Weight Management in the Performance Athlete

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Abstract
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. This brief review addresses the concept of dynamic energy balance and dietary approaches that can be successfully used with active individuals to facilitate weight loss, while retaining lean tissue and minimizing risks for disordered eating. Emphasis is placed on teaching athletes the benefits of consuming a low-energy-dense diet (e.g. high-fiber, high-water, low-fat foods), which allows for the consumption of a greater volume of food that is satiating but reduces energy intake. Other dietary behaviors important for weight loss or weight maintenance after weight loss are also emphasized, such as eating breakfast, spreading food and protein intake throughout the day, eating after exercise, elimination of sweetened beverages, and avoiding fad diets. As the general population becomes heavier, more young athletes will come to their sport needing to alter bodyweight or composition to perform at their peak. Health professionals need to be prepared with effective and evidence-based dietary approaches to help the athletes achieve their bodyweight goals.

Introduction
Achieving energy balance and maintaining bodyweight should be easy – balance energy intake with energy expenditure. Achieving weight loss also appears to be simple – just increase energy expenditure and/or reduce energy
intake. So why isn’t it simple? Why don’t people lose or gain lean tissue as we predict from our calculations? Many athletes have weight concerns, they frequently want to lose weight to be competitive and improve performance, while maintaining or gaining lean tissue. They also differ from the sedentary overweight individuals because they are already active, and increasing exercise or altering their training routine may not be an option. This brief review will primarily address dietary approaches that can be successfully used with active individuals to facilitate weight loss, while retaining lean tissue. Of course, any approach to weight loss also needs to minimize the risk of disordered eating behaviors and pathogenic weight loss practices that can arise when an athlete is dieting. This review will not address weight gain in athletes, which has been reviewed elsewhere [1].

Achieving a Healthy Bodyweight

The need or desire to lose weight and/or change body composition is common among competitive and recreational athletes. As the number of young overweight and obese individuals increase in the population, more young athletes will come to their sport heavier, which may increase the pressure placed on them to lose weight to be competitive. This also means the amount of weight loss needed to reach a competitive and/or healthy weight and body composition may be higher. Although the overweight or obese athlete may not approach weight loss for the health benefits, for these athletes weight loss can reduce the risk of chronic disease, and improve their overall health and ability to participate in sport. For example, Borchers et al. [2] found that 21% of their division 1 college football players (mean age = 20 years) were obese ($\geq$25% body fat) and had insulin resistance, while 9% had metabolic syndrome (all obese). Currently, approximately 66% of the US adult population is either overweight and/or obese, with $\sim$34% being obese [3, 4]. The overweight and obesity rates in US children are also high, which means more children and young adults participating in sports will be heavier [5]. Unfortunately, obesity is a worldwide problem, and the high rates of obesity seen in the US are mimicked in other developed countries around the world [6].

Conversely, there are those elite and recreational athletes, who based on either body mass index (BMI) or body composition data, are at normal weight or have low bodyweights. Yet, these individuals also want to lose weight for their sport to improve performance and/or to achieve an aesthetically pleasing body shape. Some of these individuals are young and still growing, which is the least desirable time to severely restrict energy intake, while participating in high lev-
els of exercise. At the same time, it is imperative that the risk of introducing disordered eating behaviors is minimized, especially in those athletes participating in lean build sports [7]. Finally, it can be difficult to manage safe weight loss in athletes who need to meet a designated weight on competition day, such as lightweight rowers, jockeys or wrestlers. Few athletes are naturally lightweight enough for these types of competitive sports, so weight loss will be required the weeks or days prior to competition [8].

What is the best approach to manage weight and weight loss in these different groups – those who are already lean and want to be leaner, while retaining lean tissue, and those who are overweight, who need to lose body fat but also want to retain lean tissue?

**Energy Balance – Understanding the Factors**

The classic energy balance equation states that if energy intake (total kcals consumed) equals energy expenditure (total kcals expended), then weight is maintained. Although the concept of energy balance appears simple, it is a dynamic process [9]. Changing one factor on the energy intake side can also impact factors on the energy expenditure side. Thus, numerous factors are working together to influence each side of the energy balance equation, which ultimately determines bodyweight. For example, total energy expenditure will be influenced by total energy intake and macronutrient composition of the diet, which can change the thermic effect of food (see table 1) and substrate oxidation during exercise [10–12]. Conversely, high-intensity exercise can blunt appetite-regulating hormones, which could reduce energy intake [13, 14]. Another factor that can confound the assessment of energy needs is the total amount of non-sport-related activities (e.g. walking, biking for transpiration, etc.) and the amount sitting, standing and fidgeting an athlete does [15]. While some athletes are very active outside of training for their sport, others become quite sedentary

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Thermogenesis, %</th>
<th>Cost of nutrient storage, %</th>
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<tbody>
<tr>
<td>Glucose</td>
<td>6–8</td>
<td>12</td>
</tr>
<tr>
<td>Lipid</td>
<td>3</td>
<td>4</td>
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<tr>
<td>Amino acids</td>
<td>25–40</td>
<td>25–40</td>
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Adapted from Manore et al. [12].
when they are not training, which can decrease energy needs below predicted levels [16].

A common mistake made by many health professionals when explaining energy balance to athletes is to assume that changing either side of the equation by 3,500 kcal (7,700 kJ) will always result in a pound (~0.5 kg) of weight gained or lost, without considering all the other factors that might change as energy intake or energy expenditure is altered. A classic example of this concept was illustrated by Swinburn and Ravussin [17]. They demonstrated what would happen to a 75-kg man who consumed an extra 100 kcal/day (~420 kJ) every day for 40 years. Using the static energy balance equation this amount of extra energy would equal ~1.5 million kcals or an estimated weight gain of 417 pounds (~190 kg) over this period. Yet this does not happen. This simple calculation does not take into account the increase in energy expenditure that would occur, including increased resting metabolic rate, as weight increased. Thus, after a short period of positive energy balance, bodyweight would increase, resulting in an increase in energy expenditure that will eventually balance the increased energy intake. The individual would then achieve energy balance and become weight stable at a higher bodyweight. Thus, the extra 100 kcal/day would result in a more realistic weight gain of ~6 pounds (~2.7 kg). To maintain this larger body size, the individual would need to continue to eat these additional kcals. Of course, the amount of weight gained will depend on the number of extra kcals consumed, the composition of these kcals (i.e. the amount of fat, carbohydrate, protein, or alcohol), and overall energy expenditure.

Figure 1 illustrates this complex concept by showing some of the factors that can influence each side of the energy balance equation, which ultimately determine bodyweight. Some of these factors include genetics, changes in regulatory hormones that control energy balance and appetite, gut health, and the food and exercise environment that can drive eating, exercise and body composition. For a more detailed explanation of these factors, see Galgani and Ravussin [9].

Achieving a Healthy Bodyweight

Determining an optimal or healthy weight for an athlete competing in a sport is difficult because no charts or tables provide the answer. However, the following criteria are frequently used to help determine a person’s healthy bodyweight, regardless of his/her activity level [12]. This list might help the athlete determine what weight works best for him/her during the off-season and amount of time
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and energy required to maintain a lower bodyweight during the competitive season, while remaining healthy and injury free.

- Weight that minimizes health risks and promotes good health and eating habits, while allowing for optimal training and performance in one's sport.
- Weight that takes into consideration genetic makeup and family history of body weight and shape.
- Weight that is appropriate for age and level of physical development, including normal reproductive function in women.
- Weight that can be accepted by the individual and be maintained without constant dieting or restraining food intake, which could lead to disordered eating or an eating disorder.

Thus, optimal bodyweight should promote good health and be ‘reasonable’ in terms of whether or not it can be achieved and maintained. If an individual is constantly dieting or repeatedly gaining and losing weight, they may be trying to achieve or maintain an unrealistic bodyweight. Conversely, in sports that require a low bodyweight, an athlete may purposefully drop to a lighter weight during periods of high competition or choose to compete at a lower

Fig. 1. Factors regulating and influencing energy balance. PA = Physical activity.
weight class. For example, a ski jumper, wrestler or cyclists will be lighter during the competitive season, while gaining weight during the off-season, since it is unrealistic, and unhealthy, to maintain a low bodyweight the entire year. While it is important for athletes to achieve and maintain a healthy bodyweight throughout the year, some athletes will target bodyweights that are difficult to maintain after competition. Thus, it is important for these athletes to regain some weight during the off-season, but not so much that severe weight loss is required for the next competitive season. It is also important to prevent disordered eating in athletes, which requires that the athlete maintain healthy eating habits. It also requires that the medical and coaching staff know and can recognize risk factors for disordered eating when they occur and initiate early intervention if necessary [7].

**Targeting Weight Loss: Dietary Strategies for Athletes**

What dietary and physical activity behaviors/changes will produce the desired body composition and weight changes, while being sustainable and manageable by the individual? Although the answers will be different depending on the individual and his/her sport, the following section highlights diet behaviors with research to support their recommendation to athletes who are interested in losing weight, maintaining lean tissue and prevention of weight regain. This section does not address changes in exercise strategies or training routines since the coach typically determines 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 Plan**

A low-energy-dense diet is a diet that is high in whole fruits and vegetables, whole grains, and incorporates low-fat dairy, legumes/beans, and lean meats. Overall, the diet is low in fat and reduces or eliminates beverages containing calories, especially sweetened beverages and alcohol. This high-fiber, high-water, low-fat diet means an individual can consume a greater volume of food for an overall lower energy intake and still feel satiated. The energy density of a diet or a food is determined by measuring the amount of energy (kcals) for a given amount (g) of food (kcal/day). Evidence shows that a low-energy-density eating plan is effective at reducing energy intake, facilitating weight loss and prevention of weight regain, and maintaining satiety in well-controlled feeding studies and in free-living conditions [18, 19]. For example, Bell et al. [20] examined the effectiveness of a low-energy-density eating plan on energy intake and weight
loss. They found that when they fed three different levels of energy-dense diets, the women ate a similar amount and weight of food, but on the lowest low-energy dense diet condition, participants consumed 30% less energy than the high-energy density diet. Furthermore, the women did not report any differences in hunger and fullness ratings or enjoyment of the meals across test conditions. In a follow-up study, Rolls et al. [21] examined the effect of changing portion size, energy density or a combination of the two conditions on total energy intake over a 2-day 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/day (10% decrease); however, reducing energy density by 25% decreased energy intake by 575 kcal/day (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 reduce energy intake; however, just reducing the energy density of the foods consumed reduces energy intake more than reducing portion sizes.

Overall, reducing the energy density of the diet is more effective at lowering energy intake than reducing portion size, without effecting 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. Finally, following a lower energy-dense diet can help the athlete maintain his/her weight loss.

In summary, a key component of a low-energy-density eating plan is to increase intake of foods high in water and fiber to promote satiation, while reducing both high-fat foods (i.e. potato chips, cheese, cookies) and low water and fiber foods (i.e. baked tortilla chips, pretzels). Consumption of low-fat, low-water, low-fiber foods are not as satiating. Another advantage of the low-energy-density plan is that it increased total fiber intake, which also increases sense of fullness and helps individuals achieve adequate dietary fiber.

**Eating Breakfast and Timing of Meals**

For the athlete, timing of food intake around exercise training and spreading food intake throughout the day will assure that the body has the energy and nutrients needed for exercise and the building and repair of lean tissue. This approach can also prevent the athlete from becoming too hungry and consuming foods or beverages not on their diet plan.
A growing body of research evidence shows that eating breakfast is associated with a lower energy intake and bodyweight and better diet quality and weight management [22, 23]. For example, Astbury et al. [24] found that men who ate breakfast consumed 17% fewer kcals at lunch. Data from the National Weight Control Registry also show that 80% of individuals who had lost at least 30 pounds (6.6 kg) and kept the weight off for at least one year were breakfast eaters [25]. Skipping breakfast may lead to an upregulation of appetite, which could lead to weight gain over time [23]. For the athlete, breakfast is especially important; it helps replenish glycogen after an overnight fast and provides fuel for exercise. Fortunately, it is easy to consume a low-energy-dense, high-nutrient-dense breakfast by including low-fat high-quality protein (e.g. low-fat dairy or soy products, egg whites, lean meats) and fiber- and nutrient-rich foods (e.g. whole grains and fruits).

Athletes also need to consume adequate high-quality protein throughout the day, but especially after exercise and at breakfast [26]. This dietary approach can benefit the athlete trying to lose weight in two ways. First, it assures that adequate protein is available for building, repair and maintenance of lean tissue throughout the day. Second, higher protein diets have been associated with increased satiety and reductions in energy intake. For example, Weigle et al. [27] reported a decrease in energy intake (−441 ± 64 kcal/day) over a 12-week period in individuals (BMI = 26.2 ± 2.1) 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). Although most athletes get plenty of protein [12], they may not be strategic about getting this protein after exercise and spreading it out across the day. It may be more typical for the majority of the energy and protein to come in a large meal at the end of the day. Finally, it is important that protein intake remain high, even when energy is being restricted for weight loss. For active individuals not attempting weight loss, the recommended protein intake is 1.2–1.7 g protein/kg [28]. When energy is restricted, protein intake may need to be higher than this to help maintain lean tissue and preserve strength. For example, Mettler et al. [29] fed 60% of habitual energy intake to lean (16% body fat) resistance-trained males for 2 weeks. One group consumed 15% of energy from protein (~1 g/kg), while another group received 35% of energy from protein (~2.3 g/kg). At the end of the 2 week period, the 35% energy from protein group maintained their lean mass (~0.3 kg), with the majority of weight loss coming from fat while the 15% energy from protein group lost significantly more lean body mass (~1.6 kg). These data strongly suggest that when lean fit individuals reduce energy intake for weight loss while continuing to maintain a high level of physical activity, protein intake may need to be higher that typically recommended.
Refueling after exercise is still important for the athlete who wants to lose weight. 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 health snacks to meet their energy and nutrient needs while staying within their diet plan. A sport dietitian can teach the athlete how to shop, select and prepare low-energy-dense foods.

Reduce Intake of High-Calorie Beverages
High-calorie sweetened beverages and alcohol can derail any athlete trying to lose weight. They add extra energy to the diet without increasing satiety or reducing the amount of food consumed with these beverages [30]. For some athletes, just the elimination of high-calorie beverages from their diet (e.g. soda, alcohol, fruit juice, energy drinks, or flavored coffee/teas) could help them achieve their weight loss goals without making any other dietary changes.

Avoid Fad Diets
Although it is tempting for both the athlete and coach to use extreme diet practices that result in rapid weight loss, these diets should be avoided. Combining severe energy restriction with an intense endurance and strength training program can actually result in metabolic adaptations that diminish the additive effects of these two factors on weight loss [31] while being extremely stressful for the athlete. In addition, Garthe et al. [32] also showed that slower more reasonable weight loss in athletes (~0.7% loss of bodyweight/week) helped preserve lean tissue while improving strength gains over more severe weight loss (1.4% weight loss/week). Finally, severe energy restriction has a number of other negative consequences for the athletes that are bulleted below [12]:

- Decreased 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.
- Increased emotional distress due to hunger, fatigue and stress of following an energy-restricted diet.
Conclusions

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 bodyweight. This will improve their ability to design individualized and realistic weight management programs.

Disclosure Statement

The author declares that no financial or other conflict of interest exists in relation to the content of the chapter.

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