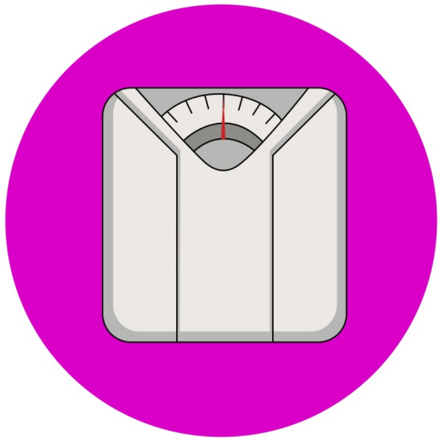
Chapter 11: Nutrition For Weight Loss



11.1 Nutrient Needs for Weight Loss

Teaching Objectives

- Reinforce understanding of human energy requirements
- Introduce energy requirement calculations
- Explain the etiology of overweight and obesity

Learning Outcomes

- Conceptualize how biological and psychosocial factors have contributed to the rise in overweight and obesity
- Recall the weekly rate of safe and maintainable weight loss
- Identify the components of energy expenditure
- Calculate TDEE using the formula provided

Dietary intake is vital to the balance of body weight in healthy adults. An **imbalanced calorie intake** produces changes in body weight and body composition that have measurable negative health outcomes. When the case is that too few a number of calories are consumed, the turnover of body tissues is impaired, and there is a net loss of cell mass and reduction of total body weight. When calories in the diet are over consumed, stored body fat accumulates and body weight continually rises.

Body weight control is a global problem today. Nearly two-thirds of Americans are **overweight** with growing segments across all races, ethnicities, ages, and demographic groups. Today, over half of those overweight adults are technically classified as **obese**, which, in simple terms, means they have 50-80 pounds of additional fat mass to manage compared to a same frame-size counterpart.

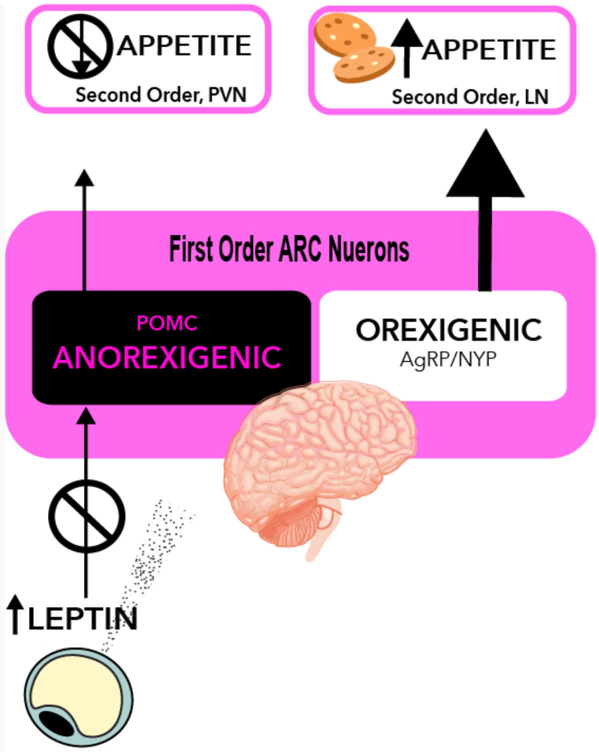
This increasing prevalence of obesity parallels surging US food consumption per capita levels. For example, annual per capita cheese consumption increased from 4 to 32 pounds from 1900 to 2000, and in that same time period, total fat and oil intake doubled. In a shorter span of time, carbohydrate intake has increased by just under 100 grams per day from only 395 grams in 1790 to 490 grams per day in 2000.

Causes of Excess Energy Intake

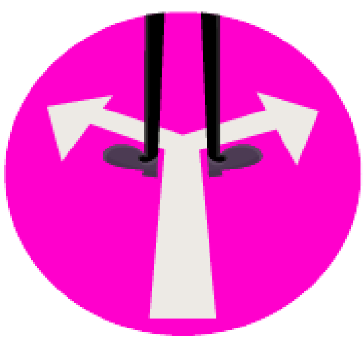
While it is generally accepted that overconsumption of food calories causes obesity, the cognitive and neurobiological controls that appropriately limit food intake are, of yet, largely unexplained. The most supported theories and etiological mechanisms are rooted in **biological**, neuro-hormonal gene expression and responses. Evidence of genetic ties first surfaced in studies of identical twins who were raised separately but, in adulthood, had similar growth endpoints in height, weight, and even BMI. Familial associations in body weight homeostasis between overweight parents and children are also strong, but with these studies, there is usually less certainty in the influence of genetics over environment.

There may also be a genetic defect if the **maternal diet** is rich in high-fat and palatable foods. In animals, this type of maternal diet elicited an enhanced pleasure response to eating desirable foods later in mature offspring, by causing in inflammation, and impairments in dopamine signaling in the hypothalamus. Mutations in the fiber projections on the **anorexic signaling** POMC neuron, is also suspected to disrupt gene expression for second-order PNV neurons so that information processing within the hypothalamus that trigger appetite suppression is also impaired.

The most severe form of obesity in humans results from a deficiency in the genes encoding leptin or the leptin-receptor. **Leptin** is the fat energy storage index hormone that reports to the brain to 'stop eating' by exciting the POMC neurons. Leptin also inhibits the AgRP/NPY neurons and the expression of ARP so that the **orexigenic signaling** that drives food intake is ceased. Thus, in humans with disrupted leptin-receptor deficiencies, hyperphasia is common, as the primary eating cessation mechanism is impaired. Abnormally large fat cells can exacerbate obesity by contributing to chronically high levels of circulating leptin and the desensitization of the CNS to leptin action. Estrogen deficiency can also promote feeding and weight gain in a way that mimics leptin dysfunction; thus, gender is another variant in the culminating biological factors underlying obesity. With leptin dysfunction, insulin signaling is disrupted so that glucose homeostasis fades, and insulin resistance develops. Moreover, insulin may act directly on **dopaminergic neurons** of the mesolimbic reward system and modulate the reward sensation and desire for high-fat or high-sugar foods by promoting dopamine release. Interestingly, the dopaminergic response to insulin is dynamic and greater in calorie and nutrient restrictive diets than in obesogenic diets.



Insensitivity to leptin inhibits the hypothalamic signaling of satiation (i.e. fullness) and leaves the hunger pathway uninhibited



Positive energy balance in modern western society is largely function of **human behavior**. Some elements of the human behavior and discretion are inherently biological, of course, like a person's innate disposition, personality and motive for intrinsic reward. However, in this discussion, behavior-driven, hedonic overeating is not biological, but rather, a product of the external interactions that take place daily in the current **obesogenic environment**.

The subject of human eating behavior is highly interdisciplinary. It is well-known that eating patterns and tendencies for certain food choices are shaped by a unique set of external exposures, and thus, there is not an effective one-size-fits-all approach to behavioral therapy for weight management. An individual's personality, personal history and a milieu of other interacting sociological factors must be first understood so that the underlying etiological factors related to obesity onset can be identified and addressed.

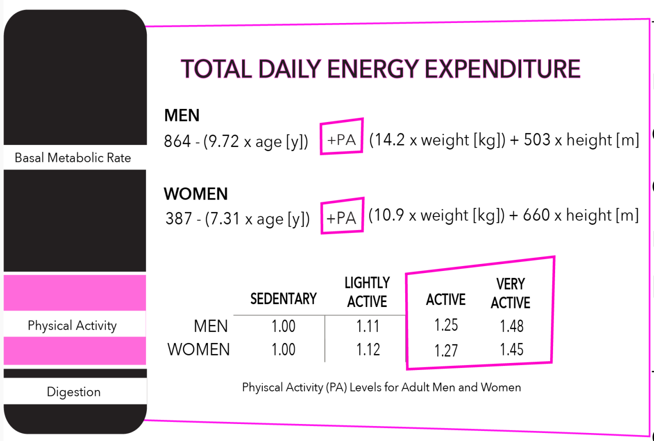
Epidemiological weight loss research has investigated many **sociological factors** and societal changes to identify underlying themes in America's changing weight status. A number of theories, old and new, are posited to explain this change including women becoming part of the work force, multi-cultural cuisine influxes, and even increased viewing of television, or more recently, use of computers, tablets and other smart devices. Others focus on differences in the prevalence of obesity between regions within nations, ethnicities within regions, and neighbors with differing levels of education or income. One of the major changes to the American eating pattern in the last half century, and a growingly accepted explanation for overconsumption, is the increasing reliance on food prepared out of the home. This notion makes perfect sense considering that meals prepared out of the home are done so by a food company with a single agenda: to sell more food. Marketing strategies that appeal to customers, such as decadent and rich tastes, product functionality (i.e., portability, speed and convenience) customization, and portion sizes that convey a greater sense of economic value, are not typically conducive to appropriate calorie intake. Average portion sizes of restaurants and quick service establishments are approximately three to four times larger today than 50 years ago. Soft drink portions, both in prepared and package food segments have also increased in size but have actually decreased in price.

Calorie Requirements for Weight Loss

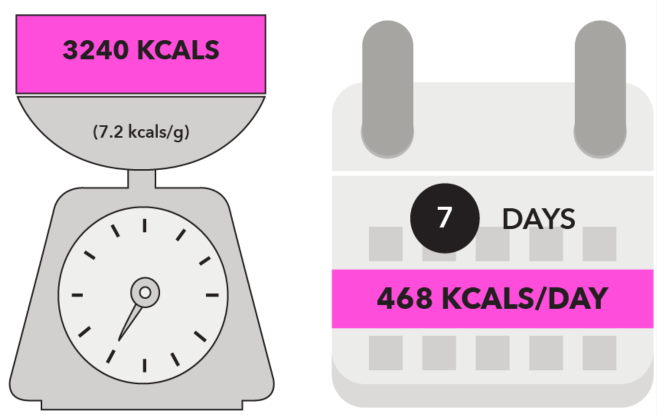
Portion Distortion

Since the estimated daily energy requirement (EER) is based the amount of energy that is needed for the maintenance of energy balance in a healthy adult of a defined age, gender, weight, height and physical activity level, it follows, then, that the energy requirement for a person with excess stored fat would be **less than** that of a healthy weight adult of similar energy expenditures and height.

A negative daily energy balance will elicit body weight and fat loss over time. The amount of energy to restrict daily depends on the amount of total body weight loss needed, the desired timing of weight loss, and the **total daily energy expenditure (TDEE)**. Over time as weight is lost, if there is no change in levels of physical energy expenditures and no change in the relative proportions of lean tissue mass, then daily calorie intake must be reduced further to maintain the programmed weight loss pace. This emphasizes the importance of **physical activity** to help counteract the reductions in resting metabolic rate that naturally accompany calorie restrictive diets and losses of lean body loss.



The total amount of weight that should be lost is the difference between the current body weight and the **ideal body weight** of a similar size person. Current consensus guidelines for the management of overweight and obesity in adults recommends a weight loss around 10% of body weight over a six-month period. Shorter term goals typically range anywhere from one to two pounds of weight loss per week, which can be achieved in daily restrictions of 500-1000 calories below the TDEE. This amount is based on estimates of tissue loss being 75% fat and 25% lean mass, and an average estimated energy value 7.2 kcals/gram body weight lost.



♀ DAILY CALORIES						
BMI Categories		22 IDEAL	25	30	35	40
HEIGHT[m] (x.0254)		WEIGHT [kg] (x 2.2 lb.)				
1.55		**51.7**	**60**	**72**	**84**	**96**
	basal	1230	1306	1409	1512	1615
	sedentary	1756	1846	1977	2108	2239
	active	2190	2299	2466	2632	2698
1.60		**55**	**64**	**77**	**89**	**102**
	basal	1280	1360	1470	1580	1690
	sedentary	1824	1922	2061	2201	2340
	active	2276	2396	2573	2750	2927
1.65		**58**	**68**	**81**	**95**	**109**
	basal	1331	1415	1532	1649	1766
	sedentary	1893	1999	2184	2296	2444
	active	2364	2477	2682	2871	3059
1.70		**62**	**72**	**86**	**101**	**115**
	basal	1383	1471	1559	1719	1834
	sedentary	1963	2078	2335	2393	2550
	active	2780	2594	2794	2994	3194
1.75		**65**	**76**	**91**	**107**	**122**
	basal	1436	1528	1659	1791	1923
	sedentary	2034	2134	2158	2235	2492
	active	2543	2695	2907	3119	3331

♂ DAILY CALORIES						
BMI Categories		22.5 IDEAL	25	30	35	40
HEIGHT[m] (x.0254)		WEIGHT [kg] (x 2.2 lb.)				
1.70		**65**	**72**	**87**	**101**	**115**
	basal	1610	1686	1832	1512	2125
	sedentary	2328	2453	2659	2108	3069
	active	2816	2961	3222	2632	3743
1.75		**69**	**76**	**91**	**107**	**122**
	basal	1678	1753	1907	1580	2217
	sedentary	2417	2540	2757	2201	3192
	active	2927	3071	3347	2750	3899
1.80		**73**	**81**	**97**	**113**	**130**
	basal	1747	1820	1984	1649	2312
	sedentary	2507	2628	2858	2296	3118
	active	3040	3183	3475	2871	4059
1.85		**77**	**86**	**103**	**120**	**137**
	basal	1818	1959	2142	1719	2507
	sedentary	2600	2810	3066	2393	3579
	active	3155	3414	3739	2994	4390
1.90		**81**	**90**	**108**	**126**	**145**
	basal	1889	1959	2142	1791	2507
	sedentary	2694	2810	3066	2235	3579
	active	3273	3414	3739	3119	4390

A **very low-calorie diet** (VLCD) provides around 800 kcal/day and a strict dietary structure with weighed foods and liquid shakes. VLCDs are not sufficient for long-term daily nutrient needs, but they are designed to preserve lean body mass, in that they provide 70 to 100 g protein/day. **Low-calorie diets** (LCD) are slightly higher in calories, and range anywhere from 1,200 to 1,600 kcal/day. While providing a wider variety of food choices than the VLCD plans, diets near the 1,000-1,500 calorie range are better when at least some meals and snacks are provided or pre-portioned. Structure and energy reductions are also achieved by use of meal replacements, including liquid shakes, high-fiber snacks and bars. These methods minimize problematic foods and, in highly individualized plans, can even target problematic eating habits, like nighttime snacking. There are also commercial low-calorie plans that teach appropriate portions using “point tracking” or portion identification systems. These types of programs are less expensive to start and would seemingly yield better long-term compliance than plans that temporarily providing pre-portioned foods.

Low-fat diets are inherently less energy dense compared to typical diets because fat has twice the energy density as the other energy macronutrients. Stated another way, one gram of dietary fat contributes twice as many calories as one gram of carbohydrates or proteins. Low fat diets that produce weigh loss are typically comprised of **less than 20% of fat kcals**, in 1500 kcal diets for women and 1800 kcals for men. **Low-carbohydrate** diets, unlike low-fat diets, are not directly energy-centric. Instead, they focus on the physiological adjustments experienced when the body is starving, which is a notable indication of the abundance of carbohydrates throughout the history of the human species. A typical low-carb diet plan has a daily limit of **20 to 60 grams of carbohydrates**, so that carbohydrates generate just 80-240 calories. Newer low-carb diets advocate for achieving daily nutrient allowances through plant foods, and by replacing red meat and processed meat options with “healthy fats” (e.g., olive oil). “Eco” versions of several traditional low

carb programs, like Atkins®, now include vegan and vegetarian plans that promote low-carb plant foods to satisfy 100% of daily protein needs. A **high-protein** diet is one that includes consumption of at least 20% of daily energy intake from protein, without regard for other macronutrient intake percentages. For weight loss, high protein diets also require an energy restriction to achieve a negative energy balance.

Figure 11.4. Caption.

11.1 Homework 1

Review

Which of the following makes this sentence FALSE?
Leptin ___.

A excites POM neurons

B Inhibits AgRP/NPY neurons

C stops eating (i.e., impedes appetite)

D stimulates feeding (i.e. promotes hunger)

Explanation

Correct. Leptin does not stimulate feeding; rather it stimulates eating cessation

Show Submitted Answer | Show Correct Answer | Check My Answer

11.1 Homework 2

Review

Women who are 5’5” (1.7 m) with a BMI of 30 should aim for what ideal body weight?

- A 120
- B 135
- C 155
- D 170

Explanation

A woman who is 5’5” tall should weight around 135 pounds regardless of BMI. Anywhere in the 130-140 range is healthy

Show Submitted Answer Show Correct Answer Check My Answer

11.1 Homework 3

Review

To lose one pound per week, a daily negative energy balance of around ______________ calories is needed.

- A 100
- B 250
- C 500
- D 1000

Explanation

To lose approximately one pound of body weight per week, the daily energy deficit needs to reach 500 calories

Show Submitted Answer

Show Correct Answer

Check My Answer

11.1 Homework 4

Review

Typical low carbohydrate weight loss plans restrict daily carbohydrate intake to less than ______________ grams per day, and typical low fat plans restrict fat calories to ______________ percent or less. Pick the answer that makes the sentence true.

- A 5 and 5
- B 50 and 50
- C 2 and 2
- D 20 and 20

Explanation

20 grams and under is common for low carbohydrate diets and a standard guideline for a diet low in fat is under 20% calories from fat.

Show Submitted Answer Show Correct Answer Check My Answer

11.2 Nutrient Sources for Weight Loss

Food energy comes in four forms: carbohydrates, fats, proteins and alcohols. The amount of energy released by oxidation of these nutrients is measured using bomb calorimetry, a technique that captures the heat combustion from the macronutrients. Taking carbohydrates as an example, glucose is slightly less energy dense than the disaccharide, sucrose, which is slightly less dense than the polysaccharide, starch. However, for simplicity's sake, Atwater factors round all carbohydrates to an energy density of 4 kcals/gram. Fat is the most energy-dense macronutrient, yielding 9 calories per gram consumed. Protein energy density measured by calorimetry is 5.6 kcals per gram, but since protein energy efficiency is imperfect, the Atwater factor was rounded down to 4.

Low energy density foods provide between 0.6 to 1.5
kcal/g, or less than 300 calories per pound. Energy density is calculated by comparing water, fiber and fat content. Foods high in fiber and water are less energy dense, and vice versa. **Fruits and vegetables**, for this reason, are notoriously low in energy as they are high in fiber and water and completely fat-free. Low-fat dairy products like milk and yogurt are even higher in water and, although entirely devoid of fiber, they still yield an energy density of 0.78 kcal/g.

Entrées comprised of foods with low energy density can reduce the number of calories by as much as 200-400 calories per serving. For instance, adding extra vegetables such as chopped spinach, shredded carrots, diced green pepper, shredded zucchini, broccoli, or mushrooms to energy-dense hot dishes like omelets, lasagna, pizza, and chili increase the food volume, reduce meal period energy intake, and increase nutrient content of the meals substantially. This concept is commonly referred to as **volumetrics**, which is a weight loss strategy that endorses calorie control through consuming foods low in energy density and high in volume, so that larger portions can be consumed and thereby increase satiety.

Figure 11.6. Balance between low energy density and high nutrient density

This approach, necessarily, aims to limit "empty calories" that are from fast foods, processed snacks and soft drinks which are inexcusably energy-dense. Soda, specifically, has a significant impact on the energy density of the overall daily diet and should, therefore, be avoided in all energy restrictive diets. Other energy-dense foods like baked goods, crackers and doughs, high-fat meats and hard cheeses, nuts and nut butters, and cooking butter and margarine should also be avoided as a very small amount can be eaten and low levels of satiation are attained.

The energy density of meals and entrées can also be reduced by using **lower fat** ingredients. For instance, using skim dairy over whole dairy in a recipe will still deliver the same amount of protein and calcium but with a fraction of the fat in the final product. Tested butter and oil substitutions for use in recipes, such as yogurt, applesauce and sweet potato puree can also be used to reduce fat in meals, with minimal effects on palatability, yet a major impact on calorie consumption. Fat-free and reduced-fat sweets and desserts, however, are rarely superior for dieting compared to their regular fat alternatives, since the starch texturizers that are used in creamy products to mimic the mouthfeel of fat in products like coffee creamer, ice cream and yogurt are converted to fat in the body.

More often the culprits in low-fat cooking is the sauces, butter and other toppings that are added to naturally fat-free foods such as beans and legumes, grains, and fruits and vegetables. There are many fat-free condiments that can be used to flavor foods while dieting, such as soy sauce, Worcestershire sauce, mustard and ketchup, which are all fat-free. Vinegar is available in a wide range of flavors to add fat-free flavor to dishes. Salsa made with natural ingredients like tomatoes, peppers, cilantro, onions, parsley, and lime juice or other vegetables is another fat-free condiment that can spice up a meal. There are also number of other fat-free condiments like barbecue sauces on the supermarket shelves, but these products should be used with careful portion control since loaded with sugar and additional calories.

Another dieting strategy champions the selection of foods that more quickly elicit feelings of **satiety**. A variety of food characteristics can promote satiation including volume, palatability, and the amount and type of dietary fiber present in foods, if any. Soluble swelling and gelatinizing fibers found in boiled white potatoes, pasta, oats and raw apples accelerate feelings of fullness. Satiety is also enhanced by liquid foods such as porridge, soups and blended high fiber fruit smoothies. Protein exhibits the most pronounced effect on satiety of the three macronutrients, with high protein beans and legumes, egg whites and Greek yogurt ranking highest in evoking feelings of fullness. One of the successes attributed to low carbohydrate diets is, in fact, increased satiety sensed from the increase in protein intake despite a general caloric deficit. Carbohydrates provide levels of satiation comparable to twice that of energy-dense fats, and when restricted in the diet, further promote appetite suppression. Unsurprisingly, highly-dissolvable and quick-digesting starch foods such as croissants, cakes and donuts produce low levels of satiety and increase overall consumption. Foods like these, and beverages containing sugar, that evoke modest feelings of satiety are usually also energy-dense, and should, in most instances, be restricted in a calorie-controlled diet.

The energy density of a diet high in sweetened products can be improved with the use of **non-nutritive sweeteners** (NNS). NNS are usually effective for promoting weight loss when sizable amounts of sugar in the diet are replaced with NNS, like moving from regular to diet soft drinks. For most other artificially sweetened foods like candy, yogurts and desserts, fewer weight loss benefits result from transitioning to sugar free versions. Well-known NNS are often sold in single use packets, mainly for use in beverage products. Aspartame (*see, e.g.,* NutraSweet®) is a highly concentrated chemical that is formulated using the aromatic amino acid, phenylalanine. For the very small proportion of children born with the metabolic disorder phenylketonuria, or PKU, products that are artificially sweetened with aspartame are extremely dangerous, and therefore, phenylalanine must be listed on their packaging. Sweet 'N Low® is slightly more powerful than aspartame, requiring less to replace the taste of sucrose, but has waned in popularity of late as consumers grow more fearful of the potential carcinogenicity of its primary ingredient, saccharin. Sucralose, the main ingredient in Splenda®, is the most concentrated NNS on the market today requiring just 5 mg to replace a 15-gram portion of sucrose. Sucralose is formulated using a process in which sucrose is chlorinated, rendering the sugar indigestible making it an even more powerful weight loss tool. A slightly more natural NNS is Sweetleaf Stevia®, a non-caloric sweetener sold in powder or liquid form. It is made with stevia leaves that have been steeped to extract the active sweetening compound, rebiana, then purified, concentrated and mixed with erythritol crystals for volume. Sorbitol and mannitol are sugar alcohols that are also used in low kcal and diabetic products, as they are lower in calories per gram, and provide a slightly lower glycemic response. These products do still have effect on blood sugar, and if overconsumed, can cause gas and diarrhea via osmosis.

Figure 11.7. Restricted on Low Carb and Carb Free Diet

Low carbohydrate foods include natural fats and oils, animal meat (including fish and seafood), eggs, cheese and vegetables that grow above the ground. These foods typically provide zero to five grams of carbohydrates per serving. Approximately 20% of carbohydrate calories should be from vegetable sources, with calories from meat, eggs, oils and most cheeses typically unrestricted. Besides limes and lemons, the most common fruits lowest in carbohydrates are avocados, berries and apricots. Nuts and seeds typically provide 1.5-3 grams of carbohydrates per ounce. Low carbohydrate grains that can be integrated in later phases of carbohydrate restrictive diets include those that provide 10 grams or less per cup, such as oat bran, Carbohydrate-free beverages include coffee, tea, club soda, seltzer and, of course, water. **High-protein** diets are often achieved through consumption of conventional foods, but high-protein, portion-controlled liquid and solid meal-replacement products can also be used on a high-protein diet. Variations of high protein diets include paleo diets, which are not restrictive of macronutrients, but by nature are high in protein.

11.2 Homework 1

Review

What is the energy density of a serving of this snack cracker?

- A 1
- B 2
- C 3
- D 4
- E 5

Explanation

150 kcals per 30 grams = 5

Show Submitted Answer | Show Correct Answer | Check My Answer

11.2 Homework 2

Review

Which snack fits best with a low carbohydrate menu (20 grams or less)?

A Celery Sticks with Peanut Butter

B . Mozzarella cheese with tomato

C Dried Mangos with almonds

D Salted Air-Popped Popcorn

Show Submitted Answer Show Correct Answer Check My Answer

11.3 Nutrient Processing for during Weight Loss

Gastrointestinal Approaches To Energy Restriction

Metabolic transformation systems adjust throughout energy restriction and weight loss periods. The major physiological changes that take place are driven by neuro-hormonal responses and the subsequent changes at the cellular and organ system level.

Physical alterations can be made to food ingredients, and now, to the gastrointestinal tract to inhibit calories from entering the body. Digestive system therapies that may help reduce energy intake in the **mouth** are increasing in popularity and creativity. On one end of the spectrum, extreme treatments include temporary surgical implants on the tongue that make chewing painful, and on the other, less invasive benzocaine candy, gums or mints that temporarily anesthetize the tongue and reduce taste sensation are seeking a foothold in market share.

For patients who are unable to achieve a reduced energy intake voluntarily, more invasive gastrointestinal procedures are now available and becoming more commonplace. **Bariatric surgery** is an option for individuals with extreme obesity (BMI $\geq$ 40 kg/m^2), or those with a BMI $\geq$ 35 kg/m^2 in complicated by obesity-related comorbid conditions. Laparoscopic gastric banding and stomach stapling reduces stomach size and, thus, food intake. Gastric banding does not permanently alter the anatomy of the gastrointestinal tract; rather, a thin, inflatable band is placed around the top of the stomach to create a new smaller pouch to connect to the esophagus. **Gastric bypass**, on the other hand, permanently alters the anatomy of the gastrointestinal tract by creating a connection between the jejunum of the small intestine and a small portion of the stomach. The bypass results in reduced food digestion and absorption, which reduces the bioavailability of protein, iron, calcium and fat-soluble vitamins. **Sleeve gastrectomy** is a newer bariatric procedure that also permanently alters the anatomy of the stomach by removing a portion of the stomach to produce a tube-shaped stomach or "sleeve."

For those who cannot lose weight on their own but are still obese, just not at life-threatening levels, **medications** may be helpful. Medications are approved for long-term use (i.e., two years) for obese individuals with a BMI over 30, or even overweight individuals with a BMI greater than 27 who are experiencing obesity-related medical issues such as high blood pressure, high cholesterol or type 2 diabetes. **Orlistat,** otherwise known as prescription-based Xenical®, or in over-the-counter weight loss categories, Alli®, is a lipase inhibitor that causes dietary fat to be excreted in the stool. Nonprescription orlistat doses are estimated to be approximately 80% as effective as prescription doses of orlistat in enhancing the long-term weight loss effects in diets comprising around 30% of fat. Since orlistat is hardly absorbed, side effects are typically limited to stool-related issues including abdominal cramps, flatulence and fecal incontinence. Due to the potential loss of fat-soluble vitamins associated with its consumption, orlistat should be taken with a vitamin supplement.

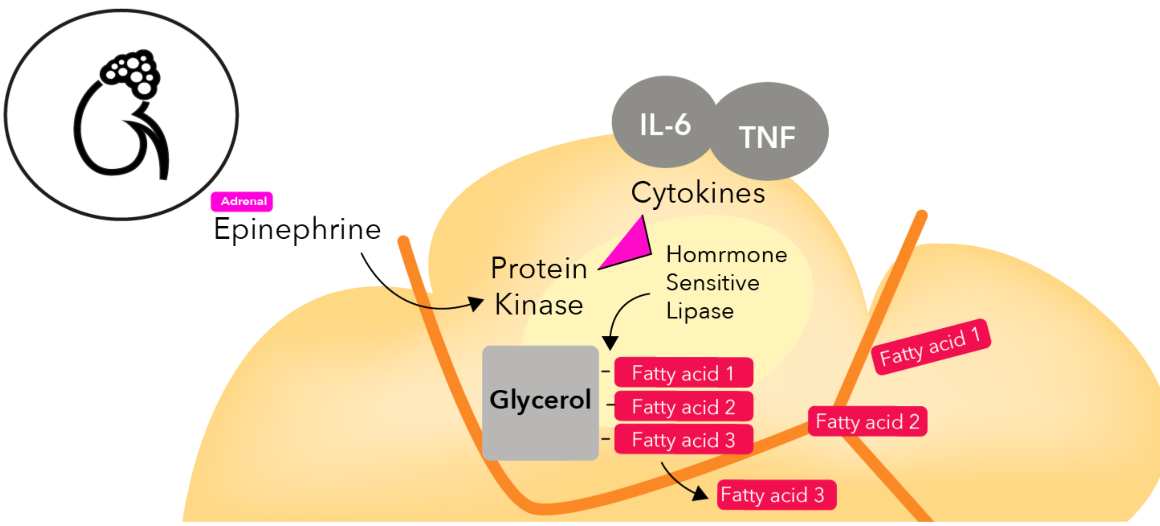
Neurohormones & Energy Restriction

Circulating hormones act on the hypothalamus to affect downstream signaling and gene expression pathways that regulate appetite control. **During fasting**, circulating ghrelin robustly stimulates the first-order orexigenic neurons of the arcuate nucleus of the hypothalamus (i.e., the ARC). **Ghrelin** activates agouti-related peptide (AgRP), and Neuropeptide Y (NPY), which project to the second-order paraventricular hypothalamic nucleus (PVN) and the lateral hypothalamus (LH). NPY directly stimulates food intake via activation of NPY Y1, and reduces energy expenditure by a receptor-mediated reduction in tyrosine hydroxylase expression in the PVN. AgRP/NPY neurons directly inhibit POMC neurons at the ARC by obstructing extra-hypothalamic neurons which, downstream, stimulates food intake and decreases sympathetic output to the brown adipose tissue (BAT) in an effort to conserve energy expended as heat. Several types of prescription medications, such as **Lorcaserin** and Contrave, have been developed to suppress the orexigenic ARC neuron so that appetite is not stimulated.

Metabolism & Energy Restriction

In the initial stages of energy restriction, muscle and liver glycogen stores are hydrolyzed to glucose via **glycogenolysis** in order to maintain circulating blood glucose homeostasis. With every gram of stored glycogen in muscle and the liver, the body stores three grams of water so that initial weight loss, especially with carbohydrate restriction, is primarily lost water. In fact, depending on the level of restriction, and an individual's glycogen storing capacity, this can surmount to as much as 3 pounds or more across the initial days of weight loss.

Also in the initial stages of energy restriction, muscle and adipose triglycerides are hydrolyzed and freed for use throughout the body. As restriction progresses over time, the majority of fatty acids are released from the adipose tissues in response to stimulation of the adrenergic receptor. The fat loss process is activated at the surface membrane of white adipocytes by two lipolytic enzymes: adipose triglyceride lipase (ATGL) and hormone-sensitive lipase (HSL). Insulin and the **catecholamines**, **adrenaline** and **noradrenaline**, are the two major signaling molecules that regulate **lipolysis**, and expression of ATGL and HSL. When catecholamines latch onto the adrenergic receptor, they activate HSL and split the stored triglycerides into free fatty acids, which are then mobilized by way of the capillary network to the muscles for oxidation. Caffeine works synergistically with adrenaline to increase the rate of lipolysis by more than two times, and promotes fatty acid oxidation by adrenergic receptor stimulation and activity.



In response to energy restriction the adrenal glands release adrenaline (i.e. epinephrine) to stimulate lipolysis in fat tissue.

Fat oxidation takes place in the mitochondria of muscle cells. Once in the cell cytoplasm, fatty acids are shuttled into the mitochondria through a transporter molecule called L-carnitine. L-carnitine supplementation is promoted for fat loss, since fatty acid transport during exercise may limited by L-carnitine availability. Acetyl-CoA produced by the beta-oxidation of fatty acids condenses with oxaloacetate to, together, enter the citric acid cycle. During each turn of the cycle, two carbon atoms leave the cycle as CO2 in the decarboxylation reactions catalyzed by isocitrate dehydrogenase and alpha-ketoglutarate dehydrogenase. Thus, each turn of the citric acid cycle oxidizes an acetyl-CoA unit while regenerating the oxaloacetate molecule with which the acetyl-CoA had originally combined to form citric acid. Key signaling molecules AMPK and PGC-1α (peroxisome proliferator-activated receptor γ coactivator 1α), which both stimulate the mitochondria to burn fat and sugar more efficiently, are stimulated during energy restrictions and fasting. Alpha-lipoic acid (ALA) increases AMPK signaling and fat burning, and drugs have been developed to artificially increase the rate at which we expend energy.

Other dietary nutrients and compounds that are postulated to activate the adrenergic receptors that enable greater fat oxidation include, but are not limited to, butyric acid, capsaicin (from cayenne peppers), chromium, curcumin, green tea polyphenols, genistein (soy), ginseng, quercetin, calcium, choline, lecithin, garcinia cambogia, taurine, conjugated linoleic acid, psyllium, pyruvate, leucine, and resveratrol. However, caffeine and green tea are the only dietary components confirmed in reputable research to enhance the rate and total amount of fat oxidation. The efficacy and safety of supplements and food additives targeting fat oxidation are still mostly unknown, and long-term randomized trails are needed to enhance our understanding of the role of stimulant supplements and energy drinks in obesity treatment.

During fasting, starvation, or ketosis-inducing diets that include less than 20 grams of carbohydrates per day, the body switches to a metabolic system that increases **ketogenesis**. Excess levels of fatty acids or acetyl-CoA from beta oxidation are diverted to the liver for conversion to acetoacetate and beta-hydroxybutyrate. Acetoacetate and beta-hydroxybutyrate are two water-soluble ketone bodies that are produced, along with acetone, in the liver. Ketones can be further metabolized to isopropanol/acetone by acetoacetate decarboxylase, which is excreted in breath or urine. Or they can be hydroxylated to acetol for subsequent propylene glycol formate and later, acetate formation. Ketones and ketogenesis intermediates are released by the liver into the blood, and taken up all cells that have mitochondria to undergo **ketosis**, or reconversion to acetyl-CoA, and subsequent use in the cell Krebs's cycle. Unlike free fatty acids, ketone bodies cross the blood-brain barrier and are available for glycolysis in the cells of the central nervous system. The **glycerol** that is released into the blood during the lipolysis of triglycerides in adipose tissue is taken up by the liver. Here, it is converted into glycerol 3-phosphate by the action of glycerol kinase, and subsequently, oxidized to dihydroxyacetone phosphate which is, in turn, converted into glyceraldehyde 3-phosphate by the enzyme triose phosphate isomerase. From there, the three carbon atoms of the original glycerol can be oxidized via glycolysis, or converted to glucose via gluconeogenesis.

11.3 Homework 1

Review

Which of the following descriptions best describes the function of the prescription weight loss medication, Orlistat?

- A Makes the stomach smaller
- B Blocks the hypothalamus from hunger signals
- C Inhibits the absorption of fat in the gastrointestinal tract
- D Inhibits production of insulin

Explanation

The prescription weight loss medication, Orlistat Inhibits the absorption of fat in the gastrointestinal tract by inhibiting the action of lipase

Show Submitted Answer   Show Correct Answer   Check My Answer

11.3 Homework 2

Review

What signal does ghrelin send to the brain?

- A Eat
- B Stop eating

Explanation

Yes, ghrelin is a hormone secreted by the stomach that signals hunger to the hypothalamus in the brain

Show Submitted Answer   Show Correct Answer   Check My Answer

11.3 Homework 3

Review

Identify the neuro-chemical that initiates adipose tissue lipolysis when energy intake is restricted.

- A Insulin
- B Ghrelin
- C Epinephrine
- D Glucose

Explanation

Epinephrine is released as a neuro-chemical response to restricted food intake (no fat influx) – Epinephrine stimulates the breakdown of fat in the adipocyte

Show Submitted Answer   Show Correct Answer   Check My Answer

11.3 Homework 4

Review

Match each tissue to the activity that occurs there during energy restriction

Premise	Response
1 Liver	
2 Adipose	
3 Hypothalamus	

Drag and drop to match

Show Submitted Answer Show Correct Answer Check My Answer

11.4 Nutrient Functions for Weight Loss

The functional outcomes of dietary restriction are apparent at every stage of weight loss. For instance, in just one day of restricted carbohydrate intake, serum free fatty acids levels increase to replace the energy requirements of resting muscles that usually come from carbohydrates. Another exceptional adjustment takes place in the brain and other gluconeogenic tissues of the central nervous system, which, early in carbohydrate restriction, demonstrate a higher capacity to rely on serum ketones, acetone and other byproducts of ketosis for energy. The more holistic outcomes of following a weight loss diet, though, are achieving a healthier body weight and composition. As little as a 5% reduction in body weight can reduce abdominal fat and fat in the liver by an amount substantial enough to reduce the risk of several common metabolic conditions and other risks associated with premature morbidity. As weight is lost, plasma fat (i.e., lipoproteins) levels are reduced, markers of inflammation are muted, and thermoregulatory responses become more efficient.

Weight loss interventions using comprehensive plans produce, on average, 10-20% of **body weight loss** over 12 months Weight loss occurs in stages that come faster or slower depending on, *inter alia*, level of dietary restriction and diet composition. Low-carb diet platforms usually produce quicker weight losses than low-fat diets. In the longer term, however, both low-carb and low-fat, Mediterranean-type diets result in similar weight losses, but low-fat diets may be easier to maintain.

Energy homeostasis is maintained partly through the surveillance of body energy stores in adipose fat. When energy intake is high, like after an energy-dense meal, fat synthesis in the adipose tissue stimulates the release of **leptin** to signal the brain that reserves are full, and eating should cease. Large, oversized fat cells are less-effective at managing homeostatic control than are normal size fat cells. Accordingly, reductions in adipose cell density and size can restore various neurological and hormonal functions which, in turn, can improve energy homeostasis.

Diet composition can impact the outcomes related to hypothalamic communication and feedback biomarkers for hunger and satiation. For instance, while leptin signaling efficiency improves with fat loss, **ghrelin** signals are most suppressed by ketogenic diets.

Insulin sensitivity in the CNS, liver and muscles is improved with weight loss. As a result, diabetic and non-diabetic overweight individuals that lose body fat typically have lowered fasting insulin levels, fewer postprandial insulin responses, and more tightly controlled blood glucose levels.

Figure 11.16. Caption.

Thermoregulatory efficiency is enhanced during times of caloric restriction. This mechanism is triggered by a reduction in the levels of serum thyroid hormone triiodothyronine T3, subsequent reductions in basal energy metabolism, and production of thermal heat. The outcome of this adaptation is a more comfortable body temperature as less thermal energy is dissipated as sweat. Reduced levels of T3 also enhance muscle efficiency by minimizing energy waste. These T3 endocrine responses prevent starvation in the face of caloric restriction. T3 decreased significantly faster on a low-carbohydrate and low-calorie diet than it did with a low-fat and calorie diet, but resting metabolic rates are unaffected by diet. Since the resting metabolic rate goes down disproportionately with decreasing body mass, a person maintaining a lower weight after weight loss still has a slower metabolism than a person who has always been that weight.

The **cardio metabolic** effects of weight loss can reverse dyslipidemia and modulate serum cholesterol and blood pressure levels. To lower triglycerides — the main fat-carrying particle in the bloodstream — a low-carb diet is superior. Compared to low-fat diets, low-carb diets produce higher triglyceride reductions by nearly nine times (i.e., 2.7 to 23.7 mg per deciliter). Low-carb and low-fat diets can also impact **lipid profiles** during the weight-loss and maintenance phases. Both low-fat and low-carb diets reduce total cholesterol and triglycerides, but low-carb diets have a more significant impact on increasing HDL cholesterol (i.e., 8.4 to 6.3 mg per deciliter).

11.5 Feedback: Energy Balance Measures

Anthropometric assessments are most commonly used to measure weight loss status. Scales, tape measurers and electric devices are used to determine changes in body dimensions and composition of tissue mass. More sophisticated techniques and tools are available for use in controlled research protocols but, for most practical clinical and counseling applications, an easy to interpret and relatively reproducible assessment of weight loss over time is **body weight for height (BMI)**. Though well-correlated with body weight loss, BMI, may inaccurately reflect intervention-related changes in body composition as it does not account for bone and muscle density, frame size, and fat distribution.

Distribution of fat can be assessed by the **waist to hip ratio (WHR)**. Circumference of the small of the waist at the midpoint of the last rib and iliac crest atop the hip, is divided by the circumference of the widest point of the hips. A WHR of more than .95 for men and .85 for women indicate android adiposity. Android obesity is especially risky for men because it is indicative higher amounts of viscerally adiposity, which is fat stored in the interior layers as opposed to those that is stored in the subcutaneous region.

Subcutaneous fat can be measured with calipers in a technique called “skin fold.” Among the spots measured include the triceps, subscapular, suprailiac, abdomen and thigh, with accuracy improving as more sites are measured.

Biochemical changes occur with energy restriction and changes in fat mass. For instance, urinary levels of creatinine and urea, a measure of protein breakdown, is elevated within two days of restricted energy intake, Serum markers of metabolism like fasting plasma glucose, and lipoproteins are also elevated in the initial stages of restriction as fat from storage is accessed and travels.

Protein intake (in excess of 200 g per day), coupled with inadequate intake of other calorie sources using extreme diets can cause metabolic disturbance and death in average-sized people. Consuming much more than 250 grams per day may be unsafe, even when consuming other calorie sources.

While less is known about the effect of more moderate protein intake in the longer-term, it is generally known that chronically high protein intake can also have effects on the kidney. High protein in the kidney filtrate increases sodium reabsorption, which over causes changes in globular sensitivity and glomular filtration rate. The increased pressure in globular capillaries contributes to permanent kidney damage.

In energy plus carbohydrate restricted diets, ketones accumulate in the urine, blood and respiratory fluid. Monitoring ketones with weight loss is important, as the side effects from ketoacidosis include nausea, headache, mental and physical fatigue, weakness, muscle cramps, and bad breath.

There are several **dietary assessment** tools for quantifying energy, nutrient and food intake behaviors. These include repeated 24-hour dietary recalls with trained interviewers, food records for varying lengths of time, diet histories, food frequency questionnaires and checklists, calorie counters, and forms for monitoring intake of various food groups.

11.5 Homework 1
Review

Which of the following statements about ketones is least accurate

- A ketones are non-toxic
- B ketones can be toxic at high levels
- C ketones can be measured in the urine

Explanation

High serum ketone levels elicits a condition called ketoacidosis. This condition is dangerous, and therefore ketones are toxic. Serum ketone levels can be assesses by blood and urine samples.

Show Submitted Answer Show Correct Answer Check My Answer

11.5 Homework 2
Review

Calipers can be used to measure what type of body fat?

- A Visceral fat
- B Subcutaneous fat
- C Brown adipose fat
- D Liquid fat

Explanation

Calipers can be used to measure subcutaneous fat that is below the skin in a technique called skin-fold analysis.

Show Submitted Answer Show Correct Answer Check My Answer