

## Energy Balance and Body Composition - 1

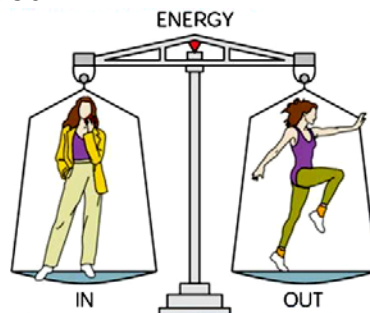
At the beginning of the quarter you did a computer dietary analysis based loosely on the following input:

- Age
- Gender
- Height
- Activity level
- Goal or actual weight

Most of us are well aware of how much we weigh, and typically equate weight to our body image or appearance. It seems that most of us are perpetually unhappy with some aspect of our "weight" or appearance. This section of our course will address energy balance and body composition, approaches to appropriate weight management for health, and obtaining and maintain fitness for optimal health.

We have been discussing throughout this course needed nutrients, energy requirements and, the proportions of nutrients needed to balance our energy needs while obtaining sufficient nutrients. When we consume excess calories, our body stores those excesses as adipose. When calories consumed are less than calories used, we lose weight, but not all in fat. Both too few calories and too many calories cause problems.

At this time we shall turn our attention to how we can best determine the appropriate level of food (or calorie) intake to obtain and maintain health and fitness – on other words – to obtain an **energy balance** between calories consumed and calories expended.

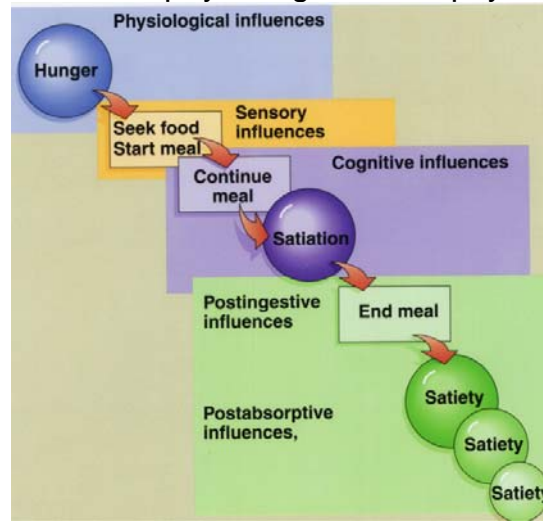


From the beginning it is important to understand that health and fitness do not mean obtaining a certain body weight or "ideal" appearance. However, there is a weight range beyond which (in either direction) health and fitness are lowered for most of us.

All of us from time to time have short-term weight fluctuations. That is normal since we don't eat exactly the same things everyday, and we don't do the same level of physical activity everyday. However, when weight consistently increases, or decreases, we have an energy imbalance, and we need to look into that. In the United States, the energy imbalance is tilted to weight gain for one-third of adults and children. For as much as 20% of us, the energy balance is tilted to unhealthy underweight. It makes sense for us to examine the factors that contribute to energy balance so we can avoid unhealthy imbalances.

## Food Consumption - Hunger, Appetite and Satiety

Our eating behaviors involve both physiological and psychological factors.



**Hunger** is the stimulus that drives our need to eat. When our bodies need fuel, signals are sent from the empty stomach and intestines that trigger feelings of "hunger". Signals are processed by the brain; we can override signals and habituate to delaying hunger response actions. People who fast or starve typically have diminished hunger responses. We can also adapt to eating more. The receptors that signal fullness can be ignored, and we can habituate to "over-consuming". Our "supersize it" national behavior attests to this.

**Appetite** is another signal to eat. We can have an appetite for food with or without hunger. Sights, smells, thoughts or discussion of foods may stimulate appetite. Stressful situations often stimulate (or repress) appetite.

**Satiety** is the feeling of fullness that stops appetite and hunger signals. Satiety signals that originate in the stomach are delayed from the start of eating, so for many, it's easy to overeat before satiety signals are received and acted upon. The length of time food stays in the stomach and intestine affects the duration of satiety and initiation of hunger signals.

### Foods and Satiety and Eating

- Protein-rich foods have a high satiety value. That's one of the reasons that high protein diets are popular.
- Foods high in fiber have a high satiety value because they stay in the stomach and intestine for longer periods of time than foods that contain concentrated sugars or highly processed foods that digest and absorb readily. People who consume quantities of whole grain products, vegetables and fruits often feel no hunger because their satiety signals remain "on".
- Foods high in fat, although calorie dense, have a low satiety value. They fail to trigger the satiety signals so we often over-consume high fat foods, those that have the most calories. Unfortunately, many high fat foods trigger appetite, compounding problems for those who consume more calories than they need.

## Hunger and Satiety Controls

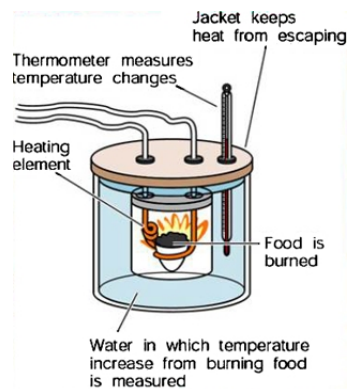
Hunger, appetite and satiety signals are all processed by the **hypothalamus** in the brain. It monitors metabolic as well as psychological signals and triggers responses. Dozens of chemical signal molecules are involved in appetite and satiety, and an active area of research. Identifying signal molecule roles may be a way to control energy balance. For example, **neuropeptide Y** increases appetite and decreases energy use; the hormone, **leptin**, diminishes appetite and promotes energy expenditure. One test of the hormone, **peptide YY<sub>3-36</sub>** (PYY), reduced hunger; those who ingested PYY ate 30% fewer calories in a buffet two hours after being injected with PYY whether they had plentiful fuel reserves or not.

People whose satiety signals are suppressed (no matter what the reason) might be given a signal molecule that will trigger satiety for them. Those who have underweight problems might be given a chemical that will trigger hunger signals that do not get overridden.

That hunger, appetite and satiety signals, can be suppressed is one of the problems we have with both overweight and underweight. Some of the health effects of suppressing hunger and satiety will be discussed later.

## Energy Expenditure – How We Use Calories

The energy of the foods we eat is measured in calories (literally kilocalories), a unit of heat energy. The energy value of foods is measured in a calorimeter that literally burns the foods and measures the amount of heat given off by the increase in water temperature within the calorimeter. 1 calorie is the amount of heat energy needed to raise 1 gram of water 1°C. Food calories are actually kilocalories.



The calories we consume, as we know, are used in the process of cell respiration, to provide ATP for cell activities. Some nutrients, especially protein, are also used for body structure, so their calories don't get used in cell respiration except when consumed beyond the body's protein needs or when insufficient carbohydrate or total calories are consumed.

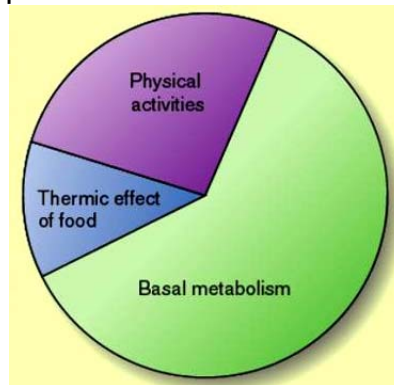
Cell respiration is only about 40% efficient, the remaining energy value of foods is given off as heat. Some of this heat is used to maintain body temperature; some is radiated to the surroundings.

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Just as we measure the calorie value of foods by heat generated, we measure energy expenditure by measuring how much heat is given off during cell respiration. This heat production (as a by-product of cell respiration) is called **thermogenesis**, except that no one ever uses that word outside of textbooks and nutrition lectures. But thermogenesis measurements are useful in helping us determine our individual energy requirements or calorie needs.

There are three components to thermogenesis, hence determining energy needs:

- Basal Metabolism (Basal Thermogenesis)
  - 60 - 70% of energy used
- Physical Activity (Exercise-Induced Thermogenesis)
  - 20 - 30% of energy used, but highly variable
- Digestion (Diet-Induced Thermogenesis)
  - 10% of energy expended



In addition, if someone needs to adapt to altered circumstances, such as recovery from trauma, starvation, exposure to extreme cold (or heat), dramatic change in physical activity, etc., there may be a change in metabolism as well, known as **adaptive thermogenesis**. Adaptive thermogenesis is usually temporary, and can be met by temporary adjustments in food consumption.

### Basal Metabolic Rate (Basal Thermogenesis)

Our basal metabolism includes the energy needed to maintain the normal activity of cells and tissues. On the average, 60 - 70% of our calories are used for basal metabolism. Basal metabolic rate is usually measured when one is at rest and comfortable.

Included in basal metabolism are:

- Heart beat
- Breathing
- Nerve transmission
- Kidney filtration and reabsorption
- Active transport (movement of materials across cell membranes)
- Protein synthesis
- Cell growth, maintenance, tissue repair, replacement, etc.

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Although basal metabolic rate is somewhat related to size and body weight, there are a number of variables:

- Age and Development
  - Younger (growing) people generally have a higher BMR
  - Older people have a lower BMR because hormones that affect metabolism change, ratio of muscle tissue to fat tissue alters and activity often decreases.
- Height – Surface area to volume ratio
  - Those who are taller may have a higher BMR based on surface area to volume ratios. Heat is lost through body surfaces. A smaller surface area to volume ratio person may have a lower BMR.



- Muscle mass
  - Denser muscles require more energy to maintain than fat tissue does.
  - Obese individuals often have a lower BMR simply because fat tissue needs less energy to be maintained.
- Health
  - Fever, illness and trauma increase metabolic rate.
- Fasting or malnutrition
  - Lower basal metabolism (evolutionary mechanism to preserve any reserves of energy)
- Hormone Activity
  - Epinephrine (Adrenalin) increases BMR for stress responses.
  - Thyroxin can increase or decrease BMR.
- Gender
  - Males usually have a higher BMR but it is related to having a higher proportion of muscle/bone to fat tissue.

### **Digestion Related Metabolism (Diet-Induced Thermogenesis)**

The process of digesting food and absorbing nutrients takes energy. The calories needed in the process of digestion are fairly constant, usually about 10% of the total calories taken in. The more calories eaten, the more energy is used to digest them, but it's in proportion to total calories. There are some differences:

- Carbohydrates, especially complex carbohydrates produce more heat during digestion, so they use a bit more energy.
- It takes a bit more energy to digest and absorb when eating a large meal than when eating more-frequent smaller meals.
- There are genetic differences among people, so that some require more energy to digest food than others. This is also reflected in individual variations in the utilization of food.

**Physical Activity Metabolism (Exercise Thermogenesis)**

The most variable component of our calorie requirements is the energy we expend in voluntary physical activity, contracting our skeletal muscles. Muscles need energy to contract. The more muscles we contract and the more frequently we contract them, the more calories we burn. In addition, metabolic rate increases during physical activity, and remains elevated for some time after physical activity. The more active one is the more calories one requires!

The variables involved in physical activity and the amount of energy used are body weight, muscle mass and activity. Duration, frequency and intensity of activity also affect calories used.

- The total time using muscles affects total energy expended.
- The amount of weight being moved by the muscles affects energy, so that someone who is heavier will burn more calories doing the same activity than someone who is lighter.
- How many muscles being used affects the calories used. Activities that involve more muscles burn more calories.
- How intensely one uses the muscles (puts demand on the muscles) will also affect calories.
- The level of fitness and skill of person doing activity also affects calories. More fit people are more efficient.

Mental activity, while voluntary, burns no calories beyond BMR needs

There have been many studies conducted to determine how much energy different physical activities require for different individuals. Your text has a table that shows some activities and energy required. Some examples are shown below for an average 150-pound person. No matter what activities one chooses, it's better to have any physical activity, about an hour a day, than not!

<b>Activity</b>	<b>Rate</b>	<b>Calories/Hour</b>
Bicycling	6 - 12 mph	240 - 410
Cross-country skiing		700
Jogging	5 1/2mph	740
Running	10 mph	1280
Swimming	25 yds/min.	275
Walking	2 mph	240
Gardening		270 - 540
Standing		60 - 120
Writing		120

Tables such as these can help determine the types of activities one wants to participate in but are too tedious to use for determining general energy needs. Formulas based on general activity level and average BMR are used for determining calorie recommendations. Example formulas are in your text and assignments.

## Body Composition, Weight and Health

Appropriate weight for any of us should meet the following criteria, and should be based foremost on health.

- We should strive for a weight within the range for our height.
- We should try and maintain a fat distribution and proportion that maintains a low risk for health problems.
- Our medical history should reflect good serum cholesterol, normal blood glucose levels and normal blood pressure.

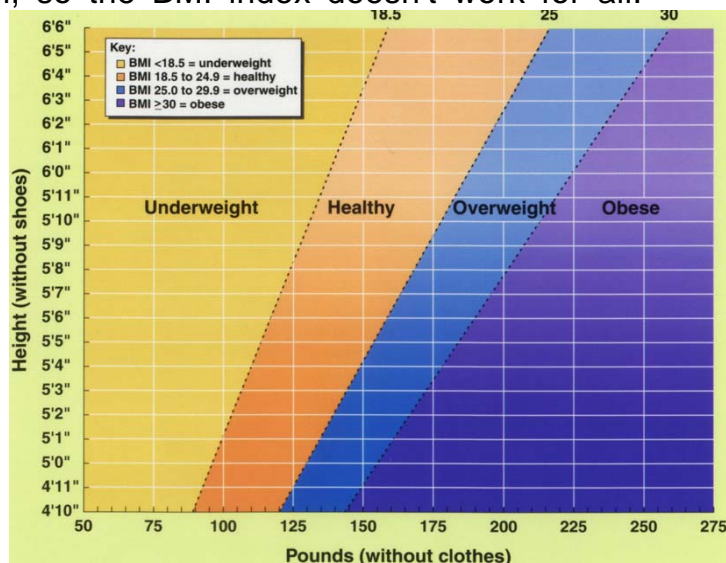
If we meet these criteria, our weight is probably appropriate for health and we need to take measures in our eating behaviors and activity level to maintain the appropriate weight. yet most of us still want to obtain and/or maintain some "weight" and associate this "weight" with well-being.

How much one weighs relative to one's height and age is just a part of determining health. The proportion of lean tissue – bone, muscle and water – to fat tissue and the distribution of fat tissues is important to health and is the basis of **body composition**.

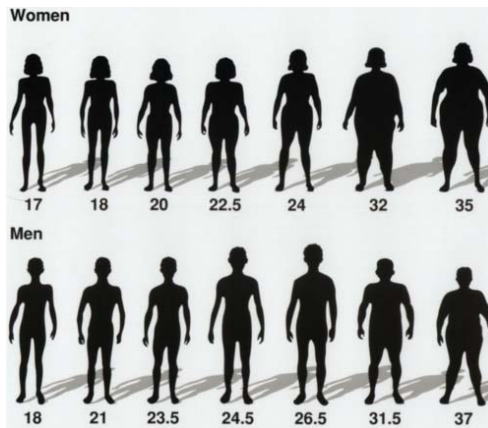
If one's weight distribution is disproportionately fat, he or she will have greater health risks than someone whose fat/lean tissue mass is better proportioned. In a similar fashion, one whose lean tissue is disproportionate can also have health issues. Gaining or losing weight doesn't necessarily relate to improved health. Today tables based on **body mass** are frequently used to determine whether one's weight is in a "healthy" range. The **body mass index** (BMI) is a calculation of weight/height. The index is then factored into appropriate weight ranges.

### Using the Body Mass Index (BMI)

BMI tables are designed to immediately tell one if his her BMI is within an appropriate weight range, underweight or overweight. In general a BMI of less than 19 reflects underweight and one over 25 reflect overweight. The higher the BMI, the greater the health risk. The BMI does not factor in muscle mass proportion to fat mass proportion, so the BMI index doesn't work for all.



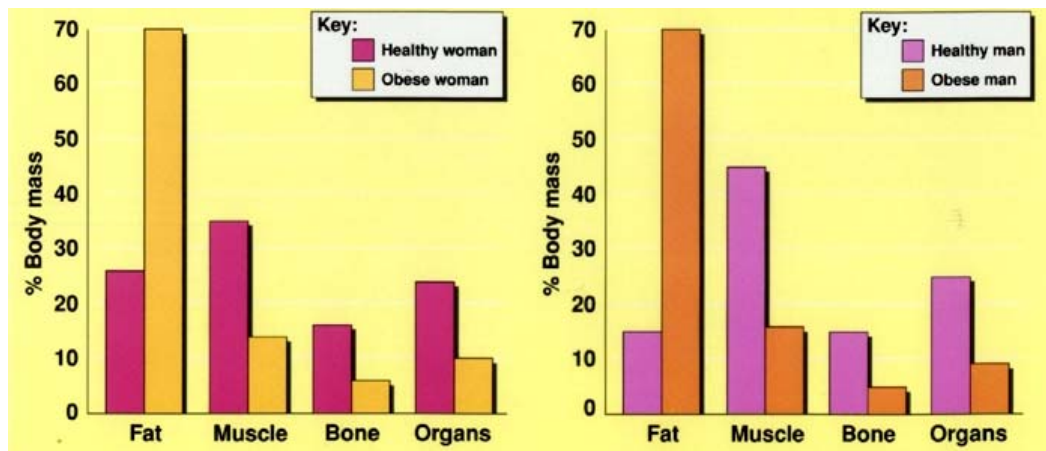
BMI also reflects, to some extent body composition. BMI is also represented by images. Again, someone whose weight is distributed disproportionately in the upper body or the lower body may not have a healthy body composition even if he or she has a healthy BMI.



### Assessing Body Composition – Distribution of Body Fat

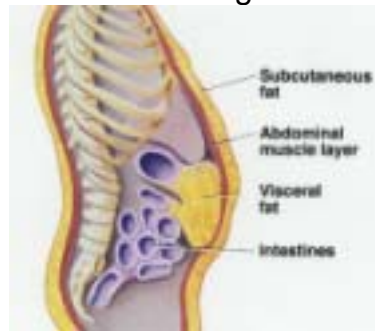
Men and women, on average, have different proportions of body fat differently distributed in the body. Ultimately we want a fat proportion and distribution pattern that promotes individual health.

- For men an average 12 – 20% body fat and for women, 20 – 30% body fat promotes health.
- The proportions of lean tissue to fat tissue in different parts of the body change with increasing fat tissue accumulation. The changing proportion patterns have impacts on health. For men, over 25% body fat may impair health, and for women, more than 35% body fat is considered health impairing.
- Some people, in particular athletes, may have a lower proportion of body fat, simply because they have more fit muscle development mass. For some male athletes, a body fat proportion of 8 – 10% may be adequate for the body's fat needs. For female athletes, body fat of 15 – 20% is OK.
- Some people, particularly those who live in very cold climates, need more subcutaneous insulating fat, so their proportion of total fat may be higher than average, but still promote health.



### Fat Distribution Patterns

Where one's fat is distributed also impacts health. Fat deposited in the abdominal cavity surrounding the internal organs has health impacts even when total fat proportion is in the healthy range. Unhealthy abdominal fat distribution is known as **central obesity**, with reference to where fat deposits are located. Abdominal fat is most common in post-menopausal women and almost all men. However, all people with central obesity are at greater risk for cardiovascular disease and increased mortality rates. It's easy to predict central obesity risk based on **waist measurements** and waist to hip comparisons. For most, a waist measurement over 35" in women and 40" in men are at higher risk for cardiovascular disease.

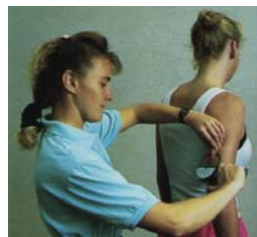


### Measuring Body Fat

A number of tools, such as **skinfold** testing, **hydrodensitometry** and **electrical impedance**, are available for measuring body fat proportions and distribution. Unfortunately, some are expensive.

### Fatfold or Skinfold Measurement

The most common measurement of body fat is the skinfold test. Calipers are used to measure the thickness of a fold of skin in different parts of the body. These measurements are compared to standards to determine body fat proportions.



### Hydrodensitometry

Body weight is measured submerged in a water tank and compared to one's normal body weight. Comparing the two gives a value for one's volume. Calculations are used to compare body volume to actual weight to obtain density. One's proportion of body fat can be determined from the body density calculation.



### Electrical Impedance

Electrical impedance measures the electrolyte proportions in body fluids using a low voltage electrical current. Since fat tissues have less water and electrolytes (fats are non-polar) they resist the electric current flow. The more resistance, the more body fat. Calculations based on the electrical impedance are used to determine body fat proportion.



### Health Risks Associated with Weight and Body Fat

If calorie intake averaged over several days equals body activity then one's weight is usually stable at whatever weight one happens to be at; it doesn't mean that one's weight is appropriate for health. We now want to address some of the health risks associated with inappropriate weight and what can be done to achieve and maintain a healthier body. Discussions seem to focus on problems of overweight, but it's just as important to examine health risks for those who do not have enough fuel reserves and are underweight.

### Overweight (Overfat) Risks

A person who is more than 20% above the appropriate weight range and the excess weight is in fat tissue is **obese**. There are so many health risks associated with obesity that it is considered to be a disease. These health problems result in 300,000 obesity-related deaths each year, untold lost wages, and health care costs. Only smoking has greater health risks for "preventable" diseases.

Some of the health risks associate with obesity are:

- Cardiovascular disease
- Hypertension
- Diabetes and insulin resistance
- Respiratory complications
- Breast and some other cancers, perhaps related to greater hormone concentrations in circulation
- Osteoarthritis
- Sleep apnea
- Pregnancy complications

Many other factors add to health risks associated with body fat and weight:

- Where one's fat is distributed, as mentioned, is an added factor.
- Unfortunately, total adult weight gain is also a factor. Gains of more than 20 pounds over one's weight at 18, no matter what one's BMI or waist measurement is, adds health risks. (This assumes one was healthy at 18, not always the case.)

- Body weight fluctuation is also a health factor. When one repeatedly gains and loses weight, body lean/fat proportions often change. When we lose weight, we too often lose muscle tissue. Weight gain more frequently is added fat tissue.
- And fitness is a big factor. Fitness enhances health no matter what one's weight. Lack of fitness impairs health, again, no matter what one's weight.

Beyond these health factors, social factors also impact the "health" of overweight persons.

- Obese people have problems with "distorted body image" and sometimes, job discrimination. Obese individuals are perceived as being unable to be responsible and "in control".
- A recent European study reported that a normal weight person "coupled" with another normal weight person was perceived as being more attractive than when partnered with an obese person. Social perceptions start young. Even children choose "thinner" people as being more attractive. We will revisit social body image pressures a bit later.
- Obese individuals may have to pay more for clothing, housing (when health conditions require special housing arrangements) and have more medical expenses.

### **Underweight (Underfat) Risks**

A person who is 10% below the desired weight range is considered underweight. Underweight individuals may be healthy or not. People are underweight for a number of reasons, including disease and illness, smoking, poverty, and eating disorders, which are also diseases, but all result in too few calories consumed relative to one's needs. Underweight induced from perceptions of ideal body image is also a concern. This issue will be addressed again later.

- As one ages, the risks of being underweight are greater because we need fuel reserves to deal with illness and undernourishment that becomes an issue with aging.
- Anyone who is underweight is less able to deal with malnourishment and the associated increased risk of infectious diseases.
- Those who are underweight have fewer reserves to recover from injuries.
- Underweight pregnant women give birth to underweight babies with associated health risks. Infertility is a problem with seriously underweight young women.
- Osteoporosis and bone loss are also associated with being underweight.
- Underweight persons who get cancer have a higher mortality rate. Cancers ravage the body, and with few reserves, the underweight person is less able to fight. This is exacerbated by needed cancer therapies. Radiation and chemotherapy both damage body tissues.

It is clear there are health risks associated with inappropriate weight, be it overweight or underweight. In our next section we will address means to manage weight to maximize health.