Energy Balance and Metabolism Module Script

UPDATED JANUARY 24, 2023

Energy Balance and Metabolism

Welcome to the module three, Energy Balance and Metabolism.

Energy and Calories

A calorie is a unit of energy, and it is the amount of energy needed to raise 1 Kg of water 1 degree Centigrade. Calories are used to describe the amount of energy in the foods you eat. It is also used to describe the amount of energy your body burns.

Energy Balance

Looking at both the energy we eat and the energy we burn is known as the energy equation. If you take in the same amount of calories that you burn, the equation is balanced, as depicted by the balanced scale. This results in weight maintenance, you would neither gain nor lose weight.

Energy Balance

If the equation is not balanced, it will result in either weight loss or weight gain. When you consume less calories than you burn, this results in weight loss. If you take in more calories that you expend, this results in weight gain. This simple equation is the basis for weight control for everyone, however, for many people regulating one or both sides of the equation can be difficult, as evidenced by the high rates of obesity among both adults and children.

Metabolism

In the first module, we discussed the energy in food from carbohydrates, protein, and fat. Now we will take a closer look at the ways our body uses this energy.

Uses of Food Energy

We will take a closer look at these 3 uses of food energy: Basal metabolic rate, physical activity, and the thermic effect of food.

Basal Metabolic rate (BMR)

The basal metabolic rate is the energy needed for the metabolic activity of cells and tissues in the body, as well as to support the circulatory, respiratory, gastrointestinal, and renal processes that occur in all bodies. The basal metabolic rate accounts for most of our energy needs, about

60-75% of total energy expenditure. Because different tissues use varying amounts of energy, the BMR is influenced by the amounts of lean body mass, mostly muscle, in the body.

Higher BMR levels result from greater levels of lean body mass. Since males tend to have more lean body mass than women, their BMR is generally higher. BMR can also decrease with age as lean body mass decreases.

Basal Metabolic Rate

BMR can be influenced by other factors, including physical activity level. People who exercise regularly can increase their BMR by 5-14% depending on the intensity of the activity. Strength training has been shown to increase BMR by 5%.

There are some studies suggesting that genetics may play a role in BMR; however, for most people the most important factor is still the amount of lean body mass.

Basal Metabolic Rate

BMR can be affected by other factors as well. BMR is increased in children who are growing and during pregnancy, BMR decreases in the first trimester then increases in the last half. Hormones related to the menstrual cycle can cause variations in BMR of about 359 calories, with needs being highest just before menstruation. Other factors that cause increased BMR include hyperthyroidism, catecholamines, epinephrine, and leptin.

Catecholamines are “fight-or-flight” hormones released by the adrenal glands in response to stress.

Epinephrine, also known as adrenaline, is a hormone and neurotransmitter.

Leptin is a hormone that plays a key role in regulating energy intake and energy expenditure, including appetite and metabolism.

Basal Metabolic Rate

Other factors influencing BMR include fever, illness, climate, and tissue damage. Illness and fever can increase BMR as the body works to maintain body temperature, as well as to fight infections. The body also has to work harder to maintain a normal body temperature as the temperature changes in the surrounding climate.

People in tropical climates have 5-20% increases in BMR over those in temperate climates. Exercising in temperatures over 86 degrees increases BMR by about 5%. Damage to tissues such as in burns can increase BMR as the body works to repair itself.

Estimating BMR

There are many equations to estimate BMR. The easiest way, although it is only 80-90% accurate, is to multiply ideal body weight by 11 for men or 10 for females. This is only for adults, BMR estimates are different for children and vary by age.

Physical Activity

The energy expended by physical activity is the most variable part of the energy needs. It will vary from person to person and even day to day for an individual depending on their activities for the day. Depending on activity levels, energy needs may be increased by 20-50% of BMR. Sedentary assumes that the person still does some light activity such as walking around the house, a completely bedridden person would have less than 20% increased energy needs.

Thermic Effect of Food (TEF)

The thermic effect of food is the increase in energy expenditure used for the absorption, digestion, and metabolism of a meal. In general, it is about 10% of the amount of a person's energy expenditure. The effect of TEF varies by the size of a meal, and also by the type of macronutrient. This is because less energy is needed to metabolize fat than protein and carbohydrates.

Fat has about 4% TEF, meaning that if you ate 100 calories of fat, the energy needed to utilize that meal would be 4 calories.

Protein has about 15-20 %TEF and carbohydrates have about 25% TEF. Since most meals do not consist of a single macronutrient, the overall TEF of a meal varies.

Other factors increase the effect of a meal on metabolism, including spicy foods and caffeine.

Calculating Actual Energy Expenditure

There are many equations to estimate a person's energy needs based on age, sex, weight, height, and activity levels. However, these are only estimates. When a more exact measurement of energy needs is needed, there are some ways to physically take a measurement.

There is direct calorimetry, which measure heat released from the body and indirect calorimetry measures the amount of oxygen a person uses because there is a direct relationship between the body's use of energy and oxygen. For doubly labeled water, subjects drink water with isotopes and then urine output is measured.

There are also Douglas bags or metabolic carts. This measures the gas exchange related to specific activities. Other methods include measuring heart rate or using a pedometer to count steps taken.

Estimating Energy Requirements

The Estimated Energy Requirements (EER) are common equations to estimate the energy needs of adult men and women. These estimates are within plus or minus 200 calories for men and plus or minus 160 calories for women. These equations take into consideration gender, age, physical activity level, body composition, and body size. Pregnant women and children have their own sets of energy equations due to increased BMRs.

The provided link to a USDA site will allow you to estimate calorie needs based on age, gender, physical activity, height, and weight: https://www.fns.usda.gov/estimated-calorie-needs-day-age-gender-and-physical-activity-level.

Energy Needs for Special Populations

Energy needs can be affected by various physiological states. Obesity, anorexia, pregnancy, and lactation increase energy needs. People with spinal cord injuries need less energy due to less physical activity.

Hunger Regulation

"Why do we eat?"

“Why do we sometimes eat too much?”

This is related to how our bodies regulate hunger.

Hunger vs Appetite

What we eat is influenced by both hunger and appetite. Hunger is defined as the primarily physiological or internal drive to eat, and is influenced by internal body mechanisms, including the interaction of organs with various hormones and nerves. The physical feeling of fullness of your stomach after a large meal is also an internal cue.

Appetite is the psychological drive to eat, it answers the question what should I eat, rather than when. It is influenced by external factors such as taste, odor, cultural preferences, medications that may change taste, and cravings such as when people have a “sweet tooth”. Sometimes, when presented with something particularly tempting, appetite may outweigh hunger, and we eat even when we are not truly hungry.

Hypothalamus

The hypothalamus is the part of the brain that is responsible for hunger regulation and satiety, or the feeling of fullness. When our body needs energy, the feeding centers of the hypothalamus are stimulated to send the signal of hunger, cueing us to eat. As we eat, the satiety centers are stimulated, sending the signal to stop eating. In some cases, chemicals, surgery, and some cancers can affect the feeding and satiety centers of the brain, causing people to either over or undereat.

Other Factors for Satiety

Other factors that influence satiety include psychological aspects, including simulating the senses of smell and taste, and the awareness that a meal was just eaten. This is why you are not supposed to eat in front of the TV. Factors contributing to the energy density of foods such as water and fiber content also effect satiety. Lower energy dense foods are those that contain

fewer calories per volume, and therefore can fill up the stomach with less caloric intake. Other factors include variety in the diet, the glycemic load of the foods eaten, the size and shape of the foods, and visual cues and expectations of what will satisfy hunger.

As people become accustomed to larger portion sizes, they may see a smaller portion and automatically assume that it is not enough food to cause satiety.

Influence of Appetite

Appetite can have a strong effect on what we eat. Often times we eat when we see a tempting dessert, even if we are full from dinner. The processes of hunger and appetite are strongly linked as well. When we see something appetizing, our body responds with internal hunger signals including the release of saliva and digestive hormones. This prepares us to eat even if we didn't initially feel hungry.

When food is readily available, as it is in most developed countries, appetite is primarily responsible for food decisions. To maintain proper energy balance, it is important to learn to follow hunger cues rather than appetite.

Test Your Knowledge…

Now is time to test your knowledge!

Question 1

Question 1: A calorie equals the amount of energy to raise 1 kg of water 1 degree Fahrenheit.

A. True B. False

Answer: B. False. A calorie equals the amount of energy needed to raise 1 kg of water 1 degree Centigrade.

Question 2

Question 2: Which of the following does not increase BMR?

A. pregnancy B. Aging C. Growth D. Climate E. Intense physical activity

Answer: B. Aging decrease the BMR, usually due to decrease of lean body mass.

Question 3

Question 3: What percent of energy expenditure is due to the thermic effect of food?

A. 0% B. 5% C. 10% D. 20% E. 30%

Answer: C. 10% of energy expenditure is due to thermic effect of food.

Question 4

Question 4: Which of the following is influenced by appetite?

A. Food decisions B. Saliva production C. Digestive hormones D. All of the above.

Answer: D. Appetite influences all of these.

Quiz Result

Results shown.

End Slide

This completes the module Energy Balance and Metabolism, presented by the Minnesota Department of Health WIC Program

Minnesota Department of Health - WIC Program, 625 Robert St N, PO BOX 64975, ST PAUL MN 55164-0975; 1-800-657-3942, health.wic@state.mn.us, www.health.state.mn.us; to obtain this information in a different format, call: 1-800-657-3942.

This institution is an equal opportunity provider.