Module 2.1: Skeletal Muscle Structure and Function

**Muscle Specialization**

All muscles fall into one of three categories

- ___________________________ Muscle: Involuntary muscle; controlled by the autonomic nervous system. Has no striations!
  - Located in the walls of blood vessels and throughout internal organs.

- ___________________________ Muscle: Controlled by the autonomic nervous and endocrine systems.
  - Located only in the heart

- ___________________________ Muscle: Voluntary muscle; controlled consciously by the somatic nervous system.
  - More than 400 different skeletal muscles located throughout the body

Primary Function of Skeletal Muscle

- Conversion of ____________________________ to mechanical movement.
  - Creates force production for locomotion.
  - Creates force production for postural support.
  - Creates force production for breathing.
  - Creates heat production during cold stress (shivering).

**Skeletal Muscle Structure**

Connective Tissue Coverings

- The mechanical movement of the muscles strain the ____________________________
  tissues, which transfers force to the ____________________________ which moves the bone.

- Epimysium – “Epi” meaning ____________________________ – Surrounds entire muscle
• Perimysium – “Peri” meaning around – Surrounds fascicles (bundles of muscle fibers)

• Endomysium – “Endo” meaning ___________________________ – Surrounds individual muscle fibers

**Individual Muscle Fiber**

• Each muscle fiber is a single muscle cell or ________________________________.

• In Skeletal Muscles, myocytes are multinucleate (more than one nucleus per cell).

• The **sarcolemma** is the cell membrane of a myocyte.

• The **sarcoplasm** is the cytoplasm of a myocyte.

  *Note: The prefix “sarco” refers to flesh*

• Sarcoplasmic Reticulum – Releases ________________________________ during muscle contraction. Absorbs calcium ions during relaxation.

• Transverse Tubules – Run perpendicular to the myofibril. Major site for the coupling of excitation and contraction. Open to extracellular fluid.

• Myofibrils – Contain contractile proteins.

**Myofibrils**

• The basic unit of a muscle.

• Contractile proteins are organized into thin filaments and thick filaments, which repeat along the length of the myofibril in sections called sarcomeres.

  - ____________________________________________ are the smallest functional units of myofibril.

**Sarcomeres**

• Sarcomeres have a specialized arrangement of actin and myosin filaments which run in parallel to each other along the length of the muscle fiber.

  - ________________________________ (thin filament) - Provides binding sites for Myosin.

  - ________________________________ (thick filament) - Long, fibrous tail and “globular heads”, which binds to Actin.

**Sliding Filament Theory**

• In its simplest form states that muscle fibers shorten when Myosin protein filaments pull together Actin protein filaments.
• ____________________________ dependent binding:
  • The sarcoplasmic reticulum releases calcium into sarcoplasm.
  • The calcium binds to Troponin, which “unlocks” Tropomyosin from blocking the binding sites on ____________________________.

• ____________________________ dependent release:
  • Once the ____________________________ is able to form a “Cross-Bridge” with the actin, it will begin a “Power Stroke”.
  • ATP is required to release the “Cross-Bridge” and prepare the myosin head for the next “Power Stroke”.

• The Full Cycle:
  • ____________________________ is pumped into the sarcoplasm.
  • Calcium binds to Troponin, which stops Tropomyosin from blocking binding sites.
  • The ____________________________ forms a cross-bridge with the actin.
  • The myosin head completes a power-stroke.
  • ____________________________ binds to the myosin head, releasing the cross-bridge.
  • Calcium ions are sucked back into the sarcoplasmic reticulum.
  • ATP is hydrolyzed to provide energy for the next power-stroke.

**Sarcomere Bands**

• Z discs – Connection between ____________________________ filaments in different sarcomeres

• ____________ zone – Gap between actin filaments within a sarcomere.

• I band – Gap between myosin filaments across two sarcomeres.

• A band – Length of the ____________________________ filament.
During contraction, the I band and H zone ________________

While the A band ________________

Force Variation in Sarcomere Length

- The greatest amount of force can be generated with the Actin and Myosin overlapping
  ________________ of their filaments.
  - Too little overlap means little force can be generated.
  - Too much overlap and there is nowhere for the myosin to move the actin.

SKELETAL MUSCLE FUNCTION

- The ________________ is comprised of a single alpha (α) motor neuron and the muscle fibers it innervates.
- α-motor neurons have large-caliber, heavily mylinated fibers to ________________ conduct action potentials.
- Once the action potential reaches the motor end plate, ________________ (ACh) is released at the neuromuscular junction.
- If enough ACh binds to receptors on the sarcolemma, an action potential is transmitted the full length of the muscle fiber
- The action potential then triggers calcium channels in the ________________ which allow calcium to flow into the cell, and activates calcium release channels in the sarcoplasmic reticulum.

SKELETAL MUSCLE TYPE

- Fast Fibers - Type II fibers are better suited for anaerobic activity
  - Type ________________ fibers play a major role in high intensity exercise
  - Type ________________ fibers are activated when the force demanded of a muscle is high
- Slow Fibers - Type ________________ fibers
  - Higher aerobic endurance
- Well suited for low-intensity endurance activities

<table>
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<tr>
<th>Characteristics</th>
<th>Fast Fibers</th>
<th>Slow Fibers</th>
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<tr>
<td># Mitochondria</td>
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<tr>
<td>Efficiency</td>
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<td>Low</td>
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<td>Resistance to Fatigue</td>
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<td>Fastest</td>
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<tr>
<td>Force Generated</td>
<td>High</td>
<td>Moderate</td>
</tr>
</tbody>
</table>

Fiber Type Characteristics
- Type II muscle fibers also have:
  - ____________________________________________________________ alpha motor neurons
  - Faster nerve conduction velocity
  - More highly developed Sarcoplasmic Reticulum which outputs more calcium.
  - Maximum velocity is always achieved at the _______________________________________.
  - At any absolute force, velocity is greater in __________________________________________ fiber muscles.

Motor Recruitment
- **Size Principle**: Motor units recruited in order of size of ____________________________.
  - But we never recruit 100% of the available fibers!
  - This strategy provides optimal ____________________________________________________.

Fiber Type Proportion
- Most individuals muscles are made up of approximately:
  - ____________________________% slow-twitch Type I fibers
  - ____________________________% Type IIa fibers
• 25% Type IIx fibers
• The percentage of each fiber type is variable among muscles, among individuals, and with exercise training.
  • Athletes in speed and strength events generally have an increased percentage of ________________________________ fibers.
  • Athletes in endurance events generally have an increased percentage of ________________________________ fibers.

  • Twin studies have suggested that the proportion of the various fiber types is genetically determined.
  • But, the extent to which training can shift the distribution of fiber types has not been well documented.
  • Fiber distribution differences by Activity type may be the result of:

    • Being born with that distribution and ________________________________ into activities to which the musculature is optimized for.

    • Chronic training changing the ________________________________ of fibers to match the demands placed on the system.

**SKELETAL MUSCLE CONTRACTIONS**

***Isometric***
• Static
• Muscle exerts force without ________________________________
• Pulling against immovable object
• Ex. Postural muscles

***Isotonic***
• Dynamic
• **Concentric** – Muscle ________________________________ during force production

• **Eccentric** – Muscle produces force but length ________________________________
**Muscle Receptors**

- The Muscle Spindles and Golgi Tendon Organ are enteroceptors which are important for proprioception of the muscles.

- **Proprioception**: Integration of information from enteroceptors regarding the position of one’s body in space.

- All skeletal muscles, with the exception of extraocular and facial musculature, contain both types of receptors.

  - Muscle Spindles provide information to the central nervous system regarding the ____________________________, and rate of ____________________________, of individual muscles.

  - Golgi Tendon Organs provide information to the central nervous system regarding the amount of muscle ________________________________________________________.

**Muscle Spindles**

- Spindles are located deep within the muscle mass, scattered widely through the muscle body, and attached to the tendon, the endomysium or the perimysium.

- Within a muscle spindle, there are several small, specialized muscle fibers known as intrafusal fibers.

  - Intrafusal fibers have contractile proteins at either end, with a central region that is wrapped by sensory dendrites.

- When the muscle lengthens and the muscle spindle is ____________________________, this opens mechanically-gated ion channels in the sensory dendrites, triggering the firing of action potentials.

  - The length, and changes in length, of the muscle are coded by the pattern and frequency of action potentials

- The intrafusal fibers are innervated by an efferent neuron known as the ____________________________ motor neuron.

- The role of the gamma motor neuron is to maintain muscle spindle ____________________________.
• **Alpha-Gamma Coactivation**: When the muscle is stimulated to contract by the alpha motor neuron, the gamma motor neuron is _____________.

• The gamma motor neuron stimulates contraction in the two ends of the intrafusal fiber, readjusting its length and keeping the central region of the intrafusal fiber taut.

**Protective Role of Muscle Spindles**

• Discharge of muscle spindle afferents evokes the _________________________________.

• A spinal reflex, which allows muscle tone to be regulated quickly and efficiently without direct intervention by higher brain centers.

• The stretch reflex causes the alpha motor neurons to stimulate muscle contraction to _________________________________.

**Golgi Tendon Organs**

• Unlike muscle spindles (which are located in parallel with muscle fibers), the Golgi tendon organs are in ________________________________ with muscle fibers, located in the tendons that attach muscle to bone.

• Because changes in muscle tension will provide different degrees of pull on the tendon, the Golgi tendon organ provides information about muscle _________________________________.

**Protective Role of Golgi Tendon Organs**

• Prevents muscle damage during excessive _________________________________.

• When the muscle contracts, it places a strain on the golgi tendon organ and opens mechanically-gated ion channels in the sensory dendrites, triggering the firing of action potentials.

• The sensory neuron transmits the action potential to an inhibitory interneuron in the spinal cord, which ________________________________ further activation of the alpha motor neuron.

**Muscle Architecture**

• The form and function of a muscle is determined by the arrangement of _________________________________.

• The shape of the muscle determines its range of motion and influences its power production.
• Longer, more parallel muscle fibers allow for greater ____________________________.

• Pennate muscles shorten very little but are ____________________________.

• Movement occurs when the muscle contraction ____________________________
  the muscle attachment sites closer together.

• Muscles are attached to at least two points.

  • Origin – attachment to ____________________________.
    • Generally the region to which the muscle moves when it contracts.
    • Generally the proximal attachment.

  • Insertion – attachment to ____________________________.
    • Generally the region away from which the muscle moves when it contracts.
    • Generally the distal attachment.
Kinesiology 173: Foundations of Kinesiology

Module 2.2: Skeletal Muscle Adaptation to Exercise

**READING ASSIGNMENT: KIN173_2_1_Garber_2011_QuantityAndQualityOf.pdf**

**WHAT IS THE DIFFERENCE BETWEEN STRENGTH AND POWER?**

**Strength**
- Refers to the ability of a muscle or muscle group to exert ________________ against a resistance.
- Traditionally tests which only allow __________________________ of a task are considered measures of strength.
- The standard for dynamic strength assessment is the __________________________.
- 1-RM - the greatest resistance that can be moved through the full range of motion in a controlled manner.

**Power**
- Refers to the ability to exert __________________________ or the amount of work done per unit of time.
- “The expression of strength exerted quickly”
- Power = Force × Velocity = Force × \( \frac{\text{distance}}{\text{Time}} \)

**HOW DO YOU EXPRESS STRENGTH AND POWER?**

- __________________________ - Represent the actual external load. Commonly measured in units (lbs, kgs, N)
- __________________________ - Represents the external load in relation to some aspect of body weight.
- For comparisons made on the same person, absolute values are preferred.
- For comparisons made __________________________, a relative expression is preferred.
Who is stronger Men or Women?

- When men and women are compared as to ____________________________ strength, men are stronger than women.

- When force production per unit of muscle (strength / muscle mass) is compared, there are ____________________________ in muscle strength between men and women.

**MUSCLE QUANTIFICATION TERMINOLOGY**

Muscular Endurance

- Refers to the ability of a muscle or muscle group to ____________________________ against a resistance.

- Traditionally tests requiring ____________________________ repetitions of a task are considered tests of muscular endurance.

**SHOULD WE FOCUS ON STRENGTH OR ENDURANCE?**

Problem with Strength

- 1-Rep Max tests are typically performed incorrectly resulting in _____________________________.

- Typically focus on a small number of muscle groups.

- Increased cost of needing large numbers of weights.

Problem with Endurance

- Performing 12 to 30 repetitions is difficult for most people.

- ____________________________.

- Associated with increased muscle soreness.

The modern perspective is now focused more on ____________________________:

- Instead of performing 1-Rep Max tests, the focus is on the number of repetitions able to be performed at a fixed weight.

**MUSCLE QUANTIFICATION TERMINOLOGY**

Muscular Flexibility

- Refers to the ability to move a joint through its complete range of motion.
Laboratory tests quantify flexibility in terms of range of motion expressed in degrees using a goniometer.

**PRINCIPLES OF AN EXERCISE PROGRAM**

2 Principles Apply to Any Type of Exercise Program

- **Overload**
  - The principle of progressive overload states that for a tissue or organ to improve its function, it must be exposed to a stimulus.
  - Repeated exposure is associated with an adaptation by the tissue that leads to improved functional capacity or efficiency.

- **Specificity**
  - The principle of specificity states that training effects derived from an exercise program are specific to the muscles involved.

**Recommendations**

- The ACSM recommendations for resistance training intensity depend on the goal of the training.

- To Improve Strength and Power: ___________% of 1-RM, ___________ Repetitions

- To Improve Endurance: ___________% of 1-RM, ___________ Repetitions

- The ACSM recommendations for resistance training time depend on the goal of the training.

- But, no specific duration of training has been identified for effectiveness.

- To Improve Strength and Power: ___________ sets, Rest intervals of 2–3 min between each set of repetitions

- To Improve Endurance: ___________ sets, Rest intervals of 2–3 min between each set of repetitions
WHY DO WE GET STRONGER WITH RESISTANCE TRAINING?

Increases in strength with resistance training are due to 2 factors.

Neural Adaptations

• Strength gains during the first _______________________ of training are

_______________________________________________________.

• Muscle strength can increase 25 to 100% with little-to-no increase in ______________________.

• The nervous system elicits greater muscular force by:

  • Innervating more _____________________________.

  • Increasing the rate of firing of motor units.

  • Improving _______________________________ of motor units for more efficient muscle recruitment.

  • Inhibition of the _____________________________ to allow greater maximal force.

  • Increases in the perimeter length and area of the motor end plate.

  • Increased dispersion of acetylcholine receptors.

Structural and Biochemical Adaptations to Resistance Training

• Associated with increases in muscle strength with resistance training are:

  • Increases in the number of _____________________________.

  • Increased capillary density and myoglobin in skeletal muscles.

  • Increased cross sectional area for Type II muscle fibers.

  • Shift in Type __________ muscle fibers to Type __________ muscle fibers.

HYPERTROPHY VS HYPERPLASIA

• __________________________ – The increase in the size of existing muscle fibers.

• __________________________ – The increase in the number of muscle cells.

• Muscle enlargement is generally paralleled by increased muscle strength.

• Increased muscle strength is NOT always paralleled by gains in muscle size.
Hypertrophy

- Enlargement of muscles thought to be due primarily to muscle fiber hypertrophy.
  
  - Transient hypertrophy - Tissue edema
  
  - Chronic hypertrophy - Structural changes
    
    - More actin & myosin, sarcoplasm
    
    - More surrounding muscle fiber

- Hypertrophy does not occur until more than weeks of training.

- When muscle fibers receive any form of trauma, damage, or injury (such as from resistance training overload),

- Satellite cells then proliferate (multiply), and the daughter cells are drawn to the damaged muscle site.
  
  - Satellite cells are located on the outer surface of the muscle fiber, contain one nucleus, and function to facilitate growth, maintenance and repair of damaged skeletal muscle tissue.

- Satellite cells fuse to the existing muscle fiber, donating their nuclei, helping to

- This satellite cell activation and proliferation period can last up to 48 hours after the trauma or shock from the resistance training session stimulus

Hyperplasia

- Muscle fibers and grow into full size muscle fibers.

- In birds, after uni-lateral weighting of a wing for 1 month, a 90% increase in the number of muscle fibers was observed.

- In rats, trained to do squat exercises in response to electrical stimulation, a 14% increase in the number of fibers occurred.

- Does Hyperplasia Occur In Humans?

  - Very difficult to directly measure the number of new fibers in humans.
  
  - But if it does happen,
    
    - It most likely is restricted to Type muscle fibers
• Only accounts for a small percent (______________%) of increased muscle size.

**WHAT CAUSES MUSCLE FATIGUE?**

• Fatigue results in the ________________________________ of muscular work or the ________________________________ a given intensity of work.

• A complex phenomenon that includes failures at one or more of the sites along the chain of events that leads to muscular contraction.

Central Fatigue

• A number of possible causes for central fatigue exist including:
  
  • Interruptions in ________________________________ in the motor cortex.
  
  • Interference in motor control circuits in the basal ganglia.
  
  • Inhibition of ________________________________ effort.
  
  • Psychological Factors such as Motivation and Perceived Competence.
  
  • ________________________________ perception and tolerance.
  
  • Neural malfunctions – membrane potentials are unable to reach sufficient levels to continue to send action potentials.

Peripheral Fatigue

• Peripheral muscle fatigue during physical work is considered an inability for the body to supply sufficient ________________________________ or other metabolites to the contracting muscles to meet the increased energy demand.

• This causes contractile dysfunction that is manifested in the eventual reduction or lack of ability of a single muscle or local group of muscles to do work.

• Mechanisms of this process broadly fall into two categories.
  
  • ________________________________ – Depletion of neurotransmitters and energy sources.
• ____________________________________________________________________ – Accumulation of metabolic by-products.

Depletion of neurotransmitters and energy sources

• Remember, for a muscular contraction to occur we need:
  
  • Acetylcholine to bind at the Neuromuscular Junction
  
  • Calcium Dependent Binding
  
  • ATP Dependent Release

• Acetylcholine and Calcium are resorbed after release, but not perfectly. Some leakage does occur and enzymes deactivate them! Eventually insufficient levels lead to reduced muscular recruitment and contractions.

• The body needs energy to survive, and eventually energy stores can be depleted impairing ATP production.

• Glycogen depletion has been found to be selective to the muscle groups ____________________________________________________________________.

• Pattern of glycogen depletion from Type I and II fibers depends on the _____________________________ and _____________________________ of the activity.

Accumulation of metabolic by-products

• During exercise, energy production systems produce a number of metabolic byproducts.

• In particular, Hydrogen and Lactic Acid are produced which act to dysregulate the muscle ____________________________________________________________________.

• The muscles operate best at a pH level between _______ and _________

• When the pH falls lower than 6.9, the cellular processes of energy production and muscle contraction begin to slow.

• When the pH reaches ____________________, myosin can no longer bind to actin and muscle contraction stops.
**MUSCLE SORENESS**

So is Lactic Acid the Reason We Get Muscle Soreness?

- Immediate or __________________________ Soreness occurs during and immediately after exercise.

- Muscular contractions can cause local ischemia (restrictions in blood supply) which can stimulate pain receptors.
  - Normal circulation patterns return following the cessation of exercise.

- Changes in muscle pH can irritate pain receptors.
  - Normal muscle pH returns rapidly following the cessation of exercise.

- Lactic Acid may play a role in __________________________ which relates to short term muscle soreness IMMEDIATELY after exercise.

So Why Do You Wake Up Sore The Day After Exercise?

- __________________________ - Muscle soreness that increases in intensity for the first 24 hours after activity, peaks from 24-48 hours, and then declines during the next 5-7 days.

- Absolutely NOT related to __________________________ accumulation!
  - Individuals who have McArdle's Syndrome do not produce lactic acid. They still suffer from Delayed Onset Muscle Soreness.
  - DOMS most commonly occurs after activities that rely heavily on __________________________ muscle contractions.

Delayed Onset Muscle Soreness Theories

- Although the exact mechanisms underlying DOMS are unknown.

- The 2 main theories of DOMS each suggest that the pain results from the bodies __________________________.

- Swelling and __________________________ are responsible for the painful sensation known as DOMS.

Local Ischemic Model

- Exercise causes swelling in the muscle tissue, which increases __________________________ resulting in local ischemia.

- Ischemia causes pain and leads to muscle spasms, which cause additional swelling and pain.
Mechanical Trauma Model

- Mechanical forces result in structural damage to the muscle fibers.

- The presence of ________________________ and immune function cells leads to swelling and inflammation.

**Reversibility**

- The Reversibility Concept holds that when a training program is stopped or reduced, the body systems readjust in accordance with the decreased physiological stimuli.

- Flexibility has been shown to persist for up to ________________________ following the cessation of exercise.

- Muscular strength is maintained to a greater degree during detraining than is ________________________.

- In space, reduced gravity reduces the load on the muscles resulting in losses of muscle mass and strength.
  - Resistance exercises can help prevent this muscle atrophy.

- During detraining, changes in the size and metabolic properties of the muscle fibers occur.
  - During the ________________________ after cessation of resistance training the size of muscle fibers decreases contributing to strength loss.
  - This muscle atrophy results from an offsetting of the balance between protein synthesis and protein degradation.
  - During atrophy, there is a down-regulation of protein synthesis pathways, and an activation of protein breakdown pathways.

- Time Course of Skeletal Muscle Mitochondrial Changes
  - Exercise training results in a doubling of the number of muscle mitochondria over the course of 5 to 8 weeks.
  - After just 1 week of detraining, ________________________% of the increased mitochondria are lost.
  - After 5 weeks of detraining, ________________________ of the increased mitochondria are lost.
  - Takes ________________________ weeks of retraining to regain the adaptations in muscle mitochondria lost in the first week of detraining.
AGE-RELATED CHANGES IN SKELETAL MUSCLE
• Aging is associated with a loss of muscle mass, known as ____________________________.
  • Between the ages of _______________________% reduction in muscle fiber mass and density and an increase in intramuscular fat.
  • Between the ages of 60 and 80, muscle strength continues to reduce approximately ___% per decade.
  • After age 80, muscle strength reduces by approximately _____% per decade.
  • Sarcopenia is typically greater in ________________________________ as they age.
• During sarcopenia there is a,
  • Decrease in the ____________________________ muscle fibers.
  • Decrease in the ____________________________ muscle fibers.
  • Loss of satellite cell function.
• Is associated with an increased susceptibility to disability in elderly, increased risk of falls, and hip fractures.

Resistance Exercise and Sarcopenia
• The benefits of resistance exercise training in elderly include:
  • Increased muscular strength and endurance, improving ________________________.
  • Increased ________________________, providing additional support for bones and enhanced thermoregulation.
• Resistance cannot completely eliminate age-related loss of muscle mass, but has been associated with:
  • ____________________________ following falls and injuries.
  • Enhanced ________________________________.
Module 2.3: Body Composition

**WHAT IS THE HUMAN BODY MADE UP OF?**

It depends on how we want to break the body down!

<table>
<thead>
<tr>
<th>The 2 Component Model</th>
<th>The 4 Component Model</th>
<th>The Anatomical Model</th>
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</thead>
<tbody>
<tr>
<td>~21% Fat Mass</td>
<td>~21% Fat Mass</td>
<td>~14% ______________</td>
</tr>
<tr>
<td>~79% ________________</td>
<td>~58% ________________</td>
<td>~7% Essential Fat</td>
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<tr>
<td>~16% Protein</td>
<td>~38% ________________</td>
<td>~13% Bone</td>
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<tr>
<td>~7% Bone Mineral</td>
<td>~11% Skin</td>
<td>~10% Organs</td>
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<tr>
<td>~7% ________________</td>
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<td>~7% ________________</td>
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Males and Females are predominately different in body composition for

____________________________________________________________________________________.

**WHEN PEOPLE TALK ABOUT BODY COMPOSITION WHICH MODEL DO THEY MEAN?**

The common nomenclature generally refers to the proportion of __________________________ and

______________________________ Mass in the body (our 2 component model).

- Healthy body composition involves a high proportion of fat-free mass and an acceptably low level of body fat, adjusted for age and gender.

**BUT, NOT ALL FAT IS BAD!**

Essential Fat consists of fat stored in major organs, muscles, bone marrow, and the central nervous system.

- This fat is required for ______________________________.
- Serves as nutritional reserve.
- Females carry additional “sex-specific reserve storage” essential fats in mammary glands and pelvic regions that are important for childbearing and hormone-related functions.
WHAT IS THE DIFFERENCE BETWEEN FAT-FREE MASS AND LEAN BODY MASS?

- Fat-Free Body Mass (FFM)
  - Defined as body mass devoid of _____________________________________________
  - FFM = Total Body Mass – Total Fat Mass
    \[
    FFM = \text{Total Body Mass} - (\text{Total Fat Mass} + \text{Fat Mass})
    \]
    \[
    FFM = 70 \text{ Kg} - (2.1 \text{ Kg} + 8.4 \text{ Kg}) = 59.5 \text{ Kg}
    \]
- Lean Body Mass (LBM)
  - Defined as body mass devoid of _____________________________________________
  - LBM = Total Body Mass – Total __________________________ Mass
    \[
    LBM = 70 \text{ Kg} - 8.4 \text{ Kg} = 61.6 \text{ Kg}
    \]
- A substantial loss of ____________________________________________ mass can identify a number of adverse physiological conditions including disease and malnutrition.
  - Rapid weight loss strategies can trigger the body's starvation response causing the body to begin breaking down muscle for energy, instead of taking it naturally from food, resulting in a deficiency in LBM.

HOW DO WE GO ABOUT MEASURING BODY COMPOSITION?

There are LOTS of ways! So it depends on:

- ____________________________
  - Availability of techniques.
  - Technical training of staff.
  - Condition of patient.
  - Location where assessment will be done.

Girth Measurements

- Requires only a ____________________________.
  - Measure the circumference of “fat” sites and “muscle sites”.
  - Enter the measurements into a prediction equation to estimate percent body fat.
  - Provides reasonable estimations!
Possible Issues:

- ___________________________________________ in consistently measuring.
- Location of sites may not reflect fat distribution.
- Validity depends on the equation used.

**Waist to Hip Ratio (WHR)**

- Requires only a measuring tape.
- Measure the circumference of the “natural waist” (smallest circumference) or at the level of the umbilicus and the circumference of the buttocks.
- Divide the hip measurement by the waist measurement.

Possible Issues:

- Skill required in consistently measuring.
- Location of sites may not reflect fat distribution.

**Body Mass Index (BMI)**

- Originally developed in the 1940’s by Insurance companies based on ____________________________ statistics. Higher BMI was related to increased risk of death!
- Based on the concept that weight should be proportional to height.
- \[ \text{BMI} = \frac{\text{_________}}{\text{_________}^2} \]
- Easy to do, very low cost!
- Moderate to Strong correlations with percent body fat estimates from other more advanced and expensive methods.

Possible Issues:

- Over-estimates highly muscular individuals.
- Under-estimates elderly individuals.

**Skinfold Measurements**

- Based on the concept that subcutaneous fat (found just under the skin) represents about ____________________________ Fat.
- Requires specialized calipers and lots of training to do accurately and consistently.
- Several sites are measured and percent fat is estimated from a formula.
- Inexpensive and relatively easy to perform.
- One of the most common research approaches to body composition over the past 30 years.
• 7 Major Measurement Sites
  • Chest
  • Axilla (Armpit)
  • Tricep
  • Subscapular (Back)
  • Abdomen
  • Supraillium (Hip)
  • Thigh

Possible Issues:
• Large risk of technician error.
• Skinfold thickness affected by factors other than amount of fat.
  • Exercise increases skin thickness
  • Dehydration ____________________________ skin thickness
  • Edema increases skin thickness
  • Dermatitis increases skin thickness
• Poorly predicts ____________________________ fat.
• Validity depends on equation used.

Bioelectric Impedance
• Based on principle that fatty tissue is a less-efficient conductor of electrical current than muscle.
  • Lean tissue has more water -> ____________________________ resistance
  • Fatty tissue has less water -> ____________________________ resistance
• Sensors are applied to the skin and a weak electrical current is run through the body to estimate body fat, lean body mass, and body water.
• Portable, Non-invasive, Quick to perform

Possible Issues:
• Very sensitive to changes in body water (less water = higher %fat).
• Sensitive to food and caffeine intake.
• Sensitive to body ____________________________.
• Sensitive to menstrual cycle in females.
• Overestimates lean individuals, underestimates obese.
• Cost of the analyzer

Hydrostatic Weighing
• Because fat and lean body tissues have relatively stable densities (Fat = 0.9 g/cc; Fat-Free Tissue = 1.1 g/cc); if we know the density of the body, we can calculate percent body fat.
• Using Archimedes principles that the amount of buoyant force on object is equal to the amount of water it displaces, we can divide a person’s body weight by the difference in body weight in air and underwater to calculate percent body fat.

• Previously considered the gold standard for body composition research for decades – some argue it still is.

Possible Issues:
• Densities of fat and fat-free tissues are variable dependent upon age, race, and activity participation.
• Requires specialized facilities.
• Requires exhaling all lung volume.
• High cost and time consuming.
• Not all participants willing to do it.

Whole Body Plethysmography
• Because fat and lean body tissues have relatively stable densities (Fat = 0.9 g/cc; Fat-Free Tissue = 1.1 g/cc); if we know the density of the body, we can calculate percent body fat.
• Measures body volume by measuring pressure changes in a closed chamber after injection of a known volume of air – Larger body volumes ________________________________.
• Participants are more willing to do this.

Possible Issues:
• Densities of fat and fat-free tissues are variable dependent upon age, race, and activity participation.
• Very expensive piece of equipment ($25 – 30K).

Dual Energy X-ray Absorptiometry (DEXA)
• Measures the absorption of two different low-dose X-rays in a whole body scanner to determine bone and soft tissue mass.
• Bone mineral content, fat mass, and muscle all have different __________________________ characteristics.
• X-ray dose is less than 1/10th the dose of a standard chest x-ray.
• Considered to be the new “gold” standard for measuring body fat and bone density.

Possible Issues:
• Some individuals are resistant to participate because of the X-rays.
• Very expensive piece of equipment.
• Requires qualified technicians.
• Takes 15 to 20 minutes per scan.
Other Medical Imaging Procedures

- Infrared Spectroscopy and Ultrasound
  - These techniques are just emerging, still very expensive, requires high degree of technical skill, questionable to what extent the data are valuable.

- CT and MRI
  - These are EXTREMELY expensive in terms of equipment, personnel, and the time for each scan (30 to 60 minutes).
  - Although low-risk, many people still fear having these procedures done.

**COMPARISON OF BODY COMPOSITION METHODS**

<table>
<thead>
<tr>
<th>Technique</th>
<th>Cost</th>
<th>Time</th>
<th>Skill</th>
<th>Comfort</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Girth</td>
<td>Low</td>
<td>Quick</td>
<td>Moderate</td>
<td>High</td>
<td>Good</td>
</tr>
<tr>
<td>Waist to Hip</td>
<td>Low</td>
<td>Quick</td>
<td>Moderate</td>
<td>High</td>
<td>Good</td>
</tr>
<tr>
<td>BMI</td>
<td></td>
<td>Quick</td>
<td>Low</td>
<td>High</td>
<td></td>
</tr>
<tr>
<td>Skinfold</td>
<td>Moderate</td>
<td>Moderate</td>
<td>High</td>
<td>Low</td>
<td>Very Good</td>
</tr>
<tr>
<td>BIA</td>
<td></td>
<td>Moderate</td>
<td>Moderate</td>
<td>High</td>
<td></td>
</tr>
<tr>
<td>Hydrostatic</td>
<td>High</td>
<td>Slow</td>
<td>High</td>
<td>Low</td>
<td>Very Good</td>
</tr>
<tr>
<td>Plethsmography</td>
<td>High</td>
<td>Slow</td>
<td>High</td>
<td>Moderate</td>
<td>Very Good</td>
</tr>
<tr>
<td>DEXA</td>
<td></td>
<td>Slow</td>
<td>High</td>
<td>Moderate</td>
<td></td>
</tr>
<tr>
<td>CT/MRI</td>
<td>Very High</td>
<td>Slow</td>
<td>Very High</td>
<td>Low</td>
<td>Excellent</td>
</tr>
</tbody>
</table>

If you had to choose 1 measure of Body Composition to be used as an International Screening Tool, which would you choose?

- ________________________________________________________________
  - Low cost, requires no training, very quick to do.
    - Although it may over-estimate risk in some cases, this applies to a very small percentage of the population!
    - Remember we are talking about SCREENING, not diagnosis!
## BMI Classifications

<table>
<thead>
<tr>
<th>Classification</th>
<th>BMI</th>
<th>Disease Risk Relative to Normal Weight and Waist Circumference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Underweight</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Normal</td>
<td>18.5 – 24.9</td>
<td></td>
</tr>
<tr>
<td>Overweight</td>
<td>25 – 29</td>
<td>INCREASED</td>
</tr>
<tr>
<td>Obesity Class:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>30 – 34.9</td>
<td>HIGH</td>
</tr>
<tr>
<td>II</td>
<td>35 – 39.9</td>
<td>VERY HIGH</td>
</tr>
<tr>
<td>III</td>
<td>≥ 40</td>
<td>EXTREMELY HIGH</td>
</tr>
</tbody>
</table>

### How Obese is the USA?

### How Obese is the USA Compared to the Rest of the World?

## Body Composition Classifications

Health-related criterion referenced standards for body fatness.

<table>
<thead>
<tr>
<th>Classification</th>
<th>Males</th>
<th>Females</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unhealthy Range (too low)</td>
<td>≤ 5%</td>
<td>≤ 8%</td>
</tr>
<tr>
<td>Acceptable Range (lower end)</td>
<td>6 – 15%</td>
<td>9 – 23%</td>
</tr>
<tr>
<td>Acceptable Range (higher end)</td>
<td>16 – 24%</td>
<td>24 – 31%</td>
</tr>
<tr>
<td>Unhealthy (too high)</td>
<td>≥ 25%</td>
<td>≥ 32%</td>
</tr>
</tbody>
</table>
Not everyone Stores Fat in the Same Way

- Most common in females.
- Pear Shape: Fat stores around hips

- Most common in males.
- Apple Shape: Fat stores around waist
- Associated with MORE health risks!

Why do we care if other people are obese?

- In the United States, the economic costs of obesity were in excess of $115,000,000 ($115 Billion) in 2000.
- As of 2008, the economic costs of obesity total approximately $147,000,000 ($147 Billion).

The economic cost of obesity in the United States includes:

- Preventive, diagnostic, and treatment services related to obesity.

Costs:

- **Morbidity costs**: value of income lost from decreased productivity, restricted activity, absenteeism, and bed days.
- **Mortality costs**: value of future income lost by premature death.

Complications of Obesity

- Increase in premature death associated with BMI
- Individuals who are obese or overweight also have a reduced

Leading Causes of Death due to different causes in the US.

1. Cardiovascular Disease
2. Cancer
3. Stroke
4. Respiratory Disease
5. Accidents
6. Diabetes
Obesity and Cardiovascular Disease

- Predicts Coronary Heart Disease, independent of smoking, cholesterol, and hypertension.
- Increased body fat increases risk factors for Cardiovascular Disease:
  - Increased Hypertension (high blood pressure)
  - Increased Dyslipidemia (high cholesterol)
- Increased risk of cardiomyopathy, ischemia, and arrhythmias.

Obesity and Cancer

- Obesity and physical inactivity have been associated with increased risk of developing:
  - Postmenopausal Breast Cancer
  - Endometrial Cancer (lining of the uterus)
  - Esophageal Cancer
  - Gallbladder Cancer
  - Ovarian Cancer
  - Pancreatic Cancer

Obesity and Stroke

- Abdominal Obesity has been found to be an independent risk factor for ischemic stroke in all Race-Ethic Groups.
- In Men, for each unit increase in BMI, a man’s chance of having a stroke increases by _____%.
  - A BMI of 30 puts men at a 30% greater likelihood of suffering a stroke.

Obesity and Respiratory Diseases

- Obesity has been found to relate to an increased prevalence of:
  - Pulmonary Hypertension
  - Shortness of Breath
  - Asthma
Obesity and Accidents?
- Obesity has been found to relate to an increased prevalence of:
  - Osteoarthritis
  - _____________________________________________________________
  - Infections
  - Poorer long-term outcome of minor injuries.

Obesity and Diabetes
- Obese individuals are more than ______________ times as likely to develop diabetes.
- Obesity has been found to relate to an increased prevalence of:
  - Insulin Resistance
  - Type II Diabetes
  - Poorer tissue perfusion

Other Complications of Obesity
- Obesity has also been found to relate to:
  - Early onset menarche in moderately obese girls (period).
  - Delayed onset menarche in morbidly obese girls.
  - Impairment of _____________________________________________
    - Reduced desire and sexual satisfaction in Females
    - Erectile dysfunction in Males
  - Impairment in fertility in both Males and Females

As the duration of Obesity increases, the risk of developing all of these comorbidities increases.

**WHAT IF YOU ARE OBESE AND PHYSICALLY ACTIVE**

- Physical Activity appears to have a ____________________________ on cardiovascular disease mortality for obese individuals.


**Kinesiology 173: Foundations of Kinesiology**

Module 2.4: Energy Balance

**Reading Assignment:**  
KIN173_2_2_Speakman_2008_ThriftyGenesForObesity.pdf  
KIN173_2_3_Prentice_2008_EvolutionaryOriginsOfThe.pdf

**Why are we becoming obese?**

There are 3 main classes of theories:

- 
- 
- 

**Genetic Contributions to Obesity**

- Genetic theories postulate that as much as ___________________% to our risk of becoming obese is the result of genetic factors.

**Thrifty Gene Theory (Neel, 1962)**

- Some individuals may be genetically predisposed to protection against starvation through more __________________________ and lower metabolic rates.
  
  - Fatter individuals carrying thrifty genes would be more likely to survive times when food was scarce.
  
  - Most commonly applied to explain escalating levels of obesity among Pacific Islanders, Native Americans, and Inuit populations.

- Based on assumptions that food scarcity was a common event for early humans.
  
  - Anthropological evidence suggests that __________________________.
  
  - In times of food surplus, this theory would predict that populations with this gene would have a __________________________.

  - Anthropological evidence suggests this is not the case.
Set-Point Theory (Bennett & Gurin, 1982)

- Each person has a genetically programmed ________________________________
  which dictates how much fat they should have.
  - In essence, a “______________________________ for body fat.”
- Attempts to explain why some individuals cannot lose weight with dieting.
  - Rebound weight-gain among dieters
  - Occasional over-eating usually does not result in weight gain.
- The set-point cannot distinguish between dieting and starvation.
  - Stringent dieting causes the body to react as though famine has set in by dramatically
    altering the metabolic rate to conserve calories.
  - Dieting becomes less effective beyond this set-point.
- Only a sustained increase in ________________________________ appears
  to alter this set-point (Wilmore et al., 1999).

Leptin Theory

- Adipose cells (fat cells) secrete a hormone known as Leptin which is believed to travel through
  the bloodstream and targets the hypothalamus to regulate

  ________________________________________________________.

- Genetically modified mice who __________________________ leptin levels,
  exhibit more frequent feeding, higher levels of insulin and body fat, and have low thyroid and
  metabolism levels.
- Injecting these mice with ________________ caused reduced appetite and losses in body
  weight.
- In humans, these relationships are still not yet understood:
  - Fat secretes leptin
    - Obese individuals already have high levels of circulating leptin
    - Injecting obese individuals with leptin resulted in a very small amount of weight loss.

Fat Genes

- A growing number of studies are investigating the influence of control genes on regulating
  networks of genes involved in metabolism.
  - KLF14 has been found to regulate genes involving obesity; cholesterol; circulating fat,
    insulin, and glucose in the blood; and the effectiveness of insulin.
• A variant of the FTO gene has been found to relate to body mass. Individuals with 2 copies of the FTO gene weight on average ______________ lbs more than individuals with no copies.

**ENVIRONMENTAL CONTRIBUTIONS TO OBESITY**

**Parents and Family**

• If one parent is obese, there is a ___________% chance that the children will also be obese.

• If both parents are obese, the children have an ______________% chance of being obese.

  Just a few highlights of possible causes:

  • Possible genetic factors.
  • Economic status of family.
  • Family habits:
    • Children do not have much input over what types of food are purchased.
    • Children do not have much input over what activities are available.

**Economics**

• Being overweight has replaced ____________________________ as the most prevalent nutritional problem for the poor!

• Adolescents in families with low Poverty to Income Ratios, indicating lower socioeconomic status, have the ____________________________.

• Adolescents in families with high Poverty to Income Ratios have the lowest incidence of obesity.

• A healthy basket of food has been found to cost more in disadvantaged economic areas than in affluent areas.

• There are ______________ times as many supermarkets in wealthy neighborhoods as in poor neighborhoods.

• The Food Industry markets mass, low-quality products with higher fat and sugar content to economic sectors with less purchasing power.

• Food availability has been found to negatively relate to obesity in women.

  • Women who have greater food security, indicating greater availability and access to food, have a ____________________________ of obesity than women who are less food secure.
• Children of low Socioeconomic Status (SES) participate less in ________________ in and out of school.

• Low SES among adolescents has been related to decreased participation in vigorous physical activity, even after controlling for sex and race/ethnicity.

**Ethnicity**

• The greatest incidence of obesity in children is for those individuals who are ________________

• Communities with higher percentages of African-American and Hispanic residents tend to have fewer available:
  - Parks and green spaces
  - Places to play sports
  - Public pools and beaches

**Other Environmental Factors**

• Increased concerns about safety have limited the time and areas in which children are allowed to play outside.
  - Nearly ________% of U.S. parents fear that their children might become victims of abduction.
  - 800,000 children are reported missing every year.
  - 204,000 of these are non-family member abductions.
  - But only ________________ of these are stereotypical abductions – Child is detained, held for ransom, intended to be kept permanently, or killed.

• Community designs are centered around cars instead of walking or biking.

• States and school districts have reduced the amount of time students are required to spend in physical education classes.
  - ________________% of elementary schools do not provide daily PE.

• Communities have failed to invest in parks and recreation centers.

**Thrifty Phenotype Theory**

• Similar in concept to the Thrifty Gene Theory proposed by Neel (1962).

• Posits that those who are exposed to ________________ during early pregnancy and development generate adaptive methods to increase energy efficiency.
**Behavioral Contributions to Obesity**

- Behavioral Theories generally focus on 2 factors:
  - 
  - 

Food Consumption

- Between 1970 and 2001, the number of fast-food outlets in the United States increased from about 30,000 to 222,000, and sales increased by about _______ percent.
- In 1970, about 25% of total food spending occurred in restaurants. By 2003 meals prepared outside the home accounted for 53% of total food spending.
- Children eat almost twice as many calories at restaurants (770) than they do during a meal at home (420).
- In 1980, approximately 50% of high school seniors reported eating Green Vegetables “nearly every day or more”.
- In 2003, that figure dropped to approximately 30%.
- Between 1978 and 2001 in children ages 6 to 11:
  - Milk consumption decreased by 39%
  - Fruit Juice consumption increased by 54%
  - Carbonated soda consumption increased by 137%
- In 1978, children aged 6 to 11 drank about 4 times as much milk as soda.
- In 2001, children aged 6 to 11 drank the same amounts of milk and soda.
- Between 1977 and 1996, portion sizes for key food groups grew markedly in the United States for food prepared both in and out of the home.
  - Salty snack portions increased by 70%.
  - Soft drink portions increased by 34%.
  - French fry portions increased by 36%.
  - Hamburger portions increased by 25%.

Physical Activity

- ________________% of children aged 9 to 13 do not participate in any kind of organized sport or physical activity program outside of school.
- Approximately 23% of children and 40% of adults get no free-time physical activity.
• A growing number of schools are eliminating daily physical activity opportunities to provide additional classroom time for formal academic topics.

**ENERGY BALANCE**

• Ultimately weight loss or gain results from Energy Balance.

  • **Positive Balance** – consuming __________________________ than you expend.
    • Results in weight gain.
  
  • **In Balance** – consuming the same number of calories as you expend.
    • Results in weight maintenance.
  
  • **Negative Balance** – consuming ___________________________ than you expend.
    • Results in weight loss.

\[
\text{Energy In} \quad \text{Energy Out}
\]

\[
\text{Caloric Balance} = \text{Food Ingested} - \text{Energy Excreted in Waste}
\]

**Metabolic Rate**

• The amount of energy required to sustain the body’s vital functions in the waking state.

  • Technically we are referring to **Basal Metabolic Rate** (BMR)
    • Resting quietly on the back, not eaten for 8 to 12 hours, body temperature between 36 and 37°C, room temperature between 27 and 29°C, and without feelings of stress.

  • In practice, ____________________________ Metabolic Rate (RMR) is most commonly used.
    • Resting quietly on back.

• Accounts for the majority of the total energy expenditure.

• Varies from approximately 60 to 75% of total energy expenditure.

• Typically measured in a laboratory setting, but can be estimated for non-clinical use (Height in cm, Weight in Kg, Age in years).
Males:

\[
RMR \text{ (kcal/day)} = 88.362 + (4.799 \times \text{Height}) + (13.397 \times \text{Weight}) - (5.677 \times \text{Age})
\]

Females:

\[
RMR \text{ (kcal/day)} = 447.593 + (3.098 \times \text{Height}) + (9.247 \times \text{Weight}) - (4.330 \times \text{Age})
\]

- Highly variable though.
- The more \_________________________\ the greater the metabolic rate.
- Men typically have higher metabolic rates than women.
  - When corrected to use Fat-Free mass, \_________________________\ occur.
- Metabolic rate slows with age (approximately 3 to 5% per decade after 30 years of age).
- Genetics are believed to be large contributors to this variability.
- Prolonged dieting (1000 kcal reduction) is associated with a \___________________________________________\.

Example:

**Participant A**: 20 year old Male; 5ft 11in; 170lbs

**Height Conversion**:

- 2.54 cm per inch

\[
((5\text{ft} \times 12\text{in in a foot}) + 11\text{in}) \times 2.54 = 180.34 \text{ cm}
\]

**Weight Conversion**:

- 2.2 lbs in a kilogram

\[
170 \text{ lbs} / 2.2 = 77.27 \text{ kg}
\]

\[
RMR \text{ (kcal/day)} = 88.362 + (4.799 \times \text{Height}) + (13.397 \times \text{Weight}) - (5.677 \times \text{Age})
\]

\[
RMR \text{ (kcal/day)} = 88.362 + (4.799 \times 180.34) + (13.397 \times 77.27) - (5.677 \times 20)
\]

\[
RMR \text{ (kcal/day)} = 88.362 + 865.45 + 1035.19 - 113.54
\]

\[
RMR \text{ (kcal/day)} = 1875.462
\]

**Thermogenesis**

- Energy cost of \_________________________\, nutrient absorption, assimilation, processing, storage, and synthesis of protein, fat, and carbohydrate.
• Usually peaks about 30 to 90 minutes after eating, but depending on the size and content of the meal may last as long as 4 to 6 hours.
  • This is part of the justification behind

• Fats require little energy to digest, Proteins and Carbohydrates more.

• Contributes 10 to 15% of total energy expenditure.

• Meals with greater caloric content result in a greater Thmic Effect of Food (TEM).

• Because most meals tend to keep the percentages of protein, fat, and carbohydrates within a relatively constant rate, we can estimate the Thermic Effect of Food.
  • TEM = ______________________% of caloric intake.

Physical Activity

• Accounts for 15 to 30% of total energy expenditure.

• Includes all activities above ________________________________.

• The larger the muscle groups involved, the more energy required.

• Based on activity and intensity we can estimate energy cost as

  kcal/kg/min * body weight (kg) * time (min).

Example:  

<table>
<thead>
<tr>
<th>Participant A: 77.27 kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical Activities:</td>
</tr>
<tr>
<td>Cooking = 0.035</td>
</tr>
<tr>
<td>Moderate Walking (3mph) = 0.066</td>
</tr>
<tr>
<td>Running (6mph – 10 min mile) = 0.175</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Energy Cost = kcal/kg/min * body weight (kg) * time (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 minutes of cooking</td>
</tr>
<tr>
<td>Energy Cost = 0.035 * 77.27 * 10 = ______________________ kcal</td>
</tr>
<tr>
<td>10 minute walk to class</td>
</tr>
<tr>
<td>Energy Cost = 0.066 * 77.27 * 10 = ______________________ kcal</td>
</tr>
<tr>
<td>10 minute run</td>
</tr>
<tr>
<td>Energy Cost = 0.175 * 77.27 * 10 = ______________________ kcal</td>
</tr>
</tbody>
</table>
**HOW MANY MILES WOULD YOU HAVE TO RUN TO BURN OFF 1 LB OF FAT?**

<table>
<thead>
<tr>
<th>Running (6mph – 10 min mile) = 0.175</th>
<th>Participant A: 77.27 kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 lb of Fat = ______________________ kcal</td>
<td></td>
</tr>
<tr>
<td>1 mile run</td>
<td></td>
</tr>
<tr>
<td>Energy Cost = kcal/kg/min * body weight (kg) * time (min)</td>
<td></td>
</tr>
<tr>
<td>Energy Cost = 0.175 * 77.27 * 10 = ______________________ kcal per mile</td>
<td></td>
</tr>
<tr>
<td>3500 kcal per lb of fat / ______________________ kcal per mile = ______________________ miles</td>
<td></td>
</tr>
</tbody>
</table>

**HOW DOES CONSUMING A 20OZ PEPSI EACH DAY INFLUENCE YOUR ENERGY BALANCE?**

- Assuming a prototypical 2,500 calorie per day diet to start with.
  - Note: A food calorie is the same as a kilocalorie (kcal).
  - The amount of energy required to increase the temperature of 1 kg of water by 1°C.
- Assuming enough Physical Activity to remain “In Balance” originally.

<table>
<thead>
<tr>
<th>Participant A</th>
<th>20 oz Pepsi</th>
</tr>
</thead>
<tbody>
<tr>
<td>RMR (kcal/day) = 1875.462</td>
<td>250 calories per bottle</td>
</tr>
<tr>
<td>Diet = 2500 calories</td>
<td></td>
</tr>
<tr>
<td><strong>Energy Balance = Energy In – (RMR + TEF + PA)</strong></td>
<td></td>
</tr>
<tr>
<td>Basic Diet</td>
<td></td>
</tr>
<tr>
<td>Energy Balance = 2500 – (1875.462 + (2500 * 0.1) + ______________________)</td>
<td></td>
</tr>
<tr>
<td>Energy Balance = 2500 – 2500 = “In Balance”</td>
<td></td>
</tr>
<tr>
<td>Extra 20 oz Pepsi</td>
<td></td>
</tr>
<tr>
<td>Energy Balance = (2500 + 250) – (1875.462 + (2750 * 0.1) + 374.54)</td>
<td></td>
</tr>
<tr>
<td>Energy Balance = 2750 – __________ = __________ kcal surplus = “Positive Balance”</td>
<td></td>
</tr>
<tr>
<td>Extrapolated over the course of 1 year</td>
<td></td>
</tr>
<tr>
<td>(225 kcal per day * 365 days per year) / 3500 kcals per lb of fat = __________ lbs of fat per year</td>
<td></td>
</tr>
</tbody>
</table>
Module 2.5: Physical Activity Recommendations and Interventions

**READING ASSIGNMENT:** KIN173_2_4_USDHHS_2008_PhysicalActivityGuidelinesFor.pdf
SKIM THROUGH THE READING.

**SO HOW DO WE FIX THIS OBESITY PROBLEM?**

Obesity is Extremely Complex! But ultimately it boils down to Energy Balance

In order to get at obesity, we have to target these two factors.

**SO DO WE GO AFTER FOOD CONSUMPTION OR PHYSICAL ACTIVITY?**

- The current approach to combating food over consumption has largely been ineffective.
  - Americans already spend over $33 billion annually on weight loss products and services.
  - Over 8.5 million commercial diet centers exist in the U.S.
  - An estimated 50 million Americans go on diets each year.
  - Only __________% manage to maintain any weight loss for longer than 6 months.
- The general preference in behavioral interventions have tended to target ____________________________.
  - Largely because of the controversy, conflict, and stigma surrounding diet and nutrition.
  - Large food industries would stand to lose ____________________________ if interventions targeted food consumption.
  - Physical activity industries (sports apparel, gyms, & electronics companies) stand to benefit from physical activity interventions.
  - Some argue it may be easier to change physical activity than diet.
  - Physical activity is beneficial for more than just combating obesity!
  - Has benefits for: Cognitive health, Emotional Health, Reduce risks of cardiovascular disease, stroke, cancer!
- In 2008, the U.S. Department of Health and Human Services published the Physical Activity Guidelines for Americans to provide information and guidance to policymakers, health professionals, and members of the public on the types and amounts of physical activity that provide substantial health benefits.
**Physical Activity Recommendations for Children**

- Children and adolescents should do ___________________________ or more of physical activity daily.
  - Aerobic Activities: Most of the 60 or more minutes per day should be either moderate- or vigorous-intensity aerobic physical activity. Include vigorous-intensity physical activity at least _________________ days per week.
  - Muscle-strengthening Activities: Include muscle-strengthening physical activity on at least _________________ days of the week, as part of the 60 or more minutes.
  - Bone-strengthening Activities: Include bone-strengthening physical activity on at least 3 days of the week, as part of the 60 or more minutes.
- Activities should be age-appropriate, enjoyable, and offer variety.
- It is very important that children and adolescents participate in a variety of activities, especially activities that they enjoy.
  - This enhances skill development, reduces the risk of ___________________________ and increases the likelihood of continuing to be active as they get older.
- It is also important to know that the Guidelines take into consideration the natural activity patterns of children.
  - Children often move between ___________________________ of activity and short periods of rest.
  - All episodes of moderate- or vigorous-intensity activities count towards daily requirement and, unstructured active play can provide all 3 types of physical activity.

**How do we know if an activity is moderate or vigorous?**

- Multiple ways of prescribing “intensity” depending on the mode of exercise engaged in.
- For aerobic exercises, the gold standard is based upon percentage of maximal oxygen consumption (VO₂ max) – the ___________________________.

**Direct Method:**

- Requires both Oxygen Consumption (VO₂) and HR measures.
- Involves plotting the measured HR against VO₂.
- Calculating intensity based on a percentage of the maximal VO₂.
- Then looking up the corresponding HR for that intensity.
• **Advantages:** It doesn’t matter what _____________________________ a person might be on/have that may modulate HR.

• Because of the relatively linear relationship between Heart Rate and Oxygen Consumption, we can also use HR only.
  
  • Ideally we have Maximal Heart Rate.
  
  • But if not we can use **Age Predicted Maximal HR** = _______________ – **Age**
   
     • Maximal HR progressively declines with age.
     
     • Children can have maximal heart rates exceeding 200 bpm.
     
     • Older adults can have maximal heart rates in the 150 bpm range.
     
     • But there is quite a bit of individual variability – thus a large standard error when using Age Predicted Maximal HR.

**Zero to Peak Method:**

• One of the oldest methods of setting the target HR range.

• Uses a straight percentage of measured or predicted HRmax.

• If an individual’s HRmax 180 bpm, then an intensity of 60% of HRmax would be

  ___________ × ___________ = ___________ bpm.

• **Advantages:** Quick and requires little-to-no measurements.

• **Disadvantages:** May not account for individual variability in cardiac responses. May set target HR below _____________________________

**Karvonen Method:**

• Also known as the HR reserve (HRR) method.

• Uses resting HR to set the lower boundary point.

• **HRR** = [(HRmax – _______________ ) × Percent Intensity] + _______________  

• **HRR** = [(180 – ___________ ) × 0.6] + ___________ = ___________ bpm

• **Advantages:** Better accounts for the _____________________________ between resting and maximal exercise.
The ACSM recommends heart rate based prescriptions for exercise should utilize Heart Rate Reserve (HRR).

Moderate Intensity activities range from ________ to ________% of HRR.

Vigorous Intensity activities are above ________% of HRR.

**Absolute Intensities**

Exercise physiologists have done a great deal of the hard work for us!

- Using mobile gas analyzers, we can measure the oxygen consumption needs of various exercises.
- Researchers have put together tables which give the general intensities of specific activities.
- These intensities are considered “Absolute Intensities”.

Absolute Intensities are based on the ____________________________ per minute using the Metabolic Equivalent of Task (MET).

- METs are a physiological construct expressing the energy cost of an activity as a _____________________________.
- Doing an activity that has an intensity of 2 METs requires twice the amount of energy as laying on your back quietly.
- ________ MET is equivalent to burning ____________ per kilogram of body weight per hour.
- Moderate Intensity activities range from 3.0 to ________________ METs.
- Vigorous Intensity activities have MET values greater than ________________.
- You can access the “Compendium of Physical Activities” at: https://sites.google.com/site/compendiumofphysicalactivities/home

However, Absolute Intensities can be confusing and difficult concepts to communicate to the general public.

So we can also use Relative Intensities.

- Effort required is relative to an individual’s personal fitness level.
- Guidelines use a 0-10 scale to communicate relative intensity.
- Moderate Intensity activity is between a _____________________________. 
• Vigorous intensity activity is greater than a ____________________________.

• We can also use the “Talk Test” to determine relative intensity:
  • Moderate Intensity Activity: Can talk without pausing, but cannot _______________.
  
  • Vigorous Intensity Activity: Cannot say ____________________________ without pausing for a breath.

• Relative intensity of a brisk walk depends on baseline fitness level:
  • For elite athletes may only be light-intensity
  • For recreational walkers may be of moderate-intensity
  • For sedentary middle-aged adults may be of high-intensity
  • For near-frail older adults may be nearly impossible.

**HOW DO WE GET KIDS TO MEET THE RECOMMENDATIONS?**

• Schools can provide students with a range of opportunities for physical activity through a comprehensive physical activity program.

• Schools can promote physical activity outside of physical education through policy development, implementation, and accountability. These policies may be related to:
  • After-school care programs that provide regular opportunities for active physical play.
  • Quality physical education programs.

  • Schools should require DAILY physical education for K thru 12th grade.
    
    • Elementary schools should have at least ____________________ minutes per week
    • Secondary schools should have at least 225 minutes per week.

  • Quality physical education provides the unique opportunity for young people to acquire the knowledge and learn skills needed to establish and maintain physically active lifestyles.

  • PE should be offered in a planned, systematic program of instruction with ____________________________________________________________.

  • The general concept of physical education in schools is that it is a waste of time.
    
    • Adults tend to look back to their youth and either see it as fun but not useful, or as emotionally troubling (i.e., they got picked on, not chosen for teams, etc…).
• The American Academy of Pediatrics recommends less than 2 hours of media time per day.
  • TV, Computer, Movies, & Video games.
  • Turn commercial breaks into activity breaks.
  • Do not eat while engaged in media time.
• Social marketing campaigns aimed at promoting physical activity among youth aged 9 to 13 (“tweens”).
  • VERB Campaigns

**PHYSICAL ACTIVITY RECOMMENDATIONS FOR ADULTS**

• For substantial health benefits, adults should do:

  • Either:

    1. At least _________________ minutes a week of moderate-intensity aerobic activity.

    2. _________________ minutes a week of vigorous-intensity aerobic physical activity.

    3. An equivalent combination of moderate- and vigorous-intensity aerobic activity.

• Aerobic activity should be performed in episodes of at least _________________ minutes preferably spread throughout the week.

• Moderate or high-intensity muscle strengthening activities that involve all major muscle groups at least 2 days a week.

• Avoid Inactivity

  • Some physical activity is better than none, and adults who participate in any amount of physical activity gain some health benefits.

  • Exceeding recommendations is associated with even greater health benefits.

    • But, above _________________ minutes per week, the benefit per minute decreases and risk of injury increases.

• For individuals with low levels of fitness and/or significant chronic conditions, physical activity should be increased gradually over time.

• “Start low and go slow” by gradually increasing how often and how long activities are done.

  • Use relative intensities to guide increases.

  • Evidence suggests that adding a small and comfortable amount of light to moderate-intensity activity (5 to 15 minutes of walking) has a low risk of musculoskeletal and cardiac incidents.
HOW DO WE GET ADULTS TO MEET THE RECOMMENDATIONS?

___________________________ Strategies:
• The majority of adult physical activity promotion efforts rely on individual motivation.
  • Improves PA for individuals already inclined to do so.
  • Unsuccessful at the population level.

___________________________ Strategies:
• Efforts to make the healthful choice the default choice, ideally forces individuals to “go out of their way” to make the unhealthy choice.
  • Increases engagement.

Worksite interventions
• Adults spend the predominant amount of their time at work.
• Opportunities for physical activity outside of work hours may be limited, particularly for ethnic minority and low income populations who may work longer hours or multiple jobs.
• A large proportion of calories per day are consumed during work hours.
• Moderately active and very active employees cost companies less in health care costs than sedentary employees.
• Have largely been ____________________________________________
  • Both individuals and organizations have been receptive to integrating activity on paid work time.
  • Increased perceived workplace support.
  • Physical activity was perceived as ________________________________.
  • LL Bean’s manufacturing plant observed a __________________________ minute increase in productivity after instituting just three 5 minute activity breaks per shift.

Set SMART goals
• Even the most motivated individuals will have times when they don’t feel like exercising.
  • Using behavioral change strategies such as goal setting can help people stay regularly active.
• Specific Goals: what, where, when, why, how
• Measurable Goals: allows for progress evaluation
• Adjustable Goals: flexible to accommodate unexpected challenges
• **Realistic Goals**: challenging yet individually attainable

• **Time-based Goals**: clear end-point

• Instead of: “I will start to work out” -> “I will jog 3 laps around the track at a moderate intensity 4 times a week for the next 2 weeks”

**Rate of Progression**

• The recommended rate of progression in an exercise program depends on the

  • _____________________________
  • Medical and health status

  • _____________________________
  • Goals
  • Tolerance to the current level of training.

• The training progression for most Sedentary Low-Risk individuals can be broken down into the Initial Stage, the Improvement Stage, and the Maintenance Stage.

• The initial stage should prepare the individual for the novel activities and develop an orthopedic tolerance to the exercise stress.

  • Should include an extended warm up (10 to 15 min).
  • Should include low-to-moderate intensity activities in an interval format.

  • Should begin with approximately __________________ of activity and progress up to 30 minutes.
  • This stage may last __________________.
  • Exercise adherence may decrease if the program is initiated too aggressively.

• The goal of the improvement stage of training is to provide a gradual increase in exercise stimulus to allow for improvements and adaptations to occur.

  • Differs from the initial stage in that the participant is progressed __________________________.

  • This stage typically lasts 4 to 8 months, during which intensity is progressively increased within the upper portion of the target range.

• The goal of the Maintenance stage of training is __________________________.

  • This stage usually begins after the participant has reached their pre-established goals.
• During this stage, the individual may no longer be interested in further increasing the conditioning stimulus.

• Further improvements may be minimal, but varying the type of exercises may help exercise adherence.

What do you think the biggest difference is between those individuals who keep regaining weight after diet/exercise vs those who maintain weight loss?