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WEIGHT MANAGEMENT FOR ATHLETES AND ACTIVE INDIVIDUALS

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- Energy balance (energy intake vs. energy expenditure) is a dynamic process that assumes that numerous biological and behavioral factors regulate and influence both sides of the energy balance equation. Thus, changing one side of the energy balance equation (energy intake) can and does influence the other side of the equation (energy expenditure).
- Total energy intake and composition of the diet (level of food processing, volume of food consumed, macronutrient composition, fiber content) impact energy expenditure.
- Type, duration and intensity of exercise and type of food consumed (energy density of food) can impact appetite and the total energy consumed post-exercise.
- The energy cost of weight loss does not always equal 3,500 kcal/lb (7,700 kcal/kg) and changes over time even when the level of energy restriction is held constant. Thus, individuals will lose weight differently on the same weight loss diet, even if no exercise is part of the weight loss plan.
- Active individuals, especially lean athletes, who desire weight loss should not restrict energy intake too dramatically to avoid loss of lean tissue. Reducing energy intake by a designated amount (e.g., 300-500 kcal/d or any amount that is appropriate for the current exercise training program) vs. a designated caloric diet (eating 1,200 kcal/d regardless of exercise training) will assure there are enough energy and macronutrients to maintain lean tissue and exercise training while dieting for fat loss.
- To preserve lean tissue during periods of energy restriction, protein intake (g/kg) needs to remain high (1.2-1.7 g/kg/d).

INTRODUCTION

In concept, maintaining energy balance and body weight is very straightforward – balance energy intake with energy expenditure. Yet, this simple concept is more complicated than that and can be difficult to implement. Although many active individuals are within normal weight and body mass index (BMI, kg/m^2) ranges, many still have weight concerns. They frequently want to lose weight (and specifically fat) to be competitive and improve performance, while maintaining or gaining lean tissue. They also differ from the sedentary overweight individual because they are already active, and increasing exercise or altering their training routine may not be an option and/or need. This overview will primarily address dietary approaches that can be successfully used with athletes and active individuals to facilitate weight loss, while retaining lean tissue. Any weight loss program should also minimize the risk of disordered eating behaviors and pathogenic weight loss practices that can arise when an athlete is dieting (Werner et al., 2013).

REVISITING ENERGY BALANCE

Open any exercise physiology or nutrition textbook and you will find the classic energy balance equation: total energy intake (kcal consumed) = total energy expenditure (kcal expended).

If these two factors are in balance, then weight maintenance or energy balance is achieved. This presentation of energy balance is static and only applies when weight is stable. However, during periods of weight loss or gain, weight is not stable. Under these conditions, energy balance is a dynamic process (Galgani & Ravussin, 2008), since changing the energy intake side also impacts the energy expenditure side. Thus, for any individual numerous factors are working together to influence energy balance and body weight. For example, when exercise energy expenditure is increased we may inadvertently eat more or less food, thus changing total energy intake. The type of food selected (e.g., macronutrient or fiber content, food volume, level of food processing) can also change the thermic effect of food (e.g., energy expenditure), total energy consumed and substrate oxidation during exercise. Foods higher in protein can increase the thermic effect of food (Acheson et al., 2011), while foods higher in fiber or volume may decrease energy intake (Sweat & Manore, 2012; 2015). Finally, the type of macronutrients consumed can also alter substrates available for use during exercise (Hawley et al., 2011; Manore et al., 2009). Conversely, high-intensity exercise can blunt appetite-regulating hormones, which could reduce energy intake (Stensel, 2010). Another factor that can confound the assessment of energy needs for an athlete is the total amount of non-sport related activities (e.g., walking, biking for transportation) (Guebels et al., 2014) and the amount of sitting, standing and fidgeting that is done. While some athletes are very active outside of training for their sport, others become quite sedentary when they are not training, which can decrease energy needs below predicted levels (Thompson et al., 1993).

Research now shows that the energy cost of weight loss is also dynamic and can change over the time period of the diet. Many health professionals use the static energy balance equation when explaining energy balance to athletes. They assume that changing either side of the equation by 3,500 kcal will result in a pound (lb) (7,700 kcal for 1 kg) of weight gained or lost, without considering how changing energy intake or expenditure changes the energy balance equation. Swinburn and Ravussin (1993) provide a classic example of this mistake. Using a 75 kg man, they demonstrated what would happen if this individual consumed an extra 100 kcal/d (~420 kJ) every day for 40 y. Using the static energy balance equation, this individual would consume ~1.4 million extra kcal, for an estimated weight gain of 417 lb or ~190 kg (100 kcal x 14,240 d =1,424,000 kcal = 190 kg). Yet health professionals intuitively know this would not happen. The above calculations do not account for the increase in energy expenditure that would occur with weight gain, including increased resting metabolic rate and the energy cost of moving a larger body. Initially there would be a period of positive energy balance, where body weight would increase, resulting in an increase in energy expenditure that will eventually balance the increased energy intake. Over time this individual would achieve energy balance at a higher body weight and weight would stabilize. The extra 100 kcal/d might result in a more realistic weight gain of ~6 lb (~2.7 kg). To maintain this larger body size the individual would need to continue to eat these additional kcal. Of course, the amount of weight gained will depend on the number of extra kcal consumed, the composition of these kcal (i.e., the amount of fat, carbohydrate, protein or alcohol), and overall energy expenditure. This type of weight gain occurs frequently in our society, where there is a short period of increased energy intake (e.g., holiday eating) or decreased energy expenditure (e.g., sports injury without a concurrent decrease in energy intake) and weight is gained and a new weight plateau is achieved.

WEIGHT LOSS IN ATHLETES

There are many elite and recreational athletes that have normal or low body weights and body fat. Yet these individuals may want to lose weight and fat to improve sport performance, make the team in a weight class sport, or achieve an aesthetically pleasing body shape. When these individuals want to lose weight, it is imperative that the risk of introducing disordered eating behaviors is minimized (Sundgot-Borgen & Torstveit, 2010). In addition, inappropriate weight loss can introduce nutrient deficiencies important for sport performance, such as dehydration, inadequate protein and carbohydrate intake, and low micronutrient intakes. Managing safe weight loss in lean athletes who need to meet a designated weight on competition day (e.g., lightweight rowers, jockeys or wrestlers) can be difficult. If dehydration is used to achieve this weight loss, the health consequences can be severe (Knight, 1997). Few athletes are naturally light-weight enough for these types of competitive sports, so weight loss will be required prior to competition (Slater et al., 2005). If athletes are young and growing, this is not the time to severely restrict energy intake. Conversely, there are overweight/obese athletes where weight loss could reduce the risk of chronic disease, and improve their overall health and ability to participate in sport. For example, Borchers et al. (2009) found that 21% of their division 1 college football players (mean age: 20 y) were obese (≥ 25% body fat) and had insulin resistance, while 9% had metabolic syndrome (all obese).

Finally, at least 30% of children in the United States are overweight/obese (Ogden et al., 2010) and many obese children may participate in sports. For these children, fat loss may be necessary to reach a competitive and/or healthy body composition. Weight management approaches used in active children need to consider their growth and energy needs and place the focus on healthy eating and staying physically active, not on caloric restriction.

ACHIEVING A HEALTHY BODY WEIGHT FOR SPORT

What is the best approach to manage weight and/or weight loss in these different groups?

- Those who are already lean and want to be leaner, while retaining lean tissue.
- Those who are overweight and need to lose body fat but also want to retain lean tissue.
- Those who are young and still growing but need to learn how to manage their eating behaviors to match energy needs.

There are no charts that provide the optimal or healthy weight for an athlete competing in a designated sport. However, the following criteria can be used to determine a realistic and healthy body weight for an athlete, regardless of their activity level (Manore et al., 2009). An optimal body weight for sport should strive to meet these criteria:

- Minimizes health risks, including sport injuries, and promotes good health and eating habits, while allowing for optimal training and performance in a given sport.
- Considers genetic makeup and family history of body weight and shape.
- Accounts for age and level of physical development, including normal reproductive function in women.
- Accepted by the individual and can be maintained without constant dieting or restraining food intake.

Thus, an optimal body weight should promote good health, sport performance and be attainable. If an individual is constantly dieting or weight cycling, they may be trying to achieve or maintain an unrealistic body weight. Some sports (e.g., ski jumping, wrestling and cycling) may require an unreasonably low body weight during the competitive season. Athletes in these sports should gain weight during the off-season since it is unrealistic, and unhealthy, to maintain such low body weights all year round.

DIET AND WEIGHT LOSS STRATEGIES FOR ATHLETES

The following section highlights evidence-based diet behaviors that can help athletes and active individuals reduce body fat while maintaining

lean tissue and prevention of weight regain. Changes in exercise strategies or training routines are not addressed, since coaches typically determine these for the athlete. Since athletes are already active, they will need to rely more heavily on the dietary strategies listed below to achieve weight loss.

Adopt a Low-Energy Dense Diet

A low-energy dense diet is high in whole fruits and vegetables, whole grains, and incorporates low-fat dairy, legumes/beans, and lean meats and fish. Overall the diet is lower in fat and reduces or eliminates beverages containing kcal, especially sweetened beverages and alcohol. The energy density of a diet or a food is determined by measuring the amount of energy (kcal) for a given amount (g) of food (Table 1). This type of diet contributes to weight loss and good health in three ways:

1) It is high in fiber and water, and lower in fat, which means one can consume a greater volume of food for an overall lower energy intake and yet feel satisfied. A 10% decrease in dietary energy density will result in a ~10% decrease in energy content.
2) There is less reliance on reducing portion size and counting calories. These diets make one feel full and satisfied after a meal, thus reducing the risk of recidivism. Dietary changes take time, and if individuals can experience weight loss while still feeling full and satisfied on the diet, there is a better chance they will stay on the diet plan.
3) A low-energy dense diet is nutrient rich, meaning that while reducing energy intake it still provides adequate vitamins and minerals for good health.

Research shows that a low-energy density eating plan is effective at reducing energy intake, facilitating weight loss, preventing weight regain, and helping to maintain satiety in well-controlled feeding studies and in free-living conditions (Ello-Martin et al., 2005; Rolls, 2009). For example, Bell et al. (1998) examined the effectiveness of a low-energy density eating plan on energy intake and weight loss. They fed three different levels of energy dense diets, where the women ate a similar amount and weight of food. Results showed that on the lowest energy dense diet, individuals consumed 30% fewer calories than on the high energy density diet. The women reported no differences in hunger and fullness ratings or enjoyment of the meals across test conditions. In a follow-up study, Rolls et al. (2006) examined the effect of changing portion size, energy density or a combination of the two conditions on total energy intake over a 2 d period. Energy density was altered by changing the portions of vegetables in entrées and by substituting low-fat foods/ingredients for full-fat foods (e.g., skim milk for whole milk). They found that energy density and portion size independently altered energy intake. When portion size was reduced by 25%, energy intake decreased by 231 kcal/d (10% decrease). However, reducing energy density by 25% decreased energy intake by 575 kcal/d (24% decrease). When both energy density and portion sizes were reduced simultaneously energy intake decreased by 32%. Thus, reducing portion sizes and energy density dramatically reduced energy intake, but just reducing the energy density of the foods consumed reduced energy intake more than reducing portion sizes.

Overall, reducing the energy density of the diet can be more effective at lowering energy intake than reducing portion size, without affecting hunger, fullness or enjoyment of the food. For athletes trying to lose weight, this has important implications. It may be easier for an active individual to consume a similar amount of food and focus on changing the energy density rather than portion sizes. This approach reduces hunger and increases adherence to the weight loss diet plan. In addition, following a lower energy dense diet can help the athlete maintain their weight loss, since this type of diet is also high in fiber.

Very Low (< 0.6 kcal/g)	**Low** (0.6-1.5 kcal/g)	**Medium** (1.6-3.9 kcal/g)	**High** (> 4.0 kcal/g)
Consume these foods frequently (e.g., free foods)	Select often, but eat reasonable portion sizes	Monitor frequency and portion size; energy content per g of food is higher	Use infrequently or small portions; energy content is high per g of food
Most whole fruits: Apples, berries, citrus fruit, melons, peaches, pears, nectarines	**Other fruits:** Bananas, grapes	**Fruits:** Avocado **Dried fruits:** aApricots, raisins, apples, figs	**Nuts:** All nuts and nut butters
Most whole vegetables: Broccoli, celery, carrots, cauliflower, greens, spinach, tomatoes, zucchini	**Starchy vegetables:** Corn, peas, winter squash, baked potato w/ skin, tofu	**Vegetables/ added fat:** French fries, hummus	
Non-fat dairy foods	Low-fat dairy foods	Reduced fat feta, mozzarella, Swiss cheese	Full-fat cheeses, mayonnaise, sour cream, dressings, butter and oils
Broth based soups	**Cereals:** Cooked wet grains (e.g., oatmeal, brown rice), bran flakes, shredded wheat **Soups:** Chowders prepared with milk, split pea	**Cereals:** Whole wheat (WW)/ white breads, corn tortillas **Baked or low-fat snack foods:** Pretzels, tortilla chips **Desserts:** Ice cream, frozen yogurt	**Snack foods:** Regular potato/ tortilla chips, wheat or graham crackers, candy, chocolate, most sport and granola bars **Desserts:** Brownies, cakes, cookies, muffins, pastries, other foods with added sugar and/or fat
	Shrimp (steamed), tuna, tilapia, lean ham and turkey	Eggs, red meat, salmon, chicken breast, no skin	Bacon, pork spareribs

Adapted from Rolls & Hermann (2012).

Table 1. Classification of foods by their energy density (kcal/g)

Timing of Meals and Snacks

For the athlete, timing of food intake around exercise training and spreading food intake throughout the day will ensure that the body has the energy and nutrients needed for exercise and the building and repair

of lean tissue. Refueling after exercise is especially important for the athlete who wants to lose weight. This approach can help prevent the athlete from becoming too hungry and consuming foods or beverages not on their diet plan. Thus, the post-exercise dietary routine needs to include fluids for rehydration, carbohydrate in the form of low-energy dense foods (e.g., whole fruits and vegetables, whole grains) to replenish glycogen, and high-quality low-fat protein for building and repair of lean tissue. Because many athletes may not have these foods readily available after exercise, they must plan ahead and strategically use sport foods and/or healthy snacks to meet their energy and nutrients needs while staying within their diet plan. If possible, the best way to address refueling after exercise for athletes who are trying to reduce energy intake is to plan a healthy meal immediately after exercise and training. This will help reduce the need for the post-exercise snack. For example, an early morning workout can be immediately followed by a hearty breakfast, which then refuels and rehydrates. A sport dietitian can teach the athlete how to shop, select and prepare low energy dense foods, and to plan appropriate foods around exercise training and competition.

Consume Adequate Protein

Most athletes have little trouble consuming adequate amounts of protein (Manore et al., 2009); however, when energy intake is restricted some protein sources may be reduced. For many athletes, the majority of the energy and protein comes in a large meal at the end of the day. Thus, the athlete needs a diet plan that allows for the strategic consumption of adequate high quality protein throughout the day, but especially after exercise and at breakfast (Westerterp-Plantenga et al., 2009). This dietary approach can benefit the athlete trying to lose weight in two ways:

1) It assures that adequate protein is available for building, repair and maintenance of lean tissue throughout the day.
2) Higher protein diets have been associated with increased satiety and reductions in energy intake. For example, Weigle et al. (2005) reported a decrease in energy intake (441 ± 64 kcal/d) over a 12 wk period in individuals (BMI = 26.2 ± 2.1 kg/m^2) fed an ad libitum high protein diet (30% energy from protein, 20% fat and 50% carbohydrate) compared to an isocaloric lower protein diet (15% of energy from protein).

Thus, it is important that protein intake remains at or above the recommended range for an active individual (1.2-1.7 g protein/kg) when energy is being restricted for weight loss (Rodriguez et al., 2009).

Appropriately Manage Energy-Containing Beverages

Energy-containing sport drinks are appropriate to use around exercise, especially intense exercise of long duration and in extreme environments. However, other high energy sweetened beverages and alcohol can derail any individual trying to lose weight, including the athlete. They add extra energy to the diet without increasing satiety or reducing the amount of food consumed with these beverages (Malik et al., 2006). For some athletes, just the elimination of high caloric beverages from their diet (e.g., soda, alcohol, energy drinks or flavored coffee/teas) could help them achieve their weight loss goals without making any other dietary changes.

Set Realistic Weight Loss Goals

As indicated above, the static energy balance equation does not work well for predicting weight loss. To better predict weight change in response to changes in energy intake or expenditure, one must account for the dynamic energy imbalances that occur. To address this issue researchers have developed mathematical models to simulate how alterations in energy deficit result in adaptations of fuel selection and energy expenditure to better predict body weight and composition changes. One mathematical model has been developed by Hall et al. (2011) at the National Institutes of Health (NIH) (http://bwsimulator.niddk.nih.gov) and a second model has been developed by Thomas et al. (2009) at the Pennington Biomedical Research Center (PBRC) (http://www.pbrc.edu/research-and-faculty/calculators/weight-loss-predictor/). The reader can visit these websites to see how weight loss changes as lifestyle choices are altered.

Avoid Severe Energy Restriction

Although it is tempting to use extreme dietary practices, especially very low energy diets (< 1,200 kcal/d) that result in rapid weight loss, the athlete should avoid these diets. Combining severe energy restriction with an intense endurance and/or strength training program can actually result in metabolic adaptations that reduce the effectiveness of these two factors on weight loss (Donnelly et al., 2009). In addition, they are extremely stressful for the athlete and cannot be sustained for long periods. Research has shown that slower, more reasonable weight loss in athletes (~0.7% loss of body weight/week) helped preserve lean tissue while improving strength gains over more severe weight loss (1.4% weight loss/week) (Garthe et al., 2011). Finally, severe energy restriction has a number of other negative consequences that are listed below (Manore et al., 2009):

- Reduces the ability to train at higher intensities due to poor energy intake and glycogen replacement, resulting in decreased aerobic and anaerobic performance.
- Increased risk of injury due to fatigue and loss of lean tissue.
- Increased risk of disordered eating behaviors due to severe energy restriction.
- Increased risk of dehydration, especially if the diet is ketogenic.
- Increased risk of poor nutrient intakes, including essential nutrients, due to limited food intake. This is especially true if the diet is sustained for any length of time and no multivitamin/mineral supplements are used.
- Increased emotional distress due to hunger, fatigue and stress of following a diet that severely restricts energy intake, in which exercise expenditure is high.

SUMMARY

Management of weight is an ever-increasing challenge in societies where good-tasting food is convenient, relatively inexpensive and abundant. Developing a weight management plan is essential for everyone, including athletes that expend high amounts of energy in their sport. Weight loss can be difficult and may change body composition unfavorably; thus, managing weight during the off-season is especially important to avoid performance-damaging rapid weight loss during competition. Weight management plans need to be individualized considering both the sport and the weight loss goals. This may require a multidisciplinary approach that includes the athlete, coach, sports medicine team and sport dietitian. Finally, it is imperative that health professionals understand the many physiological and environmental factors influencing body weight. This will improve their ability to design individualized and realistic weight management programs for their athletes.

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