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Energy in-energy out: A balanced equation?

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Energy In–Energy Out: A Balanced Equation?

A HEALTHY ENERGY balance (weight maintained) is achieved when energy intake (the sum of energy [calories] derived from food and fluids) equals energy expenditure (the sum of energy expended as basal metabolism, the thermic effect of food and any voluntary physical activity).[1] Balancing this equation can be very challenging for athletes who are attempting to fuel the body for optimal performance. Many active people eat far too little food to match the total energy expenditure. Surveys completed by athletes indicate that their food choices include low intake of carbohydrates and fiber and a relatively small amount of salads and vegetables. Protein intake reported was higher than the recommended amount for athletes.[2] As energy intake decreases, fat and lean body mass are utilized for fuel rather than building tissue. Consequently, athletes may compromise utilization of the protein intake by consistently consuming too little energy. Numerous studies have indicated that an inadequate energy intake by athletes can affect their health and performance.[3] When muscle protein levels decline, decreases in power and endurance will also occur, coupled with the potential for muscle spasms, fatigue, headaches, and cramping. For the competitive athlete, the consumption of energy nutrients (especially carbohydrates) can help fuel physical efforts and promote efficient recovery and tissue adaptation.[4] The athlete should be aware of his or her daily nutrient requirements (water, carbohydrates, protein, fat, vitamins, and minerals) and the number of servings from the five food groups that will balance the individualized equation of energy in and energy out. But how is energy intake and energy expenditure determined?

Energy Intake and Energy Expenditure

Daily energy intake is expressed as kilocalories per day (kcal/d). The amount of energy contained in one gram of carbohydrates (4 kcal), fats (9 kcal), protein (4 kcal), and alcohol (7 kcal) found in each food item consumed contributes to the total daily energy intake. Vitamins, minerals, and water do not contain energy (0 kcal), but they participate in chemical reactions involved in energy release. The daily energy intake of an athlete must be a minimum of 1,500 kcal/d to prevent a vitamin or mineral deficiency.[5] The average daily energy intake for a female is 2,000-2,100 kcal/d and for a male is 2,700-2,900 kcal/d. For the athlete, these averages are usually much higher. Consider participants in the Tour de France: Cyclists will consume between 6,000 and 8,000 kcal/d.

To determine energy expenditure, exercise physiologists have calculated the number of kcal per minute per kilogram of body weight expended during participation in a given sport. Each sport imposes a differing physiological demand (aerobic or anaerobic) on the body. This demand is also dependent on gender, age, weight, and the number of minutes the athlete performs during a work-out session or competitive event. For example, a 185-pound (84 kg) male athlete would expend 352 kcal when running at a 5 mile per hour pace for 30 minutes (84 kg x .14 x 30 min). Athletes can access a calorie calculator at (www.cspinet.org/nah/09_03/calorie_calc.html/) to complete an on-line assessment of daily energy expenditure.[6] The use of such a formula can assist the athlete in determining his or her Total Daily Energy Expenditure (TDEE), which is the total number of calories the body expends in a twenty-four hour period that includes all activities.

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Formulas vary in terms of accuracy. Keep in mind that all formulas are merely estimates for determination of TDEE.

Calculating Energy Intake

The first step in designing a personal nutrition plan is to estimate the athlete's TDEE. Depending on the formula utilized, the athlete will need to input age, weight, height, Lean Body Mass (LBM), and activity. A generalized activity factor can be entered into the formula (see Table 1). The activity factor can be expressed as a number or a percentage. Table 2 presents the variability in TDEE estimates derived from various formulas for a fictitious 17-year-old male basketball player who is 6'2" (188 cm), 185 pounds (84 kg), and has 16% body fat.

Which Formula Is Best?

A 1996 study conducted by Manore and Thompson[7] determined that the most accurate formulas to estimate an athlete's daily energy expenditure were the Cunningham Formula and the Harris Benedict Formula. Of the two, the Cunningham Formula was deemed more accurate, because it determines the energy expenditure on the basis of lean body mass. However, this creates two problems. First, the athlete may not have had a body composition assessment. Second, there is the potential for error in the percent body fat versus percent lean body mass measurement (technician, instrument, and formula used). Nevertheless, this formula generally works very well. Once the percent body fat is calculated, lean body mass can be ascertained (total body mass minus body fat mass equals lean body mass).

The Harris Benedict Formula [8] includes the athlete's gender, height, weight and age to determine the basal metabolic rate (BMR). BMR is the amount

Table 1. Activity Factor

Harris Benedict Formula

To determine your Total Daily Energy Expenditure (TDEE), multiply your BMR by the appropriate activity factor, as follows:

1. If you are sedentary (little or no exercise): Calorie-Calculation = BMR x 1.2.
2. If you are lightly active (light exercise/sports 1-3 days/week): Calorie-Calculation = BMR x 1.375.
3. If you are moderately active (moderate exercise/sports 3-5 days/week): Calorie-Calculation = BMR x 1.55.
4. If you are very active (hard exercise/sports 6-7 days a week): Calorie-Calculation = BMR x 1.725.
5. If you are extra active (very hard exercise/sports & physical job or 2x training): Calorie-Calculation = BMR x 1.9.

Table 2. Formulas for a 17-Year-Old Male Basketball Player Who Is 6'2" (188 cm), 185 Pounds (84 kg) and Has 16% Body Fat to Determine TDEE

Name of Formula	Formula	17 y.o. male basketball player	BMR	TDEE (kcal/d)	Activity Factor
Quick Method	15 kcal/pounds of body weight	185 pounds x 15	N/A	2775	N/A
Cunningham	500 = 22 x LBM	500 + 22 X 70.5	N/A	2051	N/A
BMR and Total Daily Energy Needs	x wt (kg) = kcal/hr kcal/hr x 24 hours x activity factor	x 84 = 84 kcal/hr x 24 = 2016 kcal 2016 x 1.20 = 2419 kcal 2016 + 2419 = 4435	2419	4435	1.20
Harris Benedict	66 + [13.75 x wt (kg)] + [5 x ht (cm)] - [6.8 x age]	66 + 1155 + 940 - 115.6 2161-115.6	2045	3067	1.5
Katch-McArdle	370 + (21.6 x LBM in kg)	370 + [21.6 x 71 kg] = 370 + 1534 x 1.7 = 3236	1903.6	3236	1.7

of energy (in kcal) needed on a daily basis when the body is at rest. The BMR is then multiplied by an activity multiplier to determine the total daily energy intake. One drawback to the Harris Benedict Formula is the absence of LBM or muscle mass in the calculation. Since leaner bodies require more calories, the formula will underestimate the daily caloric needs for athletes who are very muscular. The Harris Benedict formula is gender-specific:

Female BMR = 655 (9.56 x wt in kg) + (1.85 x ht in cm) – (4.7 x age in years)

Male BMR = 66.47 + (13.75 x wt in kg) + (5 x ht in cm) – (6.8 x age in years)

To convert lbs to kg, divide the wt in lbs by 2.2 and to convert inches to cm, multiply the ht inches by 2.54.

After a formula has been selected and the TDEE has been estimated, a meal plan needs to be developed that will maximize athlete compliance.

Meal Planning

Meal planning for the type and amount of food that will be ingested should be a critical component of an athlete's daily routine. Remember, it is not the meal eaten the night before the competition, but rather the athlete's daily meal planning that will have the greatest impact on performance. Good meal planning consists of strategies to ensure consumption of a variety of foods, healthy food choices, and appropriate snacks before, during, and after competition or practice sessions. If done properly, the meal planning will establish a lifetime habit of healthy eating. The website (www.nat.uiuc.edu)[9] provides a mechanism for athletes to appraise his or her diet and calculate optimal daily energy intake.

Most athletes prefer not to count calories but would rather be told that they need to eat a set number of servings from each of the food groups in MyPyramid.[10]

After the athlete's optimal daily energy intake is calculated, a meal plan can be developed from the pyramid for daily practice sessions or competitive events. As long as athletes know how many servings are needed from each of the food groups daily, individuals can choose the most desirable foods that satisfy the requirement. If determined that an athlete requires 2,200 kcal/d, the servings from each of the food groups would be as follows: 9 servings from the bread group, 4 servings from the vegetable group, 3 servings from the fruit group, 2 -3 servings from the milk group, and 6 ounces from the meat group. Athletes are encouraged to limit calories from the fats, oils and sweets group (73 grams of fat and 12 tsp of sugar/d). Refer to (www.dietsite.com/dt/diets/diabetes/daily_meal_plans.asp) for additional daily meal plans for 1200-2500 kcal/d.[11] The next question should be "What is a serving size?"

What Is a Serving?

A serving is a specific amount of food that equals a certain number of calories. The recommended number of servings depends on the TDEE. To consume 2,200 kcal/day, an athlete will require 9 servings from the bread, cereal, rice and pasta group from the food guide pyramid. A serving size from this group is one slice of bread or ½ cup of cooked cereal, rice, or pasta. Serving sizes have changed over the years. During the 1950s, a family bottle of soda was 26 ounces. Today, a single serving of soda is often corresponds to a 20-ounce soda bottle from a vending machines. Take the Portion Distortion Interactive Quiz at (www.hin.nhbi.nih.gov/portion/index.htm).[12]

To determine whether or not an athlete is meeting the recommendations from MyPyramid, there are several web sites that calculate a healthy eating index. For an example, go to the www.nal.usda.gov site, select "browse by subject," select "food and nutrition," select "MyPyramid," select "mypyramidtracker."[13] Mypyramidtracker is an on-line interactive self-assessment tool that provides a quick measure of the quality of an individual's overall diet. The athlete can input the daily food intake, which includes portion size, amount of food, and brand names. Once the data is entered, the program will analyze the athlete's diet for nutrients, calories, and servings and then compare the dietary intake to a healthy diet. At (www.hin.nhlbi.hih.gov/menu/planner/menu.cgi),[14] athletes can access a personal food guide pyramid graphic. This web site allows an athlete to select a calorie level and plan meals with correct portion sizes.

Following the food guide pyramid (www.mypyramid.gov)[10] is the first step for an athlete to be sure that he or she is getting enough nutrients for a healthy diet. Similar food guides may also be found for vegetarian and diverse ethnic diets: www.oldwayspt.org.[15] Variations of MyPyramid accommodate the unique dietary needs of an individual with different food preferences or cultural background, e.g., the vegetarian diet pyra-

TABLE 3. MYPYRAMID IDENTIFICATION OF A SERVING SIZE

Bread, Cereal, Rice and Pasta	Vegetable	Fruit	Milk, Yogurt, and Cheese	Meat, Poultry, Fish, Dry Beans and Nuts
1 slice of bread	1 cup raw leafy vegetables	1 medium apple, banana, orange	1 cup of milk or yogurt	2-3 oz of cooked lean meat
1 oz ready to eat cereal	½ cup of cooked vegetables	½ cup of chopped, cooked or canned fruit	1 ½ ounces of natural cheese	½ cup of cooked dry beans
½ cup of cooked cereal, rice or pasta	¾ cup of vegetable juice	¾ cup of fruit juice	2 ounces of processed cheese	1 egg or 2 tbsp of peanut butter which counts as 1 oz of lean meat

The United States Department of Agriculture (USDA) released the 2005 MyPyramid food guidance system to replace the 1992 Food Guide Pyramid. It symbolizes a personalized approach to healthy eating and physical activity and can be accessed at (www.MyPyramid.gov).

mid has a focus on protein, iron, calcium, zinc, and vitamin B from nonanimal sources. Likewise, MyPyramid illustrates how individuals from different cultures, such as Asian, Mediterranean, Latin, and Mexican, can design a healthy diet.

Conclusion

Although determination of total daily energy intake and total daily energy expenditure with a high level of precision is not practical, athletes can estimate an appropriate total daily energy intake. Athletes need more kcal than nonathletes, but an athlete's first reaction to a dietary plan is often "that's too much food!" In response to such a reaction, provide the following information: a 2,000 kcal/d plan requires 6 ounce equivalents from the bread group, 2½ cups of vegetables, 2 cups of fruit, 3 cups from the milk group, and 5 ½ ounce equivalents from the meat group. Most athletes require at least 2,200-2,500 kcal/d. A 2,000 kcal plan does not include energy intake to compensate for the two hours of activity that is a part of a typical athlete's daily routine.

Energy intake can equal energy expenditure, which will allow the athlete to maintain body weight. To lose one pound of fat each week, deduct 500 kcal/d from the TDEE. If the dietary plan is 2,500 kcal/d, then a new total would be 2,000 kcal/d. Remember, one pound of body fat is equivalent to 3,500 kcal. To lose 3,500 kcal/week, divide by 7, which equal 500 kcal/d. To achieve a realistic weight gain of 0.5-2.0 pounds/week (0.2-0.9 kg/week), there has to be an increase in energy intake. One pound of muscle = 454 g. Thus, to gain one pound of muscle mass/week, additional energy intake should range from 1,000-3,500 kcal/d.[3]

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