CHAPTER 3: THE PHYSIOLOGY OF WEIGHT CONTROL

Objectives

After completing this section, the health and fitness professional will be able to:

- Understand the physiological components to losing and gaining weight.
- Understand how certain laws of science have a direct correlation with weight control.
- Confidently communicate and provide education about the rationale for weight gain, weight loss, and weight maintenance.

Introduction

The body is a remarkable machine that can manage many extremes of diet. For example, in the absence of carbohydrates, the body can produce them from fragments of other nutrients. But a grossly unbalanced diet in terms of energy provision and expenditure presents an insurmountable challenge. In conditions of either surplus or deficit of energy, the body will not be able to maintain a steady weight. Either an increase or decrease of body fat will result from an imbalance in the energy budget. The concept of energy balance, the basics of metabolism, and the genetic and environmental influences on body weight will be covered in this chapter.

Energy Balance

At its most basic, weight control is a demonstration of energy balance, a simple equation representing the relationship between intake and output. But given what health and fitness professionals are calling an obesity epidemic, and considering the acute frustration of someone trying to gain or lose weight, a simple energy balance explanation seems oversimplified at best. Why do some people "conserve" energy better than others? Why do some people's bodies use energy efficiently and therefore need less of it? How much science is behind the clients who claim they have a "slow metabolism"?

Individuals will be in positive energy balance when they have eaten, over time, more than they expended. Likewise, a state of negative energy balance will prevail when people expend more energy over time than they have consumed.

Energy in the context of nutrition is measured in calories. Calories are units of energy that are so small that even an apple provides tens of thousands of them. To make the calculations more manageable, scientists express energy in 1,000-calorie metric units known as kilocalories, or Calories (1).

Technically, a kilocalorie is a unit of heat equal to the amount required to raise the temperature of 1 kg of water by 1° C at 1 atmosphere of pressure. This measurement is used by nutritionists to characterize the energy-producing potential in food. In other words, a kilocalorie (sometimes called a "nutritionist's calorie") is a unit of energy-producing potential equal to the amount of heat that is contained in food and released upon oxidation by the body (1). When talking about the energy value of food, kilocalories, or Calories, are commonly written as calories, with a lowercase "c."

To understand energy balance, a brief discussion of the properties and laws of energy is required.

The Basics of Metabolism and Laws of Energy

As previously stated, body weight is determined by energy intake on one hand and energy expenditure on the other. Organisms take in and expend energy to perform the daily work required for survival, such as finding food or evading predators (2). In modern society, however, many people find themselves in energy surplus because physical demands have decreased while the availability and convenience of food has increased.

Bodies require energy to stay alive. Energy makes it possible for people to breathe, ride bicycles, study, learn, and do everything else. Energy is the capacity to do work, and although people can't touch or see it, every aspect of their lives depends on it. Energy can take on various forms: heat, mechanical, electrical, and chemical. Energy is stored in foods and in the body as chemical energy (1).

Like wood burning in the presence of oxygen, the body releases energy through metabolism. Metabolism is commonly defined as the entire range of biochemical processes that occur within any living organism. Metabolism consists both of anabolism (buildup) and catabolism (breakdown) of substances. Metabolic efficiency refers to the amount of energy an organism has to exert to perform a given amount of work.

In a discussion of nutrition, the term "metabolism" often refers specifically to those processes that break down food, transform it to energy, and store the energy surplus. This text will use "metabolism" to refer to all chemical reactions that go on in living cells, and "energy metabolism" when referring specifically to the reactions of nutrient metabolism.

The study of thermodynamics and energy conservation is an examination of the relationships and conversions between heat, work, and other forms of energy. The first law of thermodynamics (law of conservation of energy) states that the total amount of energy in any isolated system remains constant and cannot be recreated, although it may change forms. In short, the first law of thermodynamics states that energy can change from one form to another but cannot be created or destroyed. This fundamental principle of physics can be applied to biological systems in an effort to better understand the fundamentals of energy balance as they relate to weight control (3).

The regulation of energy homeostasis and body weight is controlled by numerous bioenergetic (metabolic) pathways and hormone (endocrine) control systems. The autonomic nervous system in conjunction with numerous endocrine hormones, most notably the thyroid hormone system, regulates energy expenditure (2). For example, thyroid hormones influence many metabolic functions throughout the body, including fat and carbohydrate metabolism, and growth. Thyroid hormones have a constant effect on energy expenditure and affect every cell in the body. High concentrations of thyroid hormones tend to cause an increase in resting metabolic rate (RMR), whereas lower-than-normal levels tend to cause a decrease in RMR. It is beyond the scope of this text to describe these biological systems in great detail. However, a brief review of their contribution to energy balance and weight control follows.

The laws of thermodynamics have been investigated extensively in the context of weight management. Theoretically, a human body should maintain its weight if energy input (what a person eats and drinks) is equal to energy output (what a person expends). Conversely, if there is an imbalance, energy in either greater than or lesser than energy out, weight gain or weight loss should occur. Although the potential for creating a metabolic advantage through diet in favor of energy expenditure is being explored (4,5) and may yield interesting future research, this text will concentrate on the commonly accepted interpretation of thermodynamics, and the numerous lifestyle interventions to produce a change in body weight.

Law of Thermodynamics

E in = E out	*Weight Maintenance*
E in > E out	*Weight Gain*
E in < E out	*Weight Loss*
E	*Energy/Calories*

The human body is made of trillions of cells, and each cell accomplishes metabolic work constantly. The type of activity depends on the cell. Liver cells, for example, convert certain nutrients to other nutrients, detoxify certain substances (e.g., alcohol), prepare waste products, and store other nutrients. This activity requires energy, and the sum of all these cellular physiological processes in the body is metabolism.

To measure human metabolism, scientists use a variety of technologies and accompanying equations. The term basal metabolic rate (BMR) is used to describe the rate at which the body expends energy to maintain basic physiological survival. The term resting metabolic rate is used as well, expressing the same concept but using slightly different measurement conditions. BMR is measured while a person is awake but lying still after a restful sleep and an overnight fast. RMR is slightly higher than BMR because the criteria for food intake and activity are not as strict. The term resting energy expenditure (REE) is also commonly interchanged with RMR.

BMR makes up the majority of daily energy expenditure, with the other contributions coming from the thermic effect of food (TEF) and the thermic effect of physical activity (TEPA) at approximately 10%, and 15 to 30%, respectively. TEF refers to an estimation of the energy required to digest, absorb, transport, metabolize, and store nutrients. TEPA refers to an estimation of energy required to support physical work outside of BMR. In a sedentary person, TEPA may account for less than half as much energy as BMR. An athlete, on the other hand, may have a TEPA equal to her BMR (3).

Generally, the more a person weighs, the more total energy he or she expends on BMR, but the amount of energy per kilogram of body weight may be lower. For example, the BMR of an average healthy male weighing 73 kg may be 1,500 calories, and the BMR of a healthy 5.5 kg infant may be 300 calories. The total BMR of a child is clearly lower than an adult. However, the calories per kilogram for an infant is considerably higher (6).

Adult BMR	1,500 cal/73 kg = 20.5 cal/kg
Child BMR	300 cal/5.5 kg = 54.5 cal/kg

There are several factors that influence BMR, including age, growth rate, sex, and body composition. In fact, differences in body composition probably account for most of the differences in BMR that are often attributed to age and sex. For example, it is estimated that BMR begins to decrease in early adulthood at a rate of about 2% per decade, and several studies have found that decreases in muscle mass may be wholly responsible for the age-related decrease in BMR (7). Additionally, fever, stress, fasting/starvation, and metabolic illness/abnormalities are factors that can affect BMR.

Estimating Energy Needs

■ Basal Metabolic Rate (BMR)

With BMR representing as much as 75% of total energy needs, any estimation of energy requirement must try to accurately estimate BMR. The most common methods for estimating resting energy expenditure (REE) are published prediction equations, among them Harris-Benedict, Mifflin St. Jeor, Owen, and others

(Figure 3.1). Many of these equations take into account individual weight, fat free mass (FFM), height, age, and/or sex (8).

Figure 3.1 Published Prediction Equations for Resting Energy Expenditure (REE)

Harris-Benedict*
Male: 88.362 + (13.397 x kg) + (4.799 x cm) – (5.677 x age)
Female: 447.593 + (9.247 x kg) + (3.098 x cm) – (4.33 x age)
Mifflin St. Jeor**
Male: RMR = 9.99 × weight (kg) + 6.25 × height (cm) – 4.92 × age + 5 Female: RMR = 9.99 × weight (kg) + 6.25 × height (cm) – 4.92 × age - 161
Owen***
Male: RMR = 10.2 x weight (kg) + 879
Female: RMR = 7.18 x weight (kg) + 795
*Harris J, Benedict F. A biometric study of basal metabolism in man. Washington D.C. Carnegie Institute of Washington. 1919 **Mifflin MD, St Jeor ST, Hill LA, Scott BJ, Daugherty SA, Koh YO. A new predictive equation for resting energy expenditure in healthy individuals." *Am J Clin Nutr.*, 1990 Feb;51(2):241-7. ***Owen OE, Kavle E, Owen RS, Polansky M, Caprio S, Mozzoli MA, et al. A reappraisal of the caloric requirements of women. *Am J Clin Nutr*. 1986;44:1-19

There are also metabolic assessment technologies used with equations to predict BMR. Indirect calorimetry measures respiratory gases based on the relationship between oxygen consumption and energy expenditure. This data is captured and put into an equation, and an estimated REE is generated. Until recently, these types of technologies, called metabolic carts, were available only in hospitals and metabolic testing labs. Now, more practical and less costly devices have been developed that can be used in the fitness environment. However, authoritative metabolic studies are still accomplished by controlling the testing environment and accounting for the many clinical factors that may affect measurements to eliminate potential sources for error.

For health and fitness professionals who will not be working with clients requiring clinical nutrition care, there is an easy estimate of REE that is derived from the Dietary Reference Intakes (9) using a reference male and female (1):

- Men: slightly > 1 kcal/min (1.1-1.3 kcal/min)
- Women: slightly < 1 kcal/min (0.8-1.0 kcal/min)

Even with the benefit of metabolic equations, estimating energy requirements is not always a straightforward task. Because an increase or decrease of body fat will result from an imbalance in the energy budget, sometimes it is the actual changes in an individual's body weight over time that is the most convincing evidence that there is a surplus or a deficit. For example, if a client is following a program with an estimated number of calories for weight loss and is gaining weight, the counselor can either determine that the allocation is incorrect or that the client has been eating more than the recommendation by tracking changes in weight or body fat.

Note: Evidence of client compliance can be objectively measured by changes in body composition. The health and fitness professional's opinion of whether the client is in a deficit or surplus should be compared with an objective measure over time (scale weight or body fat).

Thermic Effect of Food (TEF) and Thermal Effect of Physical Activity (TEPA)

Recall that RMR, TEF, and TEPA all contribute to total energy needs. Although TEF is estimated to be approximately 10% of energy intake (for example, a person who eats 2,000 calories probably will expend 200 of them digesting, absorbing, and transporting those nutrients), it is rarely calculated into energy estimation equations. This is because the TEF varies with dietary content, as well as because the contribution of TEF to total energy expenditure is presumably smaller than the margin of error involved in estimating overall intake and output (1).

Once REE is estimated, an approximation of physical activity expenditure must be made, which usually requires the client's self-report. Even if the health and fitness professional is working with the client, there will be time spent in activity that the client will need to report. Like with the estimations of REE, under- and overestimation of physical activity will result in a miscalculated estimation of energy needs. For example, if a client reports 5 hours per week of moderate- to high-intensity cardiovascular exercise, and in reality the client is accomplishing 1 or 2 hours per week of low- to moderate-intensity cardiovascular exercise, the resulting energy equation will be inaccurate. See Table 3.1 for examples of energy expenditures for various activities.

Table 3.1 Energy Expended on Various Activities

Activity	Calories/Pound/Minute
Aerobic dance (vigorous)	0.062
Bicycling (19 mph)	0.076
Gardening	0.045
Running (6 mph)	0.074
Soccer (vigorous)	0.097
Swimming (45 yard/min)	0.058
Vacuuming	0.030
Weight lifting (vigorous)	0.048
Walking (4.5 mph)	0.048

Data from *Understanding Nutrition* 11 ed. by Whitney & Rolfes

These values represent both the energy of physical activity and the energy of BMR. To calculate calories spent per session of activity, first multiply weight by cal/min/pound and then multiply that number by the number of minutes spent doing the activity.

Practitioners can either calculate the expenditure of calories based on the specific activity, or calculate REE and then use the well-established activity factors to estimate the additional energy a person would need to maintain a sedentary, low-active, active, or very active lifestyle (Table 3.2).

For example, once REE is calculated using any of the equations, the number would be multiplied by the activity factor (AF) to calculate total energy needs. Using the basic equation below for the reference female on the previous page, a 64 kg woman would have a REE range of 1,463 (64 kg x 0.8 cal x 24 hours) to 1,536 (64 kg x 1 cal x 24 hours). If she is low-active, the health and fitness professional would multiply 1,463 x 1.12 (AF) and 1,536 cal x 1.12 (AF) to get a range of 1,639 cal/day to 1,720 cal/day.

Once the client's daily energy needs have been estimated, this information can be used to help the client gain, lose, or maintain weight as desired. In humans, for each 3,500 calories eaten in excess, a pound of body fat is stored. Conversely, a pound of fat is lost for each 3,500 calories expended beyond those consumed.

According to the U.S. Dietary Guidelines (10), overweight and obese people should aim for a slow, steady weight loss by decreasing calorie intake while maintaining an adequate nutrient intake and increasing physical activity. Most experts agree that a safe and maintainable rate of weight loss is between 0.5 and 2 pounds per week, generated by a 250- to 500-calorie deficit per day below maintenance level.

Table 3.2 Physical Activity Factors of Estimating Energy Requirement Calculations

Category	Men	Women	Physical Activity
Sedentary	1.0	1.0	Typical daily living
Low Active	1.11	1.12	Plus 30-60 minutes moderate* activity/day
Active	1.25	1.27	Plus ≥ 60 min moderate* activity/day
Very active	1.48	1.45	Plus ≥ 60 minutes moderate* activity and 60 min vigorous or 120 min moderate* activity/day

* Moderate activity is equivalent to walking 3-4.5 mph

Data from *Understanding Nutrition* 11 ed. by Whitney & Rolfes

Estimating Energy in Foods

Recall that the energy released from carbohydrates, fats, and proteins is measured in kilocalories. Food energy can be determined by direct calorimetry (the amount of heat released when a food is burned), or indirect calorimetry (the amount of oxygen consumed). In direct calorimetry, the amount of heat given off is a direct measure of the food's energy value (because kilocalories are units of heat). To estimate the gross energy contributions of foods, nutrition and food scientists use a bomb calorimeter, an instrument that measures the heat energy released when foods are burned. Although the technology has some imprecision, for the purposes of this text, unless otherwise explained, the energy values of foods are derived by bomb calorimeter.

Set Point Theory

Research demonstrates that most people participating in a weight loss program are successful at initially losing weight. Unfortunately, their weight loss is rarely sustained. Most evidence suggests that the vast majority of people who lose weight regain it during the subsequent months or years (12, 13). One plausible hypothesis as to why individuals tend to return to their original weight is the set point theory. According to the set point theory, the body's internal biochemical processes and regulatory control systems determine an individual's natural body weight and fat percentage. Deviations from this "set point" are resisted and minimized by these processes. Accordingly, some individuals may have a naturally higher body weight (set point), making weight loss efforts difficult to sustain. The set point theory has developed over a number of years and is backed by experimental approaches (2).

Criticized by some as fostering a fatalism regarding the condition of obesity, the theory of adaptive metabolism in response to weight loss has come in and out of acceptance since it was popularly published in the work of Bennett and Gurin in 1982 (14).

Supporters of this theory maintain that the set point would incorporate the influence of nutrients, dietary composition and organoleptic properties, hormones, neural pathways, various brain nuclei, and many neurotransmitters in the regulation of food intake (12). Therefore, the regulation of body weight in relation to one specific parameter would be unrealistic, and the level at which body weight and body fat content are maintained represents the equilibrium achieved by the regulation of many parameters (3).

Clients often use the set point theory to explain reaching a plateau in weight loss that seems insurmountable. Several operative mechanisms to explain weight loss plateaus have been developed.

Energy gap: As people lose weight by energy restriction alone, their total energy expenditure decreases due to a lower energy cost of moving around a smaller body. This gap has actually been quantified at approximately 8 calories per pound, which people try to offset via energy restriction rather than increased activity. For example, if a 200-pound person loses 50 pounds, the individual will need approximately 400 fewer calories to maintain a 150- pound weight than the person did at 200 pounds (50 pounds x 8 calories/pound = 400 calories). Health and fitness professionals are in an excellent position to help clients contend with the energy gap by supporting progressive increases in activity expenditure rather than continued energy restriction (which is difficult to maintain indefinitely) (12).

Hyperplastic obesity: The actual production of more fat cells as a result of obesity creates a tissue-type potential for regain. Fat cells are capable of increasing their size by twentyfold and their number by several thousandfold. In the case of extreme weight cycling, the more fat cells that are created (even if they shrink during weight loss), the greater the potential for regain (1).

Metabolic efficiency: Defined as an actual decrease in metabolism with a weight loss of as little as 10% that cannot be explained based on body composition alone (13).

Although few would question the complexity of weight loss and regain, there is a lack of agreement in the literature, especially with the advent of more sophisticated metabolic testing technologies, that adaptive metabolic change can appreciably explain the tendency of weight-reduced persons to regain weight.

There is no doubt, however, that many internal variables contribute to making weight loss very challenging and may even work biologically to restore original weight. For health and fitness professionals, however, the challenge remains to learn as much as possible about the physiological mechanisms that cause people to be overweight and obese so that the fitness professionals can best support healthy weight achievement with members and clients.

Causes of Overweight and Obesity

If energy imbalance cannot be completely explained by the various mechanisms of the set point theory, why then do people accumulate excess body fat? Thermodynamics has given us the simple answer — people take in more than they expend. But why does this occur? Is it genetic, environmental, cultural, behavioral? Or does it have to do with influences such as economics and culture? The answer to all is probably yes.

Although the law of thermodynamics explains the consequence of energy imbalance, it does not account for the regulation of food intake. An understanding of why people overeat or undereat is more involved than a straightforward mathematical equation. These causes tend to fall in the genetic or environmental arena, or a combination of the two.

■ Genetics

Many researchers have demonstrated the influence and role of genetics in maintaining body weight. For example, some metabolic research studies examined the relationship between birth twins and weight gain. One study examined the effects of overfeeding multiple pairs of monozygotic twins (16). In this study, all sets of twins consumed the same number of calories for the same length of time (3 months). The results from the study determined the amount of weight gain was very similar within each twin pair. However, the differences between pairs was significant (8.8 lb to 29.3 lb).

The reverse also holds true regarding genetics role in weight loss efforts. Hainer et al studied moderately obese monozygotic twins kept on a low-calorie diet, and found the amount of weight loss varied greatly between different pairs of twins. However, within each pair of twins, the amount of weight loss was quite similar. These results indicate that the body's response to changes in caloric intake is dictated at least in part by genetics (17).

■ Appetite and Satiety

Significant insight has come from the cloning of genes that produce obesity in animals (18). It is thought that genes encode for proteins that play a role in the appetite system. Appetite refers to the sensations of hunger, satiation, and satiety that prompt a person to eat or not eat. Hunger describes the sensations that promote food consumption, and it is a multidimensional attribute with metabolic, sensory, and cognitive facets. Satiation follows the initiation and progression of a meal and causes hunger to subside. Satiation is determined by both meal size and duration. Eventually, feelings of satiation will contribute to the cessation of eating, and a period of abstinence from eating will begin. Satiety refers to the sensations that determine this intermeal period (19).

One gene, aptly called *ob*, is expressed primarily in adipose tissue and codes for the protein leptin. Identified in 1994, leptin signals sufficient energy stores and promotes negative energy balance by suppressing appetite and increasing energy expenditure. In contrast, the protein ghrelin, secreted primarily by gastric mucosa cells, promotes positive energy balance by stimulating appetite and promoting efficient energy storage (20, 21). Other hormones and neurochemicals that have been identified as contributing to the energy regulation neuroendocrine feedback mechanism include peptide tyrosine-tyrosine (PYY), cholecystokinin (CCK), glucagon-like peptide-1 (GLP-1), gastric inhibitory peptide (GIP), and amylin.

Although a complete review of the endocrinology of appetite is beyond the scope of this text, it is important to recognize that not only do hormones contribute to this system but also that a properly working hormonal system is, in part, genetic. In other words, if the hormonally regulated "telecommunications system" between brain, gut, and circulating nutrients is not working properly, the regulation of energy intake may not be matched with physiological need, and that broken system can be inherited.

Other Genetic Influences

Hormones are not the only arena where genetics contribute to energy imbalance. Studies show that other genes encode for proteins that determine energy storage or expenditure, affecting on a cellular level the very "energy metabolism" that was previously defined (22). Likewise, it has been suggested that the predisposition to movement and activity may be genetically programmed, making it genetically more challenging for some people to want to get up and move than others. A landmark study completed in 2005 by Levine (23) suggested that the difference in activity levels may be biological and the result of genetically determined levels of brain chemicals that govern a person's tendency to move around. The study suggests that it is the predisposition to be inactive that leads to obesity, not the other way around.

Although an ever-clearer picture of the role of genetics in weight control is emerging in the research, weight control counselors still encourage lifestyle interventions to overcome the possibility of a detrimental biological predisposition. Behavior scientists reinforce the message that long-term weight loss is difficult but achievable. For health and fitness professionals, a realistic assessment and acknowledgement of the contribution of genetics may help them overcome the perception that obesity is exclusively caused by overindulgence. Health and fitness professionals can use this deeper understanding of the complex nature of body weight regulation to help clients become committed to making lasting lifestyle changes to achieve and maintain a healthy weight.

Environment

In terms of evolution, our predecessors lived in an environment characterized by an unreliable food supply consisting of uncultivated plants, wild animals, and a high need for physical activity to survive. Due to this harsh environment and the scarcity of food, the human body evolved physiologically to conserve as much energy as possible in order to survive. Today, however, many populations are facing gradual weight gain, which is likely attributable to an abundant food supply and technology reducing the need for physical exertion in order to survive (24).

Additionally, although genetic studies indicate that body weight may be at least in part inherited, these studies do not thoroughly explain the prevalence of obesity we are experiencing today. With obesity rates rising drastically during the past three decades, and the gene pool remaining relatively unchanged, professionals point to environment as the other major contributing factor. Leaders in obesity research have begun to coin phrases such as "toxic food environment" and an "obesifying world" to describe the challenging environment that many people find their genes ill-equipped to handle.

National data have shown continuing increases of adults and children being overweight during the past 30 years (25), and examinations of the past five years show that this trend is not decelerating (26). Public health professionals try to connect various changes in environment with trends in body weight. Young and Nestle completed a frequently sited study published in the *American Journal of Public Health* (27). In the study, samples of marketplace foods were weighed, and historical changes in the sizes of those foods were identified and compared to current portions with federal standards. The results of the study showed that marketplace food portions have increased in size to far exceed federal standards. Young and Nestle's chronological examination showed that portion sizes began to grow in the 1970s, rose sharply in the 1980s, and have continued to climb in parallel with increasing body weights. In a similar study that focused on possible interventions, Young and Nestle found that most restaurant portions significantly exceed standard serving sizes. For example, fast-food servings are often two to five times larger than standard serving sizes. This discrepancy demonstrates the need for greater awareness and education to help individuals understand how portion size affects weight maintenance (28).

Environment includes all of the circumstances that people encounter daily that may push them toward energy surplus or deficit. These include the following:

- Fast food — the availability of a high-energy-dense (calorie/gram), low-nutrient-dense (essential nutrients/calorie) food at cheap prices and convenient locations.
- Supersizing and "value meals" — large sizes of food that people buy because they perceive them to be a good economic value.
- Sugary beverages — a rapidly growing sugar-added beverage market, much of it promoted as "performance enhancing" or healthful in some way.
- Decreased physical activity — escalators, elevators, automobiles, remote controls, and automated tools and recreation (computers, children's games, television, etc.) all replace physical activity at home, in the workplace, and at play.
- Media exposure — the average child sees 40,000 commercials on television each year, and many of them promote fast food, snack foods, and highly sugared foods (40).
- Socioeconomic factors — low income and less education have been linked to higher rates of obesity. This may be explained by the low cost of energy-dense, and often nutrient-poor food (i.e., fast food), or inversely, the high cost of nutrient-dense, low-calorie choices (i.e., lean protein, fruit, and vegetables).
- Cognitive stilmulation — low cognitive stimulation has shown to increase the risk of obesity in children, independent of socioeconomic factors, race, maternal marital status, or maternal BMI (30).
- Family situation — the increase in single-parent or two-working-parent homes produces time constraints that make it harder for people to have healthy food at home for all family members.
- Weight loss industry — prevalence of fad diets, weight loss "magic" products, and gimmicks. Millions of people in the United States use nonprescription weight loss products and spend billions of dollars on books and other products. Not only do these items almost always fall short of delivering their promises, but with exaggerated and false information, they undermine the scientifically validated (though often less appealing) recommendation of healthy diet and more exercise.

Summary

In conclusion, the global epidemic of obesity is driven by an environment that encourages overeating and discourages physical activity, creating a consistent bias toward positive energy balance. Public health professionals note that people have had no biological reason to develop a physiological control system to vigorously oppose a small degree of sustained, positive energy balance. The result is that most of the population is gaining weight at a rate of 0.5 to 2 kg a year (24).

Additionally, genetic and environmental factors are not mutually exclusive, and there can exist a complicated interaction between the two. Rosenbaum and Leibel (31) note that the increasing prevalence of obesity in the United States apparently represents the interaction of these genes with an environment that encourages a sedentary lifestyle and consumption of energy. For example, children of obese parents have a higher likelihood of becoming obese, but this is probably the result of both environmental and genetic circumstances. In other words, environment plays a powerful role on an already vulnerable genetic susceptibility for being overweight or obese.

Nonetheless, individuals can control their weight through daily choices. Maintaining a healthy body weight requires balancing both sides of the energy budget — intake and output — and modifying the energy budget of overweight individuals by increasing activity and reducing intake until an energy deficit is reached will result in weight loss. Establishing practical methods of doing so is discussed elsewhere in this course.

References

1. Whitney E, Rolfes SR Eds. *Understanding Nutrition.* 11th ed. Belmont, CA Thomson Higher Education; 2008, p.7.
2. Dokken BD, Tsao, T. The physiology of body weight regulation: Are we too efficient for our own good? *Diabetes Spectrum.* 2007;20 (3):166-170.
3. McArdle WD, Katch FI, Katch VL. *Essentials of Exercise Physiology*. Media, PA: William and Wilkins; 1994, p. 12.
4. Ferrer-Lorente R, Fernández-López JA, Alemany M. Estimation of the metabolizable energy equivalence of dietary proteins. *Eur J Nutr*. 2007;46(1):1-11.
5. Manninen AH. Is a calorie really a calorie? Metabolic advantage of low-carbohydrate diets, *J Int Soc Sports Nutr.* 2004;1(2):21-26.
6. Samour R, Helm KK, Lang CE. Handbook *of Pediatric Nutrition. 3 ed.* Jones & Bartlett Publishers, Lake Dallas, TX. 2003.
7. Tzankoff SP, Norris AH. Effect of muscle mass changes on age related BMR changes. *Journal of Applied Physiology* 1977;43(6):1001-1006.
8. Siervo M, Boschi V, Falconi C. Which REE prediction equation should we use in normal-weight, overweight and obese women? *Clin Nutr.* 2003;22(2):193-204.
9. Food and Nutrition Board. *Dietary reference intakes for energy, carbohydrate, fiber, fat, fatty acids, cholesterol, protein, and amino acids (macronutrients).* National Academy Press; Washington (DC): 2005.
10. U.S. Department of Health and Human Services, U.S. Department of Agriculture. *Dietary Guidelines for Americans, 2005.* Washington (DC): U.S. Department of Health and Human Services, U.S. Department of Agriculture; 2005. p. 71
11. Stout J. Fueling and weight management strategies in sports nutrition. *J Am Diet Assoc.* 2007;107:1475.
12. Hill JO, Thompson H, Wyatt H. Weight maintenance: What's missing. *J Am Diet Assoc.*2005; 105:5 (Suppl 1):S63-S66.
13. Leibel RL, Rosenbaum M, Hirsch J. Changes in energy expenditure resulting from altered body weight. *N Engl J Med.* 1995;332:621-628.
14. Bennett W, Gurin J. *The Dieter's Dilemma*. New York; Basic Books; 1982.
15. Harris RB. Role of set-point theory in regulation of body weight. *The FASEB Journal*. 1990;(4):3310-3318.
16. Bouchard C, Tremblay A, Despres JP, et al. The response to long-term overfeeding in identical twins. *N Engl J Med* . 1990;322:1477-1482.
17. Hainer V, Stunkard A, Kunesova M, Parizkova J, Stich V, Allison DB. A twin study of weight loss and metabolic efficiency. *Int J Obes Relat Metab Disord.* 2001;25:533-537.
18. Bray C, Champagne CM. Beyond energy balance: There is more to obesity than kilocalories. *J Am Diet Assoc.* 2005;105(5):S17-S23.
19. Mattes RD, et al. Appetite: Measurement and manipulations misgivings. *J Am Diet Assoc.* 2005;105:S87-S97.
20. Kojima M, Kangawa G. an orexigenic signaling molecule from the gastrointestinal tract. *Current Opinion in Pharmacology.* 2002;2 (6):655-668.
21. Pico C, et al. Gastric leptin: A putative role in the short-term regulation of food intake. *British Journal of Nutrition.* 2003;90(4):735-741.
22. Ricquier D. Respiration uncoupling and metabolism in the control of energy expenditure. *Proceedings of the Nutrition Society*. 2005;64:47-52.
23. Levine J. Interindividual variation in posture allocation: possible role in human obesity. *Science*. 2005;307(5709):584-586.
24. Hill J. Environmental Contributions to Obesity. http://www.endotext.org/obesity/obesity7/obesity7.htm. Accessed on September 22, 2008.
25. Flegal KM, Carroll MD, Ogden CL, Johnson CL. Prevalence and trends in obesity among U.S. adults. 1999-2000. *JAMA*. 2002;288(14):1723-1727.
26. Centers for Disease Control and Prevention (CDC). *Behavioral Risk Factor Surveillance System Survey Data*. Atlanta, Georgia: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, 2002-2007.
27. Young L, Nestle M. The contribution of expanding portion sizes to the US obesity epidemic. *Am J Public Health*. 2002;92(2):246-249.
28. Young L, Nestle M. Expanding portion sizes in the US marketplace: implications for nutrition counseling. *J Am Diet Assoc.* 2003;103(2):231-234.
29. Ritchie LD, et al. Family environment and pediatric overweight: What is a parent to do? *Am J Diet Assoc*. 2005;105(5): S73.
30. Strauss RS, Knight J. Influence of the home environment on the development of obesity in children. *Pediatrics*. 1999;103 (6):85.
31. Rosenbaum M, Leibel RL. The physiology of body weight regulation: relevance to the etiology of obesity in children. *Pediatrics*. 1998; 101:525-539.