# TOO GOOD TO BE TRUE?

## Eating More and Losing Weight with a Low Energy Dense Diet

by Whitney Sweat, M.S., R.D. and Melinda M. Manore, Ph.D., R.D., CSSD, FACSM

### LEARNING OBJECTIVE

- To introduce health and fitness professionals to the role of low energy dense diets as a method of promoting healthy weight loss and eating behaviors and the prevention of weight regain.

*Currently, 68% of the U.S. population is estimated to be overweight or obese. Many of these individuals struggle at weight loss and the prevention of weight regain once weight has been lost. Learning to follow a low energy dense diet that is high in whole fruits and vegetables, whole grains, and low-fat dairy and meat can be an effective method of promoting a healthy eating pattern and reducing energy intake while maintaining satisfying portions. Combining this dietary pattern with physical activity, which preserves lean tissue and helps with long-term weight maintenance, may provide clients with the skills they need for successful weight maintenance.*

**Key words:**
Dietary Strategies, Energy Intake, Weight Management, Whole Grains, Fruits and Vegetables, Fiber

### INTRODUCTION

Currently, 68% of the U.S. population is estimated to be overweight or obese (4), which increases the risk for chronic diseases, such as hypertension, cardiovascular disease, and type 2 diabetes (7). Although increased physical activity and decreased energy intake are effective components of any weight loss program, many individuals struggle to lose weight and keep it off for the long-term. Numerous complex reasons exist for this, but two factors that play a key role are that energy balance is both dynamic and hormonally regulated (16). As weight is lost, both body size and composition change, typically resulting in decreased total energy needs unless physical activity has significantly increased. Thus, once a person has achieved his or her goal body weight, he or she now requires less energy to maintain his or her reduced weight. Unless levels of physical activity increase and eating behaviors change, weight is typically regained after the diet is over (17). Hormonal regulators of energy balance may contribute to this propensity to regain lost weight. The negative energy balance that produced weight loss also alters metabolic hormones that regulate appetite, energy intake, and energy expenditure (6). These hormonal changes increase hunger and the desire to eat, thus, increasing the risk of weight regain. Is there a way of helping individuals lose the weight and keep the weight off while reducing hunger cravings and the desire to eat? Research now suggests that one approach to weight loss is the adoption of a low energy dense diet, which promotes both weight loss and prevention of weight regain while still maintaining satisfying portion sizes (10). This article reviews research evidence collected from well-controlled feeding studies and in free-living conditions, showing that a low energy dense eating plan is effective at reducing

energy intake and maintaining satiety while facilitating weight loss and prevention of weight regain.

## WHAT IS ENERGY DENSITY AND HOW IS IT MEASURED?

Energy density is defined as the amount of energy (kilocalorie) in a given weight (gram) of food and is expressed as kilocalorie per gram. Foods can be categorized as having very low, low, medium, or high energy density, as shown in Table 1 (9).

## HOW DOES A LOW ENERGY DENSE DIET WORK?

Consuming a diet composed of lower energy-dense foods may promote weight loss in two key ways. First, low energy dense foods are high in water and fiber, thus, these foods have a greater volume that occupies more space in the stomach, making you feel full. Second, low energy dense foods are as satiating as high energy dense foods while being lower in kilocalories per gram of food consumed. Thus, a meal composed of low energy dense foods will be lower in calories while making you feel just as satisfied with your meal (10).

Overall, the impact of a low energy dense diet means that you can consume a greater volume of food and feel more satiated while still reducing total energy intake. Table 2 compares commonly consumed foods and how they differ in weight, total kilocalories, and energy density (kilocalories per gram). If very low or low energy dense foods are chosen more frequently, larger portions of food can be consumed, resulting in greater satiety. When consuming foods that are medium and high in energy density, choosing smaller portions of nutrient-dense foods from these categories (*i.e.,* whole grain breads, dried fruits, nuts, nut butters) is important to maintain a lower energy intake. In summary, a key component of a low energy dense eating plan is to increase intake of foods high in water and fiber to promote satiation while reducing high-fat foods (*i.e.,* potato chips, cheese, cookies) and low-water/fiber foods (*i.e.,* baked potato chips, tortilla chips, pretzels). Although some of these foods may be lower in fat, without a high water and fiber content, they are not as satiating (2,10).

## WHAT DOES RESEARCH SHOW?

Researchers from Pennsylvania State University have done extensive work in examining the short- and long-term effectiveness of a low energy dense eating plan on energy intake and weight loss (1,2,12–15). For example, early work demonstrated the impact of a low energy dense diet on energy intake (1). First, researchers provided normal-weight women with all their meals for 2 days using three separate testing conditions where the food provided differed in energy density. Each session measured the

TABLE 1: **Examples of Very Low, Low, Medium, and High Energy Dense Foods**

| Very Low (<0.6 kcal · g$^{-1}$) | Low (0.6–1.5 kcal · g$^{-1}$) | Medium (1.5–4.0 kcal · g$^{-1}$) | High (>4.0 kcal · g$^{-1}$) |
|---|---|---|---|
| Most whole fruits: blueberries, oranges, grapes, grapefruit, peaches, pears, nectarines, and apples | Other fruits: bananas, papayas | Dried fruits: apricots, raisins, apples | Nuts and nut butters |
| Most whole vegetables: carrots, tomatoes, lettuce, broccoli, cauliflower, spinach, and zucchini | Starchy vegetables: peas, corn, winter squash, and baked potato with skin | Whole wheat (WW) breads, WW English muffins, WW bagels | Graham crackers, cookies, muffins, pastries, other foods with added sugar and fat |
| Skim milk or low-fat yogurt | Fat-free cottage cheese | Mozzarella or Swiss cheese | Other cheeses (cheddar, Brie), mayonnaise, sour cream |
| Broth-based soups | Cooked grains (WW spaghetti, oatmeal, brown rice) | Baked snack foods: pretzels, tortilla chips | Potato chips, regular tortilla chips, pretzels |
| | Legumes and low-fat meats (tuna, turkey, and chicken without skin) | Eggs, sirloin steak, pork chops | Candy (all types) (***e.g.,*** M&Ms, chocolate bars) |

*(Adapted from reference 11: Rolls BJ, Barnett R. The Volumetrics Weight Control Plan: Feel Full on Fewer Calories. New York (NY): Harper Collins; 2000. Used with permission.)*

TABLE 2: **Comparison of Low Versus High Energy Dense Foods**

| Low Energy Dense Foods | High Energy Dense Foods |
|---|---|
| Apple (1 medium, 2¾ in diameter) = 81 kcal, 138 g | Potato chips (1 bag/serving) = 153 kcal, 28 g |
| Energy density: 0.59 kcal · $g^{-1}$ food | Energy density: 5.46 kcal · $g^{-1}$ food |
| Spinach (1 cup chopped, raw) = 7 kcal, 30 g | Brownie (2-inch square) = 112 kcal, 24 g |
| Energy density: 0.23 kcal · $g^{-1}$ food | Energy density: 4.67 kcal · $g^{-1}$ food |
| Cauliflower (1 cup chopped, raw) = 25 kcal, 100 g | Cheddar cheese (1-oz slice) = 114 kcal, 28 g |
| Energy density: 0.25 kcal · $g^{-1}$ food | Energy density: 4.07 kcal · $g^{-1}$ food |

*(Adapted from: Pennington JAT, Douglass JS. Bowes & Churche's Food Values of Portions Commonly Used. 18th ed. Baltimore (MD): Lippincott Williams & Wilkins; 2005. Used with permission.)*

total amount of food consumed by weight (grams) and total energy intake (kilocalories) for three different conditions of energy density: 1) low, 2) medium, and 3) high. To alter energy density, the proportion of vegetables in the main *entrée* was either increased or decreased; the low energy dense condition had the greatest water content. Across all test conditions, the women ate a similar amount and weight of food, but 30% more energy was consumed in the high energy dense condition (1,800 kcal · $day^{-1}$) than in the low energy dense condition (1,376 kcal · $day^{-1}$). 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, researchers examined the effects of changing portion size and energy density on total energy intake during a 2-day period in young women (15). Four different dietary conditions were tested to determine the condition that resulted in the greatest reduction of energy intake, thus, resulting in the greatest weight loss if followed long-term. The four different conditions are given below:

| Condition 1 | Condition 2 | Condition 3 | Condition 4 |
|---|---|---|---|
| Normal portions | Normal portions | Reduced portions | Reduced portions |
| Normal energy density | Reduced energy density | Normal energy density | Reduced energy density |

Energy density was again altered by changing the portions of vegetables in *entrées* and by substituting low-fat foods/ingredients for full-fat foods (*e.g.,* low-fat milk instead of full-fat milk). The researchers found that the effects of energy density and portion size were independent of one another. When only the effect of reducing portion size was examined, it reduced energy intake by −231 kcal · $day^{-1}$ (Figure 1) (15). However, when the effect of only reducing energy density was examined, it reduced energy intake by −575 kcal · $day^{-1}$ (Figure 1). Furthermore, the foods provided under condition 2 (normal portions; reduced energy density) and condition 3 (reduced portions; normal energy density) provided the same energy (total kilocalories), but they differed in portion sizes and energy density. This allowed the researchers to directly compare the effects of reducing portion size and energy density on energy intake. In condition 2, where portions were maintained but energy density was reduced, total energy intake (1,937 kcal · $day^{-1}$) was lower (−288 kcal · $day^{-1}$) than total energy intake (2,225 kcal · $day^{-1}$) in condition 3, where portion sizes were reduced, but energy density did not change (Figure 2). Overall, changing the energy density of the diet reduced energy intake more than reducing portion sizes. In addition, although reducing the energy density was more effective at lowering energy intake than reducing portion size, it did not impact ratings of hunger, fullness, or enjoyment of the food. For individuals trying to lose weight, this has important implications. It may be easier for people to consume a similar amount of food and focus on changing the energy density of their diet rather than eating smaller portion sizes. For example, a person attempting to lose weight could eat the same amount of soup or casserole, but make the food with more vegetables, so that each serving is lower in kilocalories.

The previous research was short-term (2 days), but research also has demonstrated the effectiveness of reducing energy density for long-term weight loss. For example, researchers compared two different low-fat diets (~28% of energy from fat) that varied in energy density (3). One group of overweight/obese women only reduced its fat intake (RF), whereas the other group reduced its fat intake and increased its intake of fruits and vegetables (RF + FV). The RF + FV group reduced dietary energy density to a greater extent compared with that of the RF group (RF = 1.45 kcal · $g^{-1}$ vs. RF + FV = 1.23 kcal · $g^{-1}$). Both groups lost weight (RF = −6.7 kg; RF + FV = −8.9 kg), but the RF + FV group lost 33% more weight (−2.3 kg) at 6 months and maintained a lower body weight for the duration

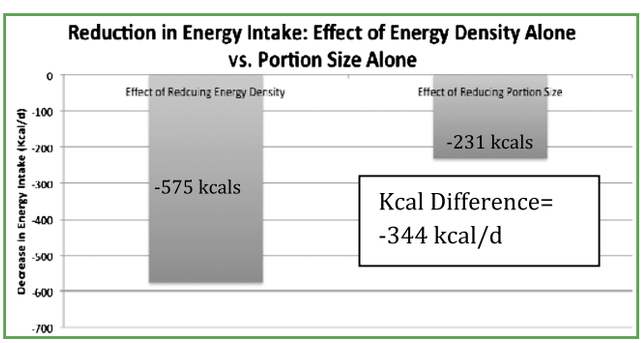


**Figure 1.** Reduction in energy intake: effect of energy density alone versus portion size alone. *(Adapted from: Rolls BJ, et al. Reductions in portion size and energy density of foods are additive and lead to sustained decreases in energy intake.* American Journal of Clinical Nutrition *2006;83(1):11–17. Used with permission.)*

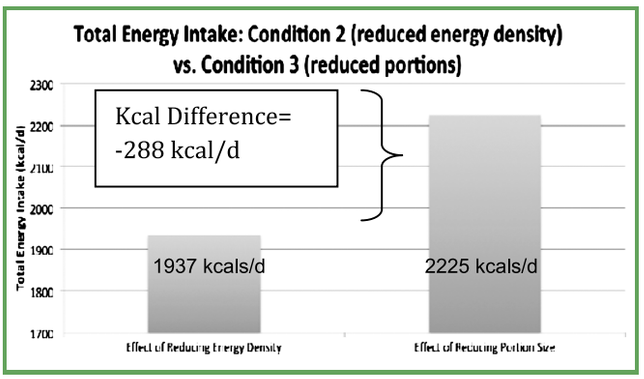


**Figure 2.** Total energy intake: condition 2 (reduced energy density) vs. condition 3 (reduced portions). *(Adapted from: Rolls BJ, et al. Reductions in portion size and energy density of foods are additive and lead to sustained decreases in energy intake.* American Journal of Clinical Nutrition *2006;83(1):11–17. Used with permission.)*

of the 1-year study (difference of 1.5 kg at 12 months; Figure 3) compared with the RF group.

The Dietary Approaches to Stop Hypertension (DASH [www.dashdiet.org]) is another low energy dense eating plan that can produce weight loss. Researchers examined the effect of the DASH diet with overweight hypertensive adults for 6 months (8). Individuals following the DASH eating plan had a dietary energy density of 1.22 kcal · $g^{-1}$, whereas those following the energy restricted only diet had a dietary energy density of 1.54 kcal · $g^{-1}$. When participants were divided into three groups based on reductions in energy density from baseline, results showed that individuals who decreased their energy density the most (−0.52 kcal · $g^{-1}$ or more; average −0.9 kcal · $g^{-1}$; −43% reduction in energy density) experienced the greatest amount of weight loss (−5.9 kg vs. −4.0 kg vs. −2.4 kg across tertiles of energy density). Larger reductions in energy density were related to increases in whole fruits and vegetables and fiber and decreases in fat and saturated fat intake.

The role of a low energy dense diet for weight maintenance also has been examined. In a 2-year follow-up study following initial weight loss, in which low energy dense foods were encouraged, dietary energy density was compared between weight maintainers (regain of <5% of postintervention body weight) and weight gainers. Researchers found that those who maintained or continued to lose weight at follow-up consumed a diet lower in energy density (1.67 kcal · $g^{-1}$) than those who regained weight (1.98 kcal · $g^{-1}$) (5).

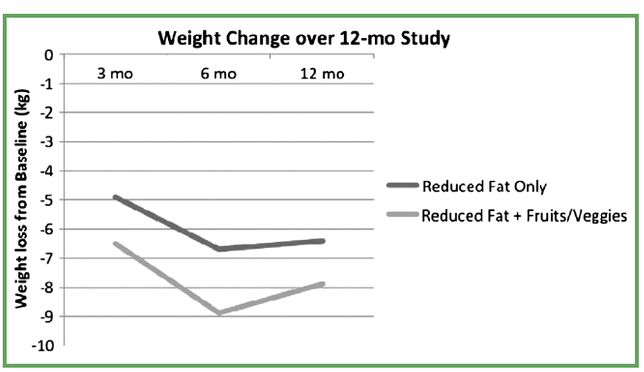


**Figure 3.** Weight change for 12 months for reduced fat-only diet versus reduced fat + increased fruits and vegetables. *(Adapted from: Ello-Martin JA, et al. Dietary energy density in the treatment of obesity: A year-long trial comparing 2 weight-loss diets.* American Journal of Clinical Nutrition. *2007;85(6):1465–1477. Used with permission.)*

What do these findings mean for individuals trying to lose or maintain weight? The key take-home points from this research are bulleted below:

- Reducing dietary energy density can reduce energy intake while maintaining satiety.
- Low energy dense diets are effective in the prevention of weight regain after weight has been lost.
- Reducing dietary energy density may be more effective at decreasing energy intake than reducing portion size alone.
- Individuals who are able to more substantially reduce energy density may experience greater weight loss.
- A low energy dense diet can be a healthy eating plan that can be maintained long-term and positively improve overall health.

## HOW DO YOU IMPLEMENT A LOW ENERGY DENSE EATING PATTERN?

Altering the energy density of your diet is simpler than you think. See Table 3 for sample menus for a high versus low energy dense eating plan. You can see that a greater amount and weight of food can be consumed for a similar energy intake. Further reductions in portion sizes, limiting higher energy density foods (avocado, dressings), and substituting high-fat foods for low-fat

TABLE 3: **Sample Menus With Lower Energy Density and Energy Levels**

| High Energy Dense Diet: 2,200 kcal | Low Energy Dense Diet: 2,200 kcal | Low Energy Dense Diet: 1,800 kcal |
|---|---|---|
| **Breakfast** | | |
| 2 slices pan-fried bacon | 1 cup cooked oatmeal | 1 cup cooked oatmeal |
| 2 eggs, scrambled | ¾ cup skim milk | ½ cup skim milk |
| 2 slices white toast | ½ cup fresh/frozen blueberries | ½ cup fresh/frozen blueberries |
| 1 TB butter | 2 TB almonds | 2 TB almonds |
| 1 TB jam | 1 TB brown sugar | ½ TB brown sugar |
| | 1 tsp cinnamon | 1 tsp cinnamon |
| **Snack** | | |
| 7 saltine crackers | 1 medium apple | 1 medium apple |
| 2 slices cheddar cheese | Low-fat string cheese | |
| **Lunch** | | |
| Roast beef sandwich | Taco Salad | Taco Salad |
| 2 slices white bread | 2 cup lettuce | 2 cup lettuce |
| 2 oz roast beef | ¼ cup chopped carrots | ¼ cup chopped carrots |
| 1 slice cheddar cheese | ¼ cup chopped cabbage | ¼ cup chopped cabbage |
| 2 lettuce leaves | ½ cup chopped tomato | ½ cup chopped tomato |
| 3 slices tomato | 2 oz shredded skinless chicken breast | 2 oz shredded skinless chicken breast |
| 1 TB mayonnaise | 1 oz shredded cheddar cheese | 1 oz shredded cheddar cheese |
| 1 oz potato chips | 1 oz tortilla chips | 1/3 cup brown rice |
| | 1/3 cup avocado | ¼ cup avocado |
| | 2 TB balsamic vinaigrette | 2 TB light balsamic vinaigrette |
| | 1 medium orange | 1 medium orange |
| **Snack** | | |
| Chocolate chip granola bar | ¾ cup plain, low-fat yogurt | ¾ cup plain, nonfat yogurt |
| | ½ banana | ½ banana |
| **Dinner** | | |
| Spaghetti | 3 oz salmon | 3 oz salmon |
| 1 cup spaghetti noodles | ½ cup roasted red potatoes with rosemary | ½ cup roasted red potatoes with rosemary |
| ½ cup ground beef | 1 cup roasted broccoli, cauliflower, onions | 1 cup roasted broccoli, cauliflower, onions |
| ½ pasta sauce | 1 TB olive oil | 1 tsp olive oil |
| ½ cup green beans | | |
| 1 cup green salad | | |
| 1 TB ranch dressing | | |
| **Snack/dessert** | | |
| 1 chocolate chip cookie | ½ cup chocolate pudding (made with 2% milk) | ½ cup chocolate pudding (made with skim milk) |
| | ½ cup sliced strawberries | ½ cup sliced strawberries |
| | 2 TB nonfat whipped topping | 2 TB nonfat whipped topping |
| Total energy: 2,225 kcal | Total energy: 2,220 kcal | Total energy: 1,792 kcal |
| Total weight: 1,087 g | Total weight: 2,250 g | Total weight: 1,900 g |
| Energy density: 2.0 kcal · $g^{-1}$ | Energy density: 0.94 kcal · $g^{-1}$ | Energy density: 0.94 kcal · $g^{-1}$ |

## TABLE 4: Strategies to Reduce Dietary Energy Density

- Incorporate a vegetable and/or fruit at each meal
- Portion your plate with vegetables first
  - Aim to make ½ the plate from nonstarchy, very low energy-dense vegetables
- Incorporate vegetables into mixed dishes like pastas, casseroles, enchiladas, and stews
- Add fruit to cereal, yogurt, and desserts
- Choose vegetables and fruits for snacks rather than crackers, pretzels, or chips
- Reduce intake of foods with added sugar and fat (cookies, crackers, chips, cupcakes, pastries)
- Choose low-fat protein sources: broiled, baked, or grilled skinless chicken, turkey, and fish, legumes, low-fat or fat-free plain yogurt, cottage cheese, or milk
  - Protein foods are satiating; aim to incorporate in most meals
  - Cook protein foods in little added fat
- Within the whole grain group, try to select more whole grains cooked with water (oatmeal, brown rice, steel cut oats, quinoa) instead of those with low water contents (whole wheat bread, ready-to-eat cereal, whole grain crackers)
- Make your own broth-based soups or select only broth-based soups when dining out
- Use fat-free Greek yogurt in place of sour cream and other high-fat spread
- Choose reduced-fat versions of condiments and cheeses
- Flavor foods with spices and seasonings rather than added fats (butter, sour cream)

options will lower the overall energy intake without substantially reducing the amount of food consumed. Table 4 also identifies steps and strategies your clients can follow to reduce dietary energy density.

## SUMMARY

Reducing dietary energy density can be an effective way to reduce total energy intake and promote weight loss and the prevention of weight regain after weight has been lost. Replacing higher calorie foods (*i.e.,* potato chips) with low-calorie, low energy dense foods (*i.e.,* apple, grapes, carrots) can lessen feelings of hunger often associated with reducing portion sizes and reducing total energy intake. Research indicates that low energy dense foods decrease energy intake and promote weight loss in both short- and long-term studies. Any dietary behaviors that promote weight loss must be sustainable for continued weight maintenance. Finally, consuming a reduced energy dense diet and increased physical activity can be the key to successfully achieving a healthy body weight. These lifestyle changes can help sustain a healthy weight for a lifetime.

## References


1. Bell EA, Castellanos VH, Pelkman CL, Thorwart ML, Rolls BJ. Energy density of foods affects energy intake in normal-weight women. *Am J Clin Nutr.* 1998;67(3):412–20.
2. Bell EA, Rolls BJ. Energy density of foods affects energy intake across multiple levels of fat content in lean and obese women. *Am J Clin Nutr.* 2001;73(6):1010–8.
3. Ello-Martin JA, Roe LS, Ledikwe JH, Beach AM, Rolls BJ. Dietary energy density in the treatment of obesity: A year-long trial comparing 2 weight-loss diets. *Am J Clin Nutr.* 2007;85(6):1465–77.
4. Flegal KM, Carroll MD, Ogden CL, Curtin LR. Prevalence and trends in obesity among U.S. adults, 1999–2008. *JAMA.* 2010;303(3):235–41.
5. Greene LF, Malpede CZ, Henson CS, Hubbert KA, Heimburger DC, Ard JD. Weight maintenance 2 years after participation in a weight loss program promoting low-energy density foods. *Obesity.* 2006;14(10):1795–801.
6. Hagobain TA, Braun B. Physical activity and hormonal regulation of appetite: Sex differences and weight control. *Exerc Sport Sci Rev.* 2010;38(1):25–30.
7. Lavie CJ, Milani RV, Ventura HO. Obesity and cardiovascular disease: Risk factor, paradox, and impact of weight loss. *JACC.* 2009;53(21):1925–32.
8. Ledikwe JH, Rolls BJ, Smiciklas-Wright H, *et al.* Reductions in dietary energy density are associated with weight loss in overweight and obese participants in the PREMIER trial. *Am J Clin Nutr.* 2007;85(5):1212–21.
9. Pennington JAT, Douglass JS. *Bowes & Churche's Food Values of Portions Commonly Used*. 18th ed. Baltimore (MD): Lippincott Williams & Wilkins; 2005.
10. Rolls BJ. The relationship between dietary energy density and energy intake. *Physiol Behav.* 2009;97:609–15.
11. Rolls BJ, Barnett R. *The Volumetrics Weight Control Plan: Feel Full on Fewer Calories*. New York (NY): Harper Collins; 2000.
12. Rolls BJ, Bell EA, Castellanos VH, Chow M, Pelkman CL, Thorwart ML. Energy density but not fat content of foods affected energy intake in lean and obese women. *Am J Clin Nutr.* 1999;69(5):863–71.
13. Rolls BJ, Bell EA, Thorwart ML. Water incorporated into a food but not served with a food decreases energy intake in lean women. *Am J Clin Nutr.* 1999;70(4):448–55.
14. Rolls BJ, Roe LS, Beach AM, Kris-Etherton PM. Provision of foods differing in energy density affects long-term weight loss. *Obes Res.* 2005;13(6):1052–60.
15. Rolls BJ, Roe LS, Meengs JS. Reductions in portion size and energy density of foods are additive and lead to sustained decreases in energy intake. *Am J Clin Nutr.* 2006;83(1):11–7.
16. Sumithran P, Prendergast LA, Delbridge E, *et al.* Long-term persistence of hormonal adaptations to weight loss. *N Engl J Med.* 2011;365(17):1597–604.
17. Wing RR, Phelan S. Long-term weight loss maintenance. *Am J Clin Nutr.* 2005;82(suppl):222S–225S.

## Recommended Readings

Ello-Martin JA, Ledikwe JH, Rolls BJ. The influence of food portion size and energy density on energy intake: Implications for weight management. *Am J Clin Nutr.* 2005;83(suppl):236S–241S.

Rolls BJ. The relationship between dietary energy density and energy intake. *Physiol Behav.* 2009;97:609–15.

Rolls BJ, Drewnowski A, Ledikwe JH. Changing the energy density of the diet as a strategy for weight management. *J Am Diet Assoc.* 2005;105(suppl):S98–S103.

Rolls BJ, Ello-Martin MS, Tohill BC. What can intervention studies tell us about the relationship between fruit and vegetable consumption and weight management? *Nutr Rev.* 2004;62(1):1–17.

Disclosure: The authors declare no conflict of interest and do not have any financial disclosures.

*Whitney Sweat, M.S., R.D., is a registered dietitian who recently completed her master's degree in nutrition with a minor in exercise science from Oregon State University. Her research focused on the effect of low energy dense diets and high-intensity physical activity on changes in body weight, waist circumference, and chronic disease risk factors in abdominally obese women.*

*Melinda M. Manore, Ph.D., R.D., CSSD, FACSM, is a professor of nutrition, at the School of Biological and Population Sciences, College of Public Health and Human Sciences at Oregon State University. Her research focuses on the role of diet and exercise in energy balance to achieve a healthy sustainable weight and the nutrition needs of active individuals.*

### CONDENSED VERSION AND BOTTOM LINE

Many individuals struggle to lose weight and maintain the weight loss long-term. Following a low energy dense diet high in whole fruits and vegetables, whole grains, and low-fat dairy and meats can be an effective method to reduce energy intake while maintaining satisfying portions. This dietary approach, when combined with increased physical activity, may result in the ability to reduce energy intake, facilitating better success at weight loss and the prevention of weight regain.