect
  - has a family history of genetic disease or birth defects
  - has a medical history of genetic traits

Prenatal Diagnostic Procedures

- **Common procedures**
  - Alpha-fetoprotein test
  - Triple marker screening blood test
  - Ultrasound
  - Amniocentesis
  - Chorionic villus sampling

- **Ontario’s Multiple Marker Screening (MMS)**
  - Integrated Prenatal Screening (IPS)

Alpha-fetoprotein (AFP) Test

- **Procedure**
  - Used mainly as a screening test
  - Performed at 15-20 weeks
  - Blood test measures the amount of AFP
  - High levels reflect neural-tube defects
  - Low levels reflect chromosomal abnormalities

- **Advantages and Risks**
  - Minimal evasiveness
  - High false positives

Triple Marker Screening

- **Procedure**
  - Conducted at 15-16 weeks
  - Blood test (triple marker)
    - Human chorionic gonadotropin (hCG)
    - Conjugated estriol (uE3)
    - Alpha-fetoprotein (AFP)

- **Used for detecting**
  - Chromosomal abnormalities (Downs, Edwards)
  - Neural tube defects

- **Advantages and Risks**
  - Minimal evasiveness
  - Only 40%-60% accuracy rate

Ultrasound

- **Sonogram**
  - Transmitter on abdomen
  - High frequency sound waves echo off the fetus
  - Computer enhanced picture

- **Used to detect**
  - Head size
  - Length of gestation
  - Placement and structure of placenta
  - Baby’s gender
  - Multiple pregnancies
  - Anatomical abnormalities
Ultrasound

- Advantages
  - No pain / no injection
  - Minimal time (30 mins)
  - No confirmed adverse biological effects on patients or operators (Rosen & Hoskins, 2000)

Doctors not fans of Tom Cruise’s baby gift. Sonogram machines aren’t meant for living rooms, experts say.

By Fran Kritz
MSNBC contributor
updated 2:20 p.m. ET, Tues., Dec. 6, 2005

Amniocentesis

- Procedure
  - Employed only when mother is at high risk
  - Administered between 15-20 weeks
  - Needle inserted through abdominal wall
  - Ultrasound is used to guide needle placement
  - 2 tbsp of fluid from amniotic sac removed
  - Fetal cells tested to determine abnormalities

Used to detect
  - Chromosomal abnormalities (Down Syndrome, Edwards Syndrome)
  - Neural tube defects (Spina Bifida)

Amniocentesis

- Advantages and Risks
  - 99% accuracy of abnormality detection
  - Needle may damage fetus
  - Procedure linked to miscarriages in 1 in 200 pregnancies

Chorionic Villus Sampling (CVS)

- Procedure
  - Employed only when mother is at highest risk
  - Administered between 10-12 weeks
  - Needle inserted through abdominal or cervix
  - Ultrasound is used to guide needle placement
  - Sample of the villi of the chorion collected from placenta and tested

Advantages and Risks
  - Can detect abnormalities earlier than amniocentesis
  - Carries a greater risk than amniocentesis (1 in 100 has problems, 3 in 200 linked to miscarriage)

Chorionic Villus Sampling (CVS)

A plastic catheter is inserted through the cervix and guided by ultrasound

Method 1: Chorionic Villus Sampling

Method 2: Chorionic Villus Sampling

Chorionic Villus Sampling (CVS)

A biopsy needle is inserted through the abdominal wall and guided by ultrasound
ONTARIO MULTIPLE MARKER SCREENING (MMS) PROGRAM

A provincial program available to every pregnant woman in Ontario

Integrated Prenatal Screening (IPS)

Detects Down syndrome, Edwards Syndrome, and neural tube defects (~90% of the time, with a 3% false positive rate).

Procedure

- 11-14 weeks
  - Blood test for biochemical marker of pregnancy associated plasma protein A (PAPP-A)
  - Ultrasound
- 15-16 weeks
  - Blood test for biochemical markers alpha feto-protein (AFP), unconjugated estriol (uE3), human chorionic gonadotrophin (HCG).

Maternal Nutrition

- Sedentary women need to increase caloric intake by 300 calories/day.
- Active women must make additional adjustments based upon caloric expenditure.
- Weight gain is based upon pregravid weight (weight prior to conception).
- Increases in caloric intake and weight gain should be primarily in second and third trimesters.

Recommended Weight Gain

<table>
<thead>
<tr>
<th>Pregravid BMI</th>
<th>Weight Gain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ideal</td>
<td>19.8</td>
</tr>
<tr>
<td>Overweight</td>
<td>&gt;26</td>
</tr>
<tr>
<td>Underweight</td>
<td>&lt;19.8</td>
</tr>
</tbody>
</table>

Maternal Nutrition

- Protein and Folic Acid
  - Essential for brain growth and development
  - Recommended protein increase of 42%
  - Recommended folic acid increase of 50%
  - Low levels in fetus associated with low IQ

- Grandmother Effect
  - The second generation effects of poor maternal nutrition
  - Even if a woman attains adequate nutrition throughout life, she has an increased chance of giving birth to an abnormal offspring if her mother was undernourished.

Where Does the Weight Go?

<table>
<thead>
<tr>
<th></th>
<th>Weight</th>
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</thead>
<tbody>
<tr>
<td>Baby</td>
<td>7.5</td>
</tr>
<tr>
<td>Placenta</td>
<td>1.5</td>
</tr>
<tr>
<td>Amniotic Fluid</td>
<td>2</td>
</tr>
<tr>
<td>Mother</td>
<td></td>
</tr>
<tr>
<td>Breasts</td>
<td>2</td>
</tr>
<tr>
<td>Uterus</td>
<td>2</td>
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<tr>
<td>Body Fluids</td>
<td>4</td>
</tr>
<tr>
<td>Blood</td>
<td>4</td>
</tr>
<tr>
<td>Maternal fat, protein, nutrients</td>
<td>7</td>
</tr>
<tr>
<td>Total</td>
<td>30</td>
</tr>
</tbody>
</table>

Pregnancy weight gain guidelines may be too high. April 2, 2007 | CP

The standard advice for how much weight a woman should gain during pregnancy may need to change, according to a rigorous and provocative study suggesting that even accepted weight gains may raise the risk of having an overweight toddler.

Women in the study who gained the recommended amount of weight ran four times the risk of having a child who was overweight at age three, compared to women who gained less than the advised amount. So what’s a pregnant woman to do? Clearly, she shouldn’t gain more weight than recommended, said the study’s lead author, Dr. Emily Oken of Harvard Medical School.

But beyond that, it’s too early to say whether women should try to gain less than the standards call for or shoot for the low end of the recommended range, Oken said. The latter course probably would be safe, she said.

The study appears in the April issue of the American Journal of Obstetrics & Gynecology.

The new work looked at 1,044 mothers, along with their three-year-olds. It compared how much weight the mother had gained during pregnancy with the BMI of their children. It defined “overweight” in the three-year-olds as having a body-mass index greater than 95 per cent of children of the same age and sex.

Researchers found that about half the mothers gained more weight during pregnancy than the guidelines called for, while about a third met the recommended gain. The remaining 14 per cent gained less weight than recommended.

Analysis suggested that sharing of poor health habits between mother and child doesn’t account for the outcome. And while the women in the study generally had health insurance and were well-educated, studies of other groups are finding similar results, she said.

Oken said gaining too much weight also carries risk for the mother, such as not being able to lose that weight and so being overweight or obese herself. Gaining too much weight also increases the risk of having a baby that is too large, which may lead to a difficult delivery or Caesarean section, she said.

But gaining too little weight in pregnancy raises the risk of having a low-birthweight baby, which poses a hazard to the child. So figuring out the proper weight gain is a balancing act, she said.

Lisa Bodner, an assistant professor of epidemiology and obstetrics-gynecology at the University of Pittsburgh Graduate School of Public Health, says the new work adds to previous indications that the IOM guidelines may need to be revised. Bodner, who didn’t participate in the new study, called it one of the most rigorous to address the question.

“We know that weight gain is important, we just have to find a middle-ground between too little and too much, she said.
Birth Weight

- Until recently – a newborn less than 5.5 pounds was considered 'premature'.
- But low birth weight is not always associated with premature birth.
- Premature and small full-term infants have very different problems.

Small for Gestational Age

- Two standard deviations below expected birth weight for their length of gestation
  - Low birth weight (LBW) < 5.5 pounds
  - Very low birth weight (VLBW) < 3.3 pounds
  - Extremely low birth weight (ELBW) < 1.1 pounds
- Effects on development
  - Physical growth retardation from inadequate nutrition in utero.
  - Poor brain development (mental retardation).
  - Motor problems later in life.

Appropriate for Gestational Age

- >3.3 pounds
- If preterm – at lower risk than SGA.
- Some developmental delay before 1 year.
- Catch up by 2 years.

Large for Gestational Age

- LGA
  - > 90th percentile in weight for given gestational age
  - Birth injuries common (due to large size)
    - Fracture of clavicle
    - Brachial plexus injury
  - Developmental difficulties
  - Respiratory distress syndrome
  - Developmental retardation
  - Diabetic mothers are often macrosomic and have LGA infants

Exercise During Pregnancy

- Traditional Medical Advice
  - Exercising women should reduce levels of exertion.
  - Non-exercising women should refrain from initiating strenuous exercise.
- Fetal Concerns
  - Increasing core body temperature
  - Increasing risk of congenital anomalies
  - Shifting oxygenated blood and energy to skeletal muscle, away from fetus.
- Maternal Concerns
  - More susceptible to musculoskeletal injury as connective tissue more lax and joints less stable.
  - Increased uterus and breast size alters posture and centre of gravity (lordosis - curvature in lower back, balance problems, back and hip pain).
Both Dr. Devoe and Dr. Davies regard the encouragement of exercise as an essential tool in combatting the growing problem of obesity. "If women see pregnancy as a time when they’re supposed to be sedentary, this only makes the problem of obesity worse, and obesity is a terrible problem in pregnancy -- it makes it difficult to gain a healthy lifestyle during pregnancy," says Dr. Lawrence D. Devoe, Professor and Chairman of Obstetrics and Gynecology, and Director of the Division of Maternal-Fetal Medicine, at the Medical College of Georgia, Augusta. The ACOG document is also less conservative recommendations that many physicians give their pregnant patients. "An increasing number of women are coming to pregnancy with well-established fitness routines and simply don’t want to hear about these kinds of restrictions. Many of them are hooked on exercise and will actually search out a more accommodating physician, rather than stop," he says.

The joint effort is testament to the medical shift from restrictive to permissive when it comes to pregnancy and exercise. "As we gain more insight and move forward we will probably become more and more liberal," says Dr. Gregory A. Glass, one of the principal authors and chief of maternal-fetal medicine at Queen’s University in Kingston, Ontario. Dr. Davies says the Canadian guidelines give physically fit patients more freedom to maintain an exercise program. "We’re allowing the message that if you’re not exercising, you need to start, and that message has never been said before. This joint effort in our guidelines that we’re concerned that there is a small but growing amount of evidence that if you don’t exercise during pregnancy you may be associated with some risks."

The SOGC’s newly released guidelines, “Exercises in Pregnancy and the Postpartum Period,” are the organization’s first ever document on the subject and were developed in conjunction with the Canadian Society for Exercise Physiology (CSEP). The 2 organizations claim this is the world’s first example of evidence-based guidelines for exercise in pregnancy. The joint effort is testament to the medical shift from restrictive to permissive when it comes to pregnancy and exercise.

Dr. Devoe, who is himself a marathon runner, says he has long been discouraged with the unnecessarily contraindications physicians give their pregnant patients. "An increasing number of women are coming to pregnancy with well-established fitness routines and simply don’t want to hear about these kinds of restrictions. Many of them are hooked on exercise and will actually search out a more accommodating physician, rather than stop," he says.

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### When and How to Start and Exercise Program

**First Trimester**
- Concerns about teratogenic effect of high core body temperature not demonstrated in studies.

**Second Trimester**
- Nausea, vomiting and fatigue of first trimester passed.

**Sedentary Women**
- Start with 15 minutes of continuous exercise 3 times / week.

**Elite Athletes**
- Require supervision by an obstetric care provider with knowledge of the impact of strenuous exercise on maternal and fetal outcomes.

### RISKS OF NOT Exercising During Pregnancy

- Maternal Concerns
  - Loss of muscular and cardiovascular fitness
  - Excessive maternal weight gain
  - Higher risk of gestational diabetes
  - Higher risk of pregnancy induced hypertension
  - Higher prevalence of varicose veins
  - Higher incidence of lower back pain
  - Poor psychological adjustment to pregnancy

### Contraindications to Exercise in Pregnancy

#### Absolute Contraindications
- Ruptured membranes
- Preterm labour
- Hypertensive disorders of pregnancy.
- Incompetent cervix
- Growth restricted fetus
- High order multiple gestation
- Placenta previa after 28th week
- Persistent 2nd or 3rd trimester bleeding
- Uncontrolled Type I diabetes, thyroid disease, serious cardiovascular, respiratory, or systemic disorder.

#### Relative Contraindications
- Previous spontaneous abortion
- Previous preterm birth
- Mild/moderate cardiovascular disorder
- Mild/moderate respiratory disorder
- Anemia (HB <100g/L)
- Malnutrition or eating disorder
- Twin pregnancy after 28th week
- Other significant medical conditions

### Recommendation 1

**All women without contraindications** should be encouraged to participate in aerobic and strength conditioning exercises as part of a healthy lifestyle during pregnancy.

### Recommendation 2

**Reasonable goals of aerobic conditioning in pregnancy** should be to maintain a good fitness level throughout pregnancy without trying to reach peak fitness or train for an athletic competition.
Recommendation 3

• Women should choose activities that will minimize the risk of loss of balance and fetal trauma.

Type of Exercise

• Aerobic Activities
  – Recommended: Walking, stationary biking, cross-country skiing, swimming, aqua-fit
  – Recommended: Warm-up and cool-down

• Strength Training
  – Less evidence
  – Concern: Hypotension from compression of vena cava by pregnant uterus
  – Difficulties: Abdominal exercises due to diastasis recti and associated abdominal weakness

• Flexibility Training
  – No studies on yoga and pilates in pregnant population

• Other
  – Dangerous: Scuba diving
  – Caution: Horseback riding, downhill skiing, ice hockey, gymnastics, cycling

Intensity of Exercise

Heart Rate
  – Resting increases 10-15 beats/minute.
  – Maximal exercise leads to blunted heart rate.
  – Return to resting heart rate after exercise may take longer.
  – Very little research conducted to determine fetal responses to maternal exercise

<table>
<thead>
<tr>
<th>Maternal Age</th>
<th>Target Zone</th>
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<tr>
<td>&lt;20</td>
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<td>130-145</td>
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<tr>
<td>&gt;40</td>
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</tbody>
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Borg’s Rating of Perceived Exertion

- 6 – very very light
- 7 – very light
- 8 – somewhat light
- 9 – fairly light
- 10
- 11 – somewhat hard
- 12
- 13 – somewhat hard
- 14
- 15 – hard
- 16
- 17 – very hard
- 18
- 19 – very very hard
- 20

Recommendation 4

• Women should be advised that adverse pregnancy or neonatal outcomes are not increased for exercising women.

Recommendation 5

• Initiation of pelvic floor exercises in the immediate post-partum period may reduce the risk of future urinary incontinence.

Recommendation 6

• Women should be advised that moderate exercise during lactation does not affect the quantity or composition of breast milk or impact infant growth.
Pregnancy barely slowed Paula Radcliffe at NYC Marathon

Marathon Nov 21, 2007 – J. Ridley

Remarkably, 34-year-old Radcliffe was running right up until the day before she went into the hospital to be induced. “I wouldn’t actually call it training because I changed the intensity and focus,” she said. “It was 35-40 minutes every other day and, in between, I was doing twice-daily sessions on an exercise bike because running was uncomfortable on my bladder.”

She started walking and jogging again, alternating in one-minute intervals for 20 minutes, just 12 days after the birth, and resumed her training schedule four weeks later. “I think it was good for me and the baby to stay fit during the pregnancy,” she said. “It’s been medically proven that it helps the baby cope with the stress of delivery and fluctuations in heart rate. “But, in my case, I don’t think being a professional athlete particularly helped my delivery because my abdominal muscles were so strong, they didn’t want to relax and dilate!”

“I was able to employ the same breathing and concentration techniques during labor which I use when I’m running.”

Isla arrived naturally following an epidural, 14 hours after Radcliffe was induced. She breast-fed for five months. Dr. Ilana Brownstein, an OB/GYN at New York Presbyterian-Weill Cornell Medical Center, said most moms-to-be - as well as women wishing to become pregnant - benefit from moderate, not extreme, exercise. “It is easier to get pregnant when you are at a healthy weight and in good physical shape,” she said. “If there are no other medical issues, exercising during pregnancy is recommended. However, it is not a time to pick up a new activity or do a sport which might cause you to fall, such as bike riding, climbing, snowboarding or skiing.” She said women who became pregnant through IVF or AI are often advised to take extra precautions in the first trimester.