Body Composition Assessment & Sport-Specific Observations

HNF 610: Nutrition & Fitness
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Reasons to Assess Body Composition

- Provides a starting point to base current and future decisions about weight loss and weight gain
- Provides realistic goals about how to best achieve an “ideal” balance between the body’s fat and nonfat compartments
- Relates to general health status, thus playing an important role in establishing short and long-term health and fitness goals for all individuals
Reasons to Assess Body Composition (cont.)

- Monitors changes in the body’s fat and fat-free components during exercise regimens and rehabilitation programs
- Delivers an important message about the potential need to alter lifestyle
- Allows the allied health practitioner to interact with the individuals they deal with to provide quality information intimately related to nutrition, weight control, exercise, training, and rehabilitation
Weight-for-Height Tables

- Serve as statistical landmarks based on the average ranges of body mass related to stature in which men and women aged 25–59 years have the lowest mortality rate
- Do not provide reliable information about the relative composition of the human body
- Have limited value as a standard to evaluate physique
Body Mass Index

- Derived from body mass related to stature
- Used to evaluate the “normalcy” of body size
- As BMI increases, so does risk for cardiovascular complications (including hypertension and stroke), type 2 diabetes, and renal disease.
- The lowest health risk category occurs for individuals with BMIs between 20 and 25.
- The highest risk category includes individuals whose BMIs exceed 40.
Desirable BMI range:

- Women: 21.3–22.1
- Men: 21.9–22.4

BMI fails to consider fat patterning.

A high BMI could lead to an incorrect interpretation of overfatness in relatively lean individuals with excessive muscle mass because of genetic makeup or exercise training.
Relationship between all-cause mortality and BMI
BMI for National Football League

Year

Body Mass Index, kg m$^{-2}$

Very low risk

Low risk

Moderate risk

High risk

Defensive back

Defensive line

Linebacker

Offensive line

Skill player
Body Composition Definitions

- Medical literature:
  - The term overweight refers to an overfat condition, despite the absence of accompanying body fat measures.
  - Obesity refers to individuals at the extreme of the overfat continuum.
- The overweight condition simply refers to a body weight that exceeds some average for stature, and perhaps age, usually by some standard deviation unit or percentage.
Body Composition Definitions (cont.)

- When body fat measures are available, one can more accurately place an individual’s body fat level on a continuum from low to high.
- Overfatness refers to a condition where body fat exceeds an age- and/or gender-appropriate average.
- The term obesity refers to the overfat condition that accompanies a constellation of comorbidities.
New Standards for Obesity Threshold

Weight
Pounds: 153, 169, 186, 203, 221, 240
Kilograms: 69.5, 76.8, 84.5, 92.3, 100.5, 109.1

Height
Feet/inches: 5'0", 5'3", 5'6", 5'9", 6'0", 6'3"
Meters: 1.52, 1.60, 1.68, 1.75, 1.83, 1.90
Reference Man and Reference Woman

- The reference man is taller and heavier, his skeleton weighs more, and he has a larger muscle mass and lower total fat content than the reference woman.

- Reference man:
  - Fat 15% of total body mass

- Reference woman:
  - Fat 27% of total body mass
Theoretical Model for Body Fat Distribution
Essential and Storage Fat

- Essential fat consists of the fat stored in the marrow of bones, heart, lungs, liver, spleen, kidneys, intestines, muscles, and lipid-rich tissues of the central nervous system.
  - Normal physiologic functioning requires this fat.
- Storage fat depot consists of fat accumulation in adipose tissue.
  - Reference man: approximately 12% storage fat
  - Reference woman: approximately 15% storage fat
Archimedes’ principle of buoyant force
Fat-Free Body Mass and Lean Body Mass

- Lean body mass (LBM) contains a small percentage of essential fat stores equivalent to approximately 3% of body mass.
- Fat-free body mass (FFM) represents the body devoid of all extractable fat.
- In normally hydrated, healthy adults, FFM and LBM differ only in the “essential” lipid-rich stores in bone marrow, brain, spinal cord, and internal organs.
Men

- To calculate the lower fat limit in men (i.e., the LBM), subtract storage fat from body mass.

- For the reference man:
  - LBM (61.7 kg) includes approximately 3% (2.1 kg) essential body fat.

- Encroachment into this reserve may impair normal physiologic function and capacity for vigorous exercise.
Women

- The lower limit for the reference woman includes about 12% essential fat.
- Equals 48.5 kg for the reference woman.
- Generally, body fat percentages for the leanest women in the population do not fall below 10–12% of body mass.
- This value probably represents the lower limit of fatness for most women in good health.
Menstrual Irregularities

- Physically active women, particularly participants in the “low-weight” or “appearance” sports increase their chances of:
  - Delayed onset of menstruation (after age 16 years)
  - Irregular menstrual cycle (oligomenorrhea)
  - Complete cessation of menses (amenorrhea)

- One-third to one-half of female athletes in endurance-type sports experience some menstrual irregularity.
Menstrual Irregularities (cont.)

- In premenopausal women, menstrual irregularity or absence of menstrual function increases risk of bone loss and musculoskeletal injury in vigorous exercise.
- Potential causes of menstrual dysfunction include the complex interplay of physical, nutritional, genetic, hormonal, fat distribution, psychosocial, and environmental factors.
- Proper nutrition that emphasizes the maintenance of energy balance can prevent or reverse athletic amenorrhea without requiring the athlete to reduce exercise training volume or intensity.
Direct Assessment of Body Composition

- One technique involves dissolving the body in a chemical solution to determine the fat and fat-free components of the mixture.
- The other technique involves the physical dissection of fat, fat-free adipose tissue, muscle, and bone.
- These techniques are time consuming and tedious, require specialized laboratory equipment, and involve ethical questions and legal problems in obtaining cadavers for research purposes.
Indirect Assessment of Body Composition

- Hydrostatic weighing
- Skinfold thickness
- Girth measurements
- Bioelectrical impedance analysis
- Near-infrared interactance
- CT or MRI
- Dual-energy x-ray absorptiometry
- BOD POD using air plethysmography
Hydrostatic Weighing

- Involves the application of Archimedes’ principle
- Because an object’s loss of weight in water equals the weight of the volume of water it displaces, specific gravity refers to the ratio of the weight of an object in air divided by its loss of weight in water.
- Dividing a person’s body mass by body volume yields body density (Density = Mass ÷ Volume) and, from this, an estimate of percentage body fat.
- Involves immersion in water
Hydrostatic Underwater Weighing
Skinfold Calipers
Skinfold Measurements

- The rationale for using skinfolds to estimate body fat comes from the relationships among three factors.
  - Fat in the adipose tissue deposits directly beneath the skin (subcutaneous fat)
  - Internal fat
  - Whole-body density
- The most common anatomic locations for skinfold measurement include the triceps, subscapular, suprailiac, abdominal, and upper thigh sites.
1. **Abdomen**: 1 inch above the umbilicus
2. **Buttocks**: Maximum protrusion of buttocks with the heels together
3. **Right thigh**: Upper thigh, just below the buttocks
4. **Right upper arm (biceps)**: Palm up, arm straight and extended in front of the body; taken at the midpoint between the shoulder and the elbow
5. **Right forearm**: Maximum girth with the arm extended in front of the body
6. **Right calf**: Widest girth midway between the ankle and knee
Skinfold Measurements (cont.)

- Requires grasping a fold of skin and subcutaneous fat firmly with the thumb and forefingers and pulling it away from the underlying muscle tissue following the natural contour of the skinfold.
- The pincer jaws of calipers used for precise measurement exert a constant tension of 10 g·mm^{-2} at the point of contact with the caliper.
- The caliper dial indicates skinfold thickness in millimeters, which is recorded within 2 seconds after applying the full force of the caliper.
Skinfold Limitations

- The person taking skinfold must develop technical expertise with the proper measurement techniques.
- With extremely obese people, skinfold thickness often exceeds the width of the caliper’s jaws.
- The particular caliper used can contribute to measurement errors.
- It often becomes difficult to determine which prediction equation to use because of lack of standards to judge the results of different investigators.
Girth Measurements

- Involves the application of a linen or plastic measuring tape lightly to the skin surface so the tape remains taut but not tight.
- Along with predicting percent body fat, girths can analyze patterns of body fat distribution, including changes in fat distribution during weight loss.
- Measures of waist girth and the ratio of waist girth to hip girth provide an important indication of disease risk.
Fat Patterning

**Waist-to-Hip Ratio**
- Waist at navel while standing relaxed, not pulling in stomach
- Hips (largest girth around buttocks)
- Divide waist girth by hip girth

**Ratio for significant health risk**
- Males: ≥0.95
- Females: ≥0.80

**Types of Body Fat Distribution**
- Apple (android)
- Pear (gynoid)
Bioelectrical Impedance Analysis (BIA)

- A painless, localized electric current is introduced, and the impedance (resistance) to current flow is determined between the source and detector electrodes.
- Conversion of the impedance value to body density—adding body mass and stature, gender, age, and sometimes race, level of fatness, and several girths to the equation—computes percent body fat from the Siri equation or another similar density conversion equation.
BIA Limitations

- Hydration level, even small changes that occur with exercise, affects BIA accuracy, and may give inaccurate information about a person’s body fat content.
- Hypohydration and hyperhydration alter normal electrolyte concentrations, which in turn affect current flow independent of a real change in body composition.
- Skin temperature (influenced by ambient conditions) also affects whole-body resistance and thus the BIA prediction of body fat.
Near-Infrared Interactance

- Assesses body composition in humans using principles of light absorption and reflection
- Safe, portable, and lightweight equipment requires minimal training to use and necessitates little physical contact with the subject during measurement.
- Available data do not support NIR as a robust, valid method to assess human body composition.
CT and MRI
CT and MRI

- Computed tomography (CT) and magnetic resonance imaging (MRI) produce images of body segments.
- CT scans can evaluate the relationship between simple anthropometric measures (skinfolds and girths) at the abdominal region and total adipose tissue volume.
- MRI effectively quantifies total and subcutaneous adipose tissue in individuals of varying degrees of body fatness.
Dual-Energy X-Ray Absorptiometry

- Quantifies fat and nonbone regional lean body mass, including the mineral content of the body’s deeper bony structures and muscle mass
- Clinical tool to assess spinal osteoporosis and related bone disorders
- Computer software reconstructs the attenuated x-ray beams to produce an image of the underlying tissues and quantify bone mineral content, total fat mass, and FFM.
BOD POD

- Uses air displacement plethysmography to estimate body volume.
- Body density computes as body mass (measured in air) ÷ body volume (measured in BOD POD).
- The Siri equation converts body density to percent body fat.
Comparisons
Sport-Specific Observations

- The Elite Athlete
  - Olympic and Elite Athletes
  - Field Event Athletes
  - Female Endurance Athletes
  - Male Endurance Athletes
  - Triathletes
  - Swimmers versus Runners
  - American Football Players
  - Professional Golfers
Comparison Lean to Fat Ratio
Comparison Body Fat in Sports

- **High Skill**
  - Tennis
  - Alpine skiing
  - Golf
  - Long jump

- **Aesthetic**
  - Dancing (ballet)
  - Diving
  - Gymnastics
  - Body building

- **Weight Category**
  - Weight lifting
  - Judo
  - Karate
  - Wrestling

- **Endurance**
  - Rowing
  - Cross-country skiing
  - Swimming
  - Marathon running

- **Ball Games**
  - Basketball
  - Soccer
  - Football, line
  - Football, backs

- **Power**
  - Shot put
  - Discus
  - Sprint

Legend:
- Male
- Female
Body Composition of Top 10 American Male Athletes