Body Composition

Fat is Something that you Have, Not Something that you Are.

Although it's bad form to define something by what it's not; in the case of body composition, it's necessary given societal misconceptualizations of this concept that are highly problematic. 'I feel fat. I need to lose weight.' reflects a particularly common statement within US culture. Yet despite the popularity of such statements, discussion of body composition and weight is a cultural taboo. As a result, there are a number of common misunderstandings about body composition, how we should assess it, and what we should do when unhealthy body composition occurs.

Topics: Body Dysmorphia — Two Component Model — White Adipose Tissue — Brown Adipose Tissue — Beige Adipose Tissue — Types of Fat Distributions — Elimination of Lipids — Four Component Model — Anatomical Model — Relative Body Composition — BMI — Obesity — Healthy Body Image

One Component Model of Body Composition — The use of overall body mass to infer body composition.

There are a number of critical issues with statements such as 'I feel fat. I need to lose weight.' First, such statements reflect the societal trend that when people talk about body composition they specifically refer to a subcomponent of body composition (fat) but do not measure that subcomponent. Instead most people use a one component model of body composition, where the individual measures their body mass and makes some inference (conclusion) about the underlying body composition. Although body composition is mathematically related to overall body mass (the parts make up the whole), focusing only on overall mass perpetuates misunderstanding about what is going on in the underlying bodily tissues. Further, consider statements along the lines of 'I just need to lose ten pounds'. Clearly the ten pound goal is arbitrary (why not eight or eleven). But would reducing overall body mass by ten pounds actually impact their self-perceptions? We could simply send the person up into space or remove a limb, both would result in a ten pound loss of body mass. We could also just continue to weigh the individual every 20 minutes throughout the course of the day over the span of a week. Natural fluctuations in body mass can result in nearly a ten pound difference between the heaviest and lightest mass over such a period in the same individual. But none of these options would necessarily positively impact the individual's health and wellness. **Body mass is not body composition**, nor does body mass inherently provide any insight into the health or wellness status of an individual.

Second, a particularly common phenomenon following medical weight loss procedures is that even when an individual loses weight, they still report perceptions of 'feeling fat.' The general statement reflects the individual's self-perceptions of their body image, which has very little relationship to their actual physical attributes/appearance. This helps explain why changing the physical attributes would not necessarily change their self perceptions. So the critical question becomes, when the individual makes a statement that they are 'feeling fat', what does that actually mean? There is no one reason for this as it can be a reflection on not being comfortable with oneself, a manifestation of impaired function (they were out of breath walking up the stairs), or even self-presentational (they don't like how they look in their clothes). It is important to understand that perceiving flaws within our own physical appearance is a natural phenomenon referred to as **Body Dysmorphia**. Although body dysmorphic disorder represents a clinically severe form of this, where the individual becomes excessively preoccupied with their body dissatisfaction (typically in excess of 3 hours per day) resulting in impairments in the ability to function; it is perfectly normal to experience some symptoms of body dysmorphia. Focusing health behaviors on acquiring greater functional capacity and **shifting focus from how an individual looks to how an individual feels/their achievements** can help reduce much of their body dissatisfaction.

Two Component Model of Body Composition — The differentiation of body composition into either fat or fat-free mass.

When most people talk about body composition they are generally referring to the **Two Component Model**, the proportion of fat and fat-free mass in the body. Contrary to general perceptions, low body fat — less than 6% for males and 9% for females — is unhealthy and is associated with a greater risk of osteoporosis and bone fractures, reduced immune function, chronic fatigue, cognitive dysfunction, irregular menstrual cycles, and fertility issues. Healthy body composition is generally viewed as having a high proportion of fat-free mass relative to fat mass. Health-related criterion referenced standards for body fatness for the two component model indicate that healthy body fat levels are between 6 to 24% for males and 9 to 31% for females. Body fat above 24% for males and 31% for females is considered high and is associated with nearly double the risk of all-cause mortality and reduced life expectancy. The prototypical distribution of the two component model of body composition for most individuals allocates 21% of body mass for fat mass and 79% of body mass for fat-free mass.

Although largely irrelevant to the overall health and wellness of an individual, the attainment of 'six-pack abs' holds substantial influence as to the general public's perceptions of health and wellness, as well as results in a halo effect for perceptions of credibility/expertise. A rule-of-thumb is that body fat can be estimated based on the appearance of the abdominals. Sharp, crisp six-pack abs, like those in bodybuilding contests, are visible when body fat is between 4 and 5%. If all abdominal rows are clearly visible, body fat is likely between 6 to 8%. Between 9 and 12% body fat is associated with a six-pack visible in some lights. If abdominal definition allows for differentiating four areas, that is usually associated with body fat between 13 and 16%. Between 17 and 20% body fat allows for some abdominal definition to begin to occur. However, such a rule-of-thumb is generally oriented towards males/masculine body types, with similar guides for females/feminine body types increasing the ranges by around 3% (so some abdominal definition begins to occur between 20 and 23% body fat for females). However, such rules-of-thumb generally are based upon assumptions about the distribution of body fat and largely ignore the influence of the type of body fat.

White Adipose Tissue — Fat cell specialized for the storage of energy.

Brown Adipose Tissue — Fat cell specialized for the creation of heat.

Beige Adipose Tissue — Fat cell specialized for both the storage of energy and the creation of heat.

Adipose tissue (the technical term for body fat) is categorized into three different cell types: white, brown, and beige **adipocytes** (fat cells). The most abundant adipocyte is white, which accounts for more than 90% of all adipose tissue in the body. When most people think about body fat, white adipocytes are what they are thinking about. These cells are specialized for the storage of energy and have an internal composition characterized by a large lipid droplet (fatty compound) and a small number of mitochondria. In excess energy conditions, the white adipocyte converts that energy into lipids to store the energy so that it can be used when energy availability is scarce.

White adipocytes have a unique property by which taking in additional lipids can allow them to undergo **hypertrophy** and increase to four times their initial size (going from 25-50 micrometers to 100-200 micrometers). However, once hypertrophic limits have been reached, white adipocytes undergo **hyperplasia** and cellularly divide to create more white adipocytes. Expending the excess energy they have taken in only serves to decrease the size (hypotrophy) of the white adipocytes and does not alter the number (hypoplasia) of white adipocytes.

Brown adipocytes are more abundant in fetal life and during infancy, but during adulthood account for less than 10% of all adipose tissue in the body. These cells are specialized for the creation of heat and have an internal composition characterized by a large number of mitochondria and many small lipid droplets. The mitochondria process the small lipid droplets in a process called **non–shivering thermogenesis** which creates heat and helps to regulate body temperature. Although the presence of brown adipocytes is relatively low, seasonal variation in accumulation has been observed with greater accumulation of brown adipocytes during the winter and lesser accumulation during the summer. However, this seasonal variation is more strongly associated with the photoperiod of available sunlight than with changes in temperature. Additionally, brown adipocytes have been speculated to play a role in diet-induced thermogenesis as the activity of brown adipocyte mitochondria increases following eating.

Beige adipocytes display the characteristics of both white and brown adipocytes and have an internal composition characterized by a small number of medium–sized lipid droplets and a moderate number of mitochondria. The normal conditions in which the beige adipocyte exist appear to bias the cell to act very similar to white adipocytes. They process and store excess energy within the lipid droplet so that it can be used later. In this way, beige adipocytes have been traditionally viewed within the context of being white adipocytes, although gene expression analyses indicate that beige adipocytes represent a distinct type separate from white adipocytes. However, when exposed to certain stimuli such as cold temperatures, beige adipocytes alter their action to stop storing energy (like white adipocytes) and instead create heat (similar to brown adipocytes) through a process referred to as **browning**. In this state, the beige adipocytes process stored lipids to generate heat and contribute to greater energy expenditure. Although proponents of cold therapy (e.g., ice-baths, cryotherapy) often promote these approaches as ways to burn body fat — by activating beige adipocytes — the duration necessary for such 'browning' to occur has been observed to take between 4 to 20 hours of continuous exposure. Chronic exposure to cold therefore appears to activate beige adipocytes to help to regulate body temperature. Interestingly, however, activation of beige adipocytes has also been observed to result from dietary practices, physical activity behaviors, pharmaceutical agents, and plant-based bioactives suggesting it may play a role in regulating other metabolic processes.

Subcutaneous Adipose Tissue — Fat cells located under the skin. Also sometimes referred to as Dermal Adipose Tissue.

Visceral Adipose Tissue — Fat cell located around the organs.

The distribution of white adipose tissue is generally characterized by segmenting adipocytes that reside just under the skin (subcutaneous) from those surrounding internal organs (visceral). As adipocytes are nearly free of water — unlike muscle cells — the adipose tissue is a poor thermal conductor allowing subcutaneous adipose tissue to act as insulation to retain body heat. Visceral adipose tissue plays a role in providing cushioning for internal organs, but can impair the function of those organs if excess accumulation occurs. This is what makes the **Android Fat Distribution** — where visceral adipose tissue accumulates around the area of the chest and abdomen (giving an apple shape to the body, also referred to popularly as a beer belly) — a strong risk factor for cardiovascular disease and diabetes. When the term **central adiposity** is used, this is what is being referred to. In contrast, the **Gynoid Fat Distribution** — where subcutaneous adipose tissue accumulates around the area of the hips and upper legs (giving a pear shape to the body) — is only a modest risk factor. Although observed to vary across populations, subcutaneous adipose tissue usually makes up approximately 50% of body fat.

Another popular framework for fat distribution attempts to categorize individuals by body morphology. This framework originally came out of Somatotype Theory which proposed using body shape and physiological tendencies as a way of predicting psychological characteristics — a highly flawed and problematic approach. Nevertheless, the general observations associated with body shape and physiological tendencies have remained a useful framework. Individuals who exhibit an **Endormorphic** body shape tend to exhibit higher levels of subcutaneous body fat and have larger/more dense bone structures. Physiologically, these individuals tend to exhibit a tendency for more efficient metabolic rates making it easier to gain excess adipose tissue and more difficult to reduce adipose tissue. As a result of the adipose tissue it is also more difficult to observe increases in muscle tissue.

Individuals who exhibit an **Ectomorphic** body shape tend to exhibit lower levels of body fat and are often described as ``tall and lanky" as they have longer long bone structures. As a result of this body morphology, such individuals tend to exhibit less visible changes in muscles whereby the muscles grow stronger but do not appear to grow substantially larger. They also tend to be more sensitive to increases in adipose tissue where it becomes visible earlier even with small changes in body fat. Individuals who exhibit an **Mesomorphic** body shape tend to be described as ``short and stocky" or as having ``broad shoulders". This naturally muscular body shape is largely attributed to physiologic tendencies where they have shorter long bones and tend to store adipose tissue within and underneath the muscle tissue rather than subcutaneously. As a result changes in muscle tissue tends to be much more pronounced while it is much more difficult to observe changes in adipose tissue — as it can appear externally to be associated with muscle tissue.

The challenge is that classically these categories have been thought of as a box that individuals fall into and would be unable to deviate from.Ultimately, these body morphologies reflect genetic tendencies and more modern evidence suggests that they exist on a continuum rather than reflecting strict categories. It is also important to note that an individual with an endomorphic body shape can become more muscular or reduce adipose tissue. These body morphologies simply characterize particular tendencies wherby such an individual is likely to have a more difficult time reduce body fat and showing muscular adaptations in contrast to an individual with a mesomorphic body morphology who seems to appear highly muscular with minimal training and poor diet.

How Do We Get Rid of Adipose Tissue?

One of main misconceptions about the use of physical activity and exercise to reduce adipose tissue is the extent to which fat utilization is under local control. In reality, fat utilized in energy metabolism is not necessarily pulled from adipose tissues close in proximity to the active muscle, but rather systemically driven mechanisms will preferentially pull fat from certain areas while sparing others. So fat appears to be under systemic rather than local control. Doing abdominal exercises will not specifically target the removal of adipocytes within the abdominal area. This process has a large genetic component and explains the occurrence of 'hard-to-lose' areas of body fat. Similarly, in contrast to a variety of beliefs, the vast majority of adipose tissue that is 'burned' is expelled from the body as carbon dioxide (a byproduct of energy metabolism). Through energy metabolism, an individual who loses 10 kg of adipose tissue will have exhaled nearly 8.5 kg of that mass as carbon dioxide. So the lungs are the primary excretory organ for fat.

Four Component Model of Body Composition — The differentiation of body composition into either fat, water, protein, or mineral mass.

Another popular misconception for reducing body fat relates to altering body water. This misconception can be understood through the use of the four component model of body composition which specifically separates bodily tissues into either fat, water, protein, or mineral mass. Water, protein, and mineral mass represent subdivisions of fat-free mass. The prototypical distribution of the four component model of body composition for most individuals allocates 21% of body mass to fat mass, 58% of body mass to water mass, 16% of body mass to protein mass, and 7% of body mass to mineral mass. Each individual's proportions will differ, so measurement of these components is essential.

Consider popular claims relating to the use of body 'cleanse' products as a means of excreting fat as waste. In reality, with the exception of pharmaceuticals that block fat from being absorbed, such body 'cleanse' products only serve to reduce body water. The use of natural or synthetic diuretics to cause the body to excrete body water also results in the excretion of foods/bacteria currently in the digestive tract. While overall body mass is reduced, this can result in increases in body fat as individuals engage in compensatory/rebound eating. There is also evidence to suggest that the removal of microbiota in the gut through such diuretics can result in the body storing more body fat. Nevertheless, since fat is stored in adipose tissue without water, adjusting total body water has little effect on fat mass; but it does alter the percent of body mass that fat represents.

> Consider the example of a 60 kg individual (132 lbs). Using the four component model:
> • 21% fat mass ⇒ 12.6 kg fat
> • 58% water mass ⇒ 34.8 kg water
> • 16% protein mass ⇒ 9.6 kg protein
> • 7% mineral mass ⇒ 4.2 kg mineral
>
> That individual then uses a body 'cleanse' product to lose 5 kg (11 lbs) of mass.
> • 34.8 kg water ⇒ 29.8 kg water
>
> So the new percent of body mass (55 kg, 121 lbs) will be:
> • 12.6 kg fat ⇒ 23% fat mass
> • 29.8 kg water ⇒ 54% water mass
> • 9.6 kg protein ⇒ 17.5% protein mass
> • 4.2 kg mineral ⇒ 7.6% mineral mass

Although the body 'cleanse' product reduced the overall mass of the individual, it had no effect on the actual fat mass and effectively served to increase the percent body fat (from 21% to 23%; the numerator [number on top] stayed the same but the denominator [number on bottom] got smaller). Now consider the opposite of this situation. What would happen if we increased total body water by drinking eight glasses of water every day. Total body mass would increase, but the actual fat mass would stay the same. Such recommendations, however, result in the percent fat decreasing (the numerator [number on top] stayed the same but the denominator [number on bottom] got bigger). So an individual who does not understand this relationship is likely to believe that they are losing body fat when all they are doing is altering the percentage of total body mass that fat accounts for. A subtle but important difference.

Anatomical Model of Body Composition — The differentiation of body composition into either fat or fat-free mass. Fat mass constitutes both storage fat and essential fat mass. Fat-free mass constitutes muscle, bone, skin, organs, and blood mass.

A critical issue with the two and four component models of body composition is that fat is considered as a unitary (singular) construct. The anatomical model of body composition acknowledges that some fats are required for normal physiological function and segments fat mass into the separate components of storage fat and essential fat. Storage fat refers to both visceral and subcutaneous fat which makes up approximately 14% of body mass in a prototypical individual. Essential fats consists of fat located in major organs, muscles, bone marrow, and the central nervous system (such as myelin sheaths around axons) which make up approximately 7% of body mass in a prototypical individual. Essential fats also include nutritional reserves with females carrying additional sex-specific reserve essential fats in mammary glands and pelvic regions that are important for childbearing and hormone-related functions. The anatomical model of body composition also separates fat-free mass into muscle (approximately 38% of body mass), bone (approximately 13% of body mass), skin (approximately 11% of body mass), organs (approximately 10% of body mass), and blood mass (approximately 7% of body mass). The predominate difference between males/masculine body types and females/feminine body types on the anatomical model of body composition is males have higher levels of muscle mass, whereas females have higher levels of essential fats.

How Do We Assess Body Composition?

Given the wide assortment of methods of assessing body composition, the specific method chosen usually is a reflection on the compartment of interest, the cost, the time, the skill necessary for the assessment, the level of discomfort for the individual being assessed, and the accuracy that is necessary. Measures such as bioelectric impedance are relatively cost effective and accurate, but greater accuracy and different component models can be obtained through plethsmography or dual-energy x-ray absorptiometry for higher costs, time, and skill necessary. Measures such as computed tomography (CT, essentially a 3-D x-ray) and structural magnetic resonance imaging (sMRI) provide exceptional accuracy concurrent with exceptional cost, time, skill necessary, in addition to greater discomfort for the individual being assessed.

Body Mass Index — $\frac{Weight\ (in\ kg)}{Height^2\ (in\ meters)}$

Although frequently discussed within the context of body composition assessment methods, **Body Mass Index** (BMI) is best though of as a **screening tool** that provides a low cost, low skill tool to determine morbidity associated with excess adipose tissue and risk of premature death (mortality). BMI is based upon the concept that weight should be proportional to height. The World Health Organization provides risk classifications differentiating individuals who are considered **Underweight** (under 18.5), **Normal weight** (18.5 to 24.9), **Overweight** (25 to 29.9), and **Obese** ($\geq$ 30). However, alternative cutpoints are provided for individuals identifying as of Asian decent: **Underweight** (under 18.5), **Normal weight** (18.5 to 22.9), **Overweight** (23 to 27.4), and **Obese** ($\geq$ 27.5). For individuals under the age of 20, the Centers for Disease Control prefer the use of BMI-for-age percentiles that use normative data based upon age and biological sex to account for expected changes in growth. The risk of morbidity and mortality follows a curvilinear relationship with BMI such that elevated risk is present for individuals in the Underweight and Overweight classifications, with the highest risk of premature death observed for individuals in the Obese classification.

Popular criticisms regarding the use of BMI generally stem from inappropriate use of the measure and lack of understanding about what it fundamentally means. As the measure is only dependent on height and weight and it does not take into consideration different levels of adiposity based on age, physical activity levels and biological sex; it is expected that it should overestimate adiposity in some cases and underestimate it in others. For instance, exceptionally muscular individuals exhibit body densities that may result in overestimation of risk of obesity. However, this is actually a relatively rare phenomenon impacting around 2% of the population, and although risk of obesity is overestimated in such individuals they still exhibit higher risk of all-cause mortality. Older adults exhibit a tendency for BMI to underestimate risk of obesity as a result of age-related reductions in muscle mass, similarly the risk of premature death is also underestimated in this population. The key point is that BMI is fundamentally a secondary prevention approach used for screening individuals to determine if further assessment is necessary and as an epidemiological tool used for morbidity and mortality monitoring.

When comparing BMI as a screening tool for high levels of body fat in middle aged adults, BMI $\geq$ 30 exhibits high specificity (97%) but a poor sensitivity (42%) for identifying body fat levels above 25% in men and 35% in women (the World Health Organization reference standard for obesity based on body fat percentage). So if body fat is not high, obtaining a BMI $\geq$ 30 would be relatively unlikely. But just because BMI is less than 30 does not necessarily mean that an individual does not have high levels of body fat (high **Sp**ecificity, **P**ositive test, rule **I**n). However, as a epidemiological tool, BMI $\geq$ 30 exhibits moderate specificity (77%) and sensitivity (65%) for identifying risk of a cardiovascular related disease within the next 10 years. As a population-based metric, BMI provides good predictive validity and when used with the prediction formula below has a very high correlation with other measures of adiposity.

Method to Predict Body Fat from BMI

$$Percent\ Fat = (1.2 \times BMI) + (0.23 \times Age\ [in\ years]) - 5.4 - (10.8\ [if\ male])$$

The Health Impact of Obesity

Although obesity is not typically viewed as an underlying cause of death, globally the World Health Organization notes that at least 2.8 million people die each year with obesity as a contributing factor. Epidemiological evidence regarding obesity have generally defined obesity using the World Health Organization BMI criteria (BMI $\geq$ 30 or BMI $\geq$ 27.5 for individuals identifying as of Asian decent). National surveys in the US have shown a marked increase in the prevalence of obesity over time. In 1994, no state had an obesity prevalence more than 20%. In 2010, no state had less than 20% of the population considered obese, and now as of 2021 the statewide prevalence of obesity ranges from 25 to 45%. This trend is not restricted just to the US, however, as obesity is now so common within the world's population that it is beginning to replace undernutrition and infectious diseases as the most significant contributor to ill health.

Obesity is not simply a cosmetic factor affecting certain individuals, but an epidemic that threatens global health and wellness. Obesity causes or exacerbates many health problems, both independently and in association with other diseases. In particular, obesity is associated with the development of diabetes (relative risk of 7), coronary heart disease (relative risk of 6), an increased incidence of certain forms of cancer (relative risk ranging from 1.5 to 3), respiratory complications (relative risk ranging from 1.2 to 2), osteoarthritis of large and small joints, as well as increase risk of fractures and falls. Problematically, the impacts of excess adiposity appear to exert a delayed effect such that increased morbidity may take up to ten years to manifest even after the individual is no longer obese.

Beyond morbidity, both life-insurance reports and epidemiological studies have observed that the risk of death increases 1% for each extra pound once an individual is obese and that risk of death increases 2% for each extra pound after the age of 50. Obesity also appears to exert functional impairments relating to reduced desire and sexual satisfaction/function, alterations in the onset of puberty, and obese women are three times more likely to suffer infertility than women with a normal body mass index. As the duration of Obesity increases, the risk of developing all of these comorbidities increases.

Despite the critical importance of health promotion and disease prevention efforts surrounding obesity, a common misconception is that such efforts directly conflict with **Healthy Body Image** campaigns. This is in large part due to US approaches to primary prevention which have focused on so called 'anti-fat' campaigns that emphasize the obesity ramifications of behavioral lifestyle choices with slogans such as 'Big bones didn't make me this way, Big meals did' and 'Fat kids become Fat adults'. As well as commercial industry and social media related phrasing to 'Do this everyday to lose weight' and 'The secret exercise to lose fat fast', which feature individuals with exceptionally low body fat promoting exercise as the cure for obesity. The reality is that there is very little evidence to suggest that exercise can be effectively used to reduce levels of body fat. The complex nature of obesity requires prevention efforts to be multifaceted (come from multiple perspectives) and encompass a much broader range of behaviors than the few minutes a day a person might spend exercising. This requires changes in physical activity behaviors throughout the entire day, avoiding sedentary behavior, dietary practices, and lifestyle changes which can be particularly difficult as a primary prevention effort without broader population level changes.

Such primary health promotion efforts align well with healthy body image campaigns that try to get individuals to focus on their individual qualities and strengths that make them feel good about themselves. The common misconception is that healthy body image campaigns are 'pro-fat', when in reality the emphasis is on functional abilities (health) and perceptions of such abilities (wellbeing). So both primary health promotion efforts surrounding obesity and healthy body image campaigns emphasize a common focus on **changing lifestyle behaviors to enhance health and function, without a central focus on weight loss** (because weight loss is the wrong thing to focus on and the least likely to change).

This perspective reflects a risk reduction approach that is critical for prevention programs. The primary aim is to reduce the risks associated with obesity, even if changes in obesity are a very distant future outcome that may never occur. Internationally, the shift has been to better align health promotion surrounding obesity and healthy body image campaigns to emphasize that being overweight or obese only becomes problematic when it starts to influence your health.

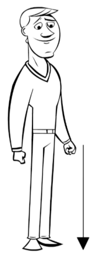
Tertiary prevention of obesity through pharmacological approaches predominately rely upon appetite-suppressants and the blocking of dietary absorption of fats. Although surgical approaches such as gastric portioning and gastric by-pass remain an option, quaternary prevention efforts have attempted to highlight that nearly 60% of those undergoing bariatric surgery return to pre-surgical levels of obesity within two years. Such failure rates and the medical complications associated with these surgerical options suggest that these approaches could do more harm than good. Behavior modification programs to alter dietary patterns, reduce caloric consumption, and increase physical activity and exercise behaviors are consistently recommended within tertiary prevention efforts to reduce the risks of obesity. However the key difference is that such programs are typically recommended to be done in clinical context with higher levels of supervision.

Additional Resources:

Kajimura, S., Spiegelman, B. M., & Seale, P. (2015). Brown and beige fat: physiological roles beyond heat generation. Cell Metabolism, 22(4), 546-559.http://dx.doi.org/10.1016/j.cmet.2015.09.007

Nammi, S., Koka, S., Chinnala, K. M., & Boini, K. M. (2004). Obesity: an overview on its current perspectives and treatment options. Nutrition Journal, 3(1), 1-8.https://doi.org/10.1186/1475-2891-3-3

- Although body mass and body composition are mathematically related, body mass does not provide any insight into health/wellness.
- Changes in body mass could be attributed to many different things
  - Over the course of a week, natural fluctuations in body mass can result in nearly 10 lbs of difference between heaviest and lightest mass.



1 Component Model

Use of overall body mass to infer body composition.

The Realities of Statements such as

'I feel fat'

Body Dysmorphia

Perceiving flaws within our own physical appearance.

- Is typically unrelated to body mass or even body composition.
  - Following medical weight loss procedures, patients still commonly report perceptions of 'feeling fat'.
- Is typically unrelated to physical attributes or appearance.
- Multi-causal statement that could reflect:
  - Not feeling comfortable with self.
  - Manifestation of impaired function.
  - Self-presentational / self-referential influences.

The Realities of Statements such as

'I feel fat'

Body Dysmorphia

Perceiving flaws within our own physical appearance.

- Most individuals experience some level of body dysmorphia.
  - Although more often reported within women, evidence suggests that such perceptions occur for all individuals.
  - Is not just about 'feeling fat' but also encompasses disordered perception related to 'lack of muscle.'
- **Body Dysmorphic Disorder**: Clinical severe form of body dysmorphia where excessive preoccupations with body dissatisfaction impairs ability to function.
  - Typically in excess of 3 hours per day.

Common Nomenclature on

Body Composition

- The common nomenclature generally refers to the proportion of Fat and Fat-Free Mass in the body.
  - **This is referred to as the 2 Component Model.**
- Healthy body composition involves a high proportion of fat-free mass.

Body Fat

Percentages

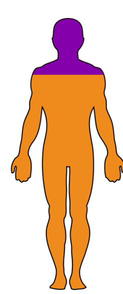
Health-related criterion reference standards for body fatness

Classification	Males	Females
Unhealthy Range (too low)	< 6%	< 9%
Acceptable Range	6 – 24%	9 – 31%
Unhealthy (too high)	> 24%	> 31%

Common Nomenclature on

Body Composition

2 Component Model

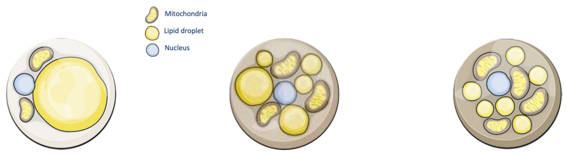


~21% Fat Mass

~79% Fat-free Mass

What is

Body Fat?



White Adipocyte

Cell specialized for the storage of energy.

Beige Adipocyte

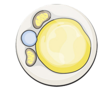
Cell specialized for both the storage of energy and the creation of heat.

Brown Adipocyte

Cell specialized for the creation of heat.

What is

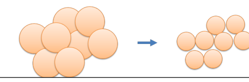
Body Fat?



White Adipocyte

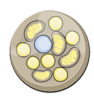
White Adipose Tissue

- What most people are thinking about when they think of fat.
- White adipocyte converts energy into lipids to store the energy so that it can be used as an energy source later.
- White adipocytes can undergo hypertrophy and expand 4 times their initial size before they undergo cellular division (hyperplasia).
- Decreasing body fat only decreases the size (hypotrophy), the number stays the same (not hypoplasia).



What is

Body Fat?



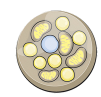
Brown Adipocyte

Brown Adipose Tissue

- Much more abundant during fetal life and during infancy.
  - Persist into adulthood to a limited extent.
- Located around the back, neck, and shoulders.
- Mitochondria process the small lipid droplets in a process called **non–shivering thermogenesis** which creates heat and helps to regulate body temperature.

What is

Body Fat?



Brown Adipocyte

Brown Adipose Tissue

- Brown adipocytes increase in abundance during the winter and have lower abundance during the summer.
  - Actually related more to changes in photoperiod of available sunlight than to changes in temperature.
- Following eating, brown adipocyte mitochondria activity increases, contributing to increases in thermogenic effects of food.

What is

Body Fat?

Beige Adipocyte

Beige Adipose Tissue

- Typically present very similarly to white adipocytes, storing excess energy within lipid droplets to be used later.
  - Genotyping indicates they have a unique cellular origin and are different from other adipocytes.
- When exposed to certain stimuli such as cold temperatures, beige adipocytes alter their action through a process referred to as browning.
  - Stop storing energy (like white adipocytes)
  - Start creating heat (similar to brown adipocytes)

Can Cold Exposure

Burn Body Fat

- Cold exposure can activate beige adipocytes causing them to process stored lipids to generate heat and expend more energy.
- The duration necessary for such 'browning' to occur has been observed to take between 4 to 20 hours of continuous exposure.
  - A short 20 minute plunge in a cold tank induces relatively minimal effects on beige adipocytes.
- Activation of beige adipocytes also occurs in response to certain dietary practices, physical activity, pharmaceutical agents, and plant-based bioactives suggesting it may play a role in other metabolic processes.

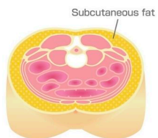
Body Fat

Storage

Subcutaneous (dermal)

Adipocytes located underneath the skin.

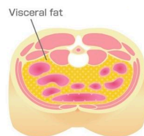
Adipose tissue is a poor thermal conductor due to its low water content. So subcutaneous fat provides thermal insulation.



Visceral

Adipocytes located around organs.

Adipocytes located around organs provide cushioning for internal systems and are involved with hormone secretion.



Body Fat

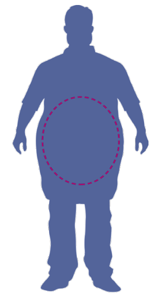
Storage

Android Fat Distribution

Visceral adipose tissue accumulation around the chest and abdomen

More commonly observed within males.

Strong risk factor for cardiovascular disease and diabetes.



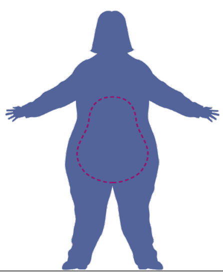
Body Fat

Storage

Gynoid Fat Distribution

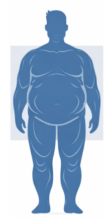
Subcutaneous adipose tissue accumulation around the hips and upper legs.

Only a modest risk factor for cardiovascular disease and diabetes.



Body Morphology

Derived from Somatotype Theory which described patterns of body shape and physiological tendencies.



Endomorph

- Tend to exhibit higher levels of subcutaneous body fat and be more resistant to losing body fat.
- Tend to exhibit more efficient metabolic tendencies (i.e., lower metabolic rates).
- Tend to exhibit larger bone structures.
- Tend to have less visible gains in muscle.

Body Morphology

Derived from Somatotype Theory which described patterns of body shape and physiological tendencies.

Ectomorph

- Tend to exhibit lower levels of body fat.
- Tend to have longer long bones (i.e., be tall and lanky).
- Tend to have less visible changes in muscles (i.e., the muscles grow stronger but do not appear to get bigger).
- Tend to show increases in body fat earlier.

Body Morphology

Derived from Somatotype Theory which described patterns of body shape and physiological tendencies.

Mesomorph

- Tend to have adipose stored within/underneath the muscle tissue rather than subcutaneously causing a naturally muscular appearance.
- Tend to have shorter long bones (i.e., be short and stocky, broad shoulders).
- Tend to have more visible changes in muscles (i.e., muscles quickly appear to get bigger).
- Tend to have less visible changes in body fat.

How do we get rid of

Adipose Tissue

- Lipids are not necessarily pulled from adipose tissue close in proximity to active muscles.
- Systemically driven mechanisms appear to preferentially pull lipids from adipose tissue within certain areas while sparing others.
  - Explains 'hard-to-lose' areas of body fat.

Adipose utilization is systemically driven.

How do we get rid of

Adipose Tissue

- Lipids pulled from adipose tissue for use in energy metabolism are predominately broken down into carbon dioxide.
  - 10 kg of adipose tissue will be broken down into nearly 8.5 kg of carbon dioxide.
  - The carbon dioxide is transported to the alveoli through the blood stream, transferred to the air in the lungs through the process of respiration, and then exhaled from the body through the process of ventilation.

The lungs are the primary excretory organ for fat.

Can you

'Cleanse' Body Fat

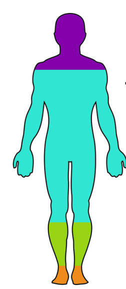
Products claiming to 'Cleanse' the body have no effect on body fat, They only alter body water.

- They use natural or synthetic diuretics to cause the body to excrete body water along with foods/bacteria currently in the digestive tract.
- While overall **body weight** is reduced, this can result in increases in body fat as individuals engage in compensatory/rebound eating.
- Evidence also suggests that the removal of microbiota in the gut causes the body to store more body fat.

Can you

'Cleanse' Body Fat

4 Component Model



~21% Fat Mass

~58% Water Mass

~16% Protein Mass

~7% Mineral Mass

Not all fat is

Bad

Essential Fat

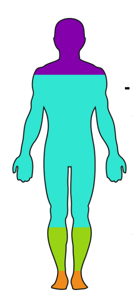
Fat located in major organs, muscles, bone marrow, and the central nervous system (such as myelin sheaths around axons) that is required for normal physiological function.

- Without essential fats nerve conduction begins to degrade, hormones are dysregulated, and the systems will not effectively function.
- Essential fats also include nutritional reserves.
- Females carry additional **'sex-specific reserve'** essential fats in mammary glands and pelvic regions that are important for childbearing and hormone-related functions.

Not all fat is

Bad

Anatomical Model



~14% Storage Fat Mass

~7% Essential Fat Mass

~38% Muscle Mass

~13% Bone Mass

~11% Skin Mass

~10% Organ Mass

~7% Blood Mass

Body Mass Index

$$BMI = \frac{Weight\ (in\ kg)}{Height^2\ (in\ meters)}$$

- Often confused with measures of body composition, BMI is a tool for assessing morbidity associated with excess adipose tissue and risk of premature death (mortality).
- Based on the concept that weight should be proportional to height.
- Very little cost or skill required.

Body Mass Index

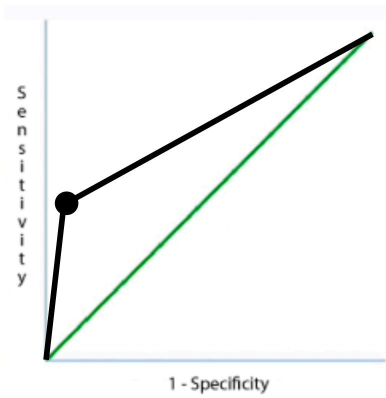
$$BMI = \frac{Weight\ (in\ kg)}{Height^2\ (in\ meters)}$$

	BMI	WHO Cutpoints for individuals identifying as of Asian decent
Underweight	< 18.5	< 18.5
Normal	18.5 – 24.9	18.5 – 22.9
Overweight	25 – 29.9	23 – 27.4
Obese	≥ 30	≥ 27.5

Body Mass Index

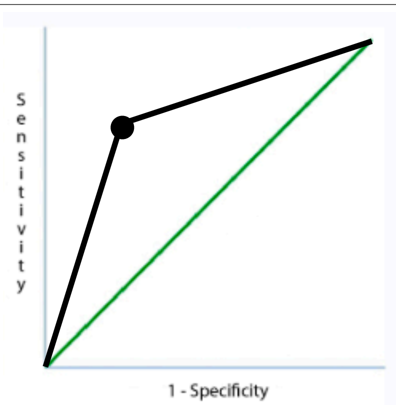
$$BMI = \frac{Weight\ (in\ kg)}{Height^2\ (in\ meters)}$$

- BMI is only dependent on height and weight and it does not take into consideration different levels of adiposity based on age, physical activity levels and biological sex; it is expected that it should overestimate adiposity in some cases and underestimate it in others.
  - Over-estimates highly muscular individuals.
    - Applies to less than 2% of the population.
  - Under-estimates elderly individuals.
    - Age related loss of muscle mass can have a dramatic effect.



As a screening tool for high levels of body fat in middle aged adults, **BMI ≥ 30 exhibits high specificity (97%) but poor sensitivity (42%) for identifying body fat levels above 25% in men and 35% in women** (the World Health Organization reference standard for obesity)

For middle aged adults, a BMI ≥ 30 would be unlikely if body fat is not high.



BMI ≥ 30 exhibits moderate specificity (77%) but sensitivity (65%) for identifying risk of a cardiovascular incident within the next 10 years.

A BMI ≥ 30 indicates that there is greater risk of a cardiovascular incident.

Body Mass Index

$$BMI = \frac{Weight\ (in\ kg)}{Height^2\ (in\ meters)}$$

- Although BMI is a population-based screening tool, it is moderately well correlated with percent body fat.
  - Which contributes to it's misuse.

To predict Body Fat Percentage from BMI:

$$Percent\ Fat = (1.2 * BMI) + (0.23 * Age\ [in\ years]) - 5.4 - (10.8\ [if\ male])$$

Percent Fat = (1.2 * 30_{bmi}) + (0.23 * 55_{years}) - 5.4 - 10.8

Percent Fat = 36 + 12.65 - 5.4 - 10.8 = **32.5% body fat**

The Health Impact of

Obesity

Globally obesity is beginning to replace undernutrition and infectious disease as the most significant contributor to ill health.

- Obesity is not typically viewed as an underlying cause of death, but is a contributing factor in the deaths of 2.8 million people each year.
- Obesity is a causal or contributing factor in a wide range of diseases.
  - Host level attribute that increases sensitivity to the Agent-Environment interaction.
  - For some diseases, high levels of adipose tissue are the antecedent of the Agent.

Obesity and

Cancer

- Obesity and high levels of adipose tissue have been associated with increased risk of developing:
  - Pancreatic Cancer
  - Colon Cancer
  - Esophageal Cancer
  - Postmenopausal Breast Cancer
  - Ovarian Cancer
  - Kidney Cancer
  - Endometrial Cancer (lining of the uterus)

Risks Associated with

Obesity

- Obesity has been found to relate to an increased prevalence of:
  - Obstructive Sleep Apnea
  - Pulmonary Hypertension
  - Shortness of Breath
  - Asthma
  - Osteoarthritis
  - Compression Fractures
  - Infections
  - Poorer long-term outcome of minor injuries

Risks Associated with

Obesity

- The health risks of excess adiposity for morbidity associated with the leading causes of death are often minimized as there is not an immediate association.
  - The delayed effects can take up to 10 years to manifest.
  - The effects persist even if the individual is no longer obese.
  - As the duration of obesity increases, the morbidity risk increases.
- Prior to age 50, the risk of premature death increases by 1% for each pound of body weight after becoming obese.
- After age 50, the risk of premature death increases by 2% for each pound of body weight after becoming obese.

Risks Associated with

Obesity

- Obesity also appears to exert functional impairments relating to:
  - Reduced desire and sexual satisfaction/function
  - Erectile dysfunction in males.
  - Alterations in the onset of puberty
    - Early onset menarche in moderately obese girls (period).
    - Delayed onset menarche in morbidly obese girls.
  - Obese women are three times more likely to suffer infertility than women with a normal body mass index

Despite the morbidity and mortality risks associated with

Obesity

Physical Activity

Appears to exert a protective effect by reducing the risks even if the person remains obese

Physical Activity to Prevent

Obesity

- There is very little evidence to suggest that exercise can be effectively used to reduce levels of body fat.
  - Exercise is a very specific form of physical activity.
  - Exercise accounts for relatively few minutes a day.
- Obesity prevention efforts must be multifaceted and encompass:
  - Changes in physical activity behaviors throughout the entire day
  - Avoiding sedentary behavior
  - Dietary practices
  - Lifestyle changes

Internationally, the shift has been to better align Physical Activity Promotion and Healthy Body Image Campaigns to emphasize that being overweight or obese only becomes problematic when it starts to influence your health.

The focus on changing lifestyle behaviors to enhance health and function, without a central focus on weight loss reflects a risk reduction approach.

The primary aim is to reduce the risks associated with obesity, even if changes in obesity are a very distant future outcome that may never occur.

Tertiary Prevention of

Obesity

- Pharmacological approaches primarily rely upon appetite-suppressants and the blocking of dietary absorption of fats.
- Surgical approaches such as gastric portioning and gastric by-pass are typically restricted to only those with particularly high levels of obesity.
  - Nearly 60% of those who undergo bariatric surgery return to pre-surgical levels of obesity within 2 years.
  - 20% develop medical complications as a result of the surgery.

Tertiary Prevention of

Obesity

- Regardless of the tertiary prevention approach, behavior modification programs are nearly always mandated in an attempt to:
  - Alter dietary patterns
  - Reduce caloric consumption
  - Increase physical activity and exercise behaviors

Due to the risks associated with obesity, these are typically recommended to be done in one-to-one settings to enable a higher level of supervision.