Nutrition Interventions for Obesity

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KEYWORDS

• Obesity • Dietary therapy • Energy balance • Weight loss
• Maintenance of weight loss • Weight-reducing diet

KEY POINTS

- Obesity is a complex, chronic disease that requires a period of negative energy deficit followed by restoration of energy balance to successfully reduce body weight.
- Multiple dietary strategies have been shown to be effective for reducing body weight. The particular components of the dietary strategy, including macronutrient balance, amount of energy deficit, and foods/food types, can have an impact on adherence and comorbid risk factors.
- Maintenance of weight loss of 3% or more of body weight can lead to significant improvements in risk factors. Specific guidance should be provided on strategies that are most effective for weight loss maintenance to help sustain risk factor improvements and reduce body weight.

INTRODUCTION

Obesity is among the most prevalent chronic diseases in the United States and much of the world, contributing to substantial morbidity, mortality, and health care expenditures. Nearly every health care professional has to manage obesity or comorbid conditions related to obesity. The most recent NHANES (National Health and Nutrition Examination Survey) data show that 36.5% of American adults fit the definition of obesity.[1] Prevalence of obesity is significantly higher in certain subgroups, with Hispanic Americans and African Americans having rates of 42.5% and 47.8%, respectively.[2] Globally, approximately 600 million people have obesity, with more of the world's inhabitants overweight than underweight, and most of the world's population living in countries where overweight and obesity cause more deaths than underweight.[3]

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Although the causes of obesity are multifactorial, the common pathway is a sustained state of positive energy balance, leading to an increase in fat mass. The excess accumulation and storage of adipose tissue that defines obesity leads to a wide array of comorbid conditions. To successfully treat obesity, the primary tenet of nutrition therapy is to create a negative energy balance, leading to reduction of fat stores that are being used as a source of energy. Weight loss of 3% or more of body weight can lead to clinically meaningful improvements in risk factors associated with obesity. This article provides an overview of obesity and its classification, dietary strategies for treatment, expected outcomes and challenges, and considerations for successful maintenance of weight loss. It discusses specific nutrition considerations for patients with obesity and common comorbid conditions, and addresses several popular claims for diets and weight loss supplements.

Background and Classification

Obesity is a condition of excess accumulation and storage of adipose tissue, which is a metabolically active tissue that has many bodily functions in addition to energy storage, including hormone synthesis and thermoregulation. Obesity is associated with nearly 200 comorbid conditions, including cardiometabolic disorders (eg, type 2 diabetes, cardiovascular disease, hypertension, dyslipidemia), gastrointestinal disorders (eg, gallbladder disease, pancreatitis, esophageal reflux), mechanical disorders (eg, osteoarthritis of weight-bearing joints, hypoventilation), numerous cancers, and mental health conditions (eg, depression), as well as functional limitations and decreased health-related quality of life.[4]

Obesity is most commonly defined by body mass index (BMI; body weight [kg [/height [meters] squared) greater than or equal to 30 kg/m^2. For adults, a normal BMI is defined as 18.5 to 25 kg/m^2, overweight as BMI 25 to 29.9 kg/m^2, and obesity as BMI greater than or equal to 30 kg/m^2, with severe obesity defined as BMI greater than or equal to 40 kg/m^2 (**Table 1**). BMI is highly correlated with total body fat, based on studies of body composition using various techniques in the general population, and is positively associated with morbidity and mortality.[5–7] However, BMI has several limitations. First, BMI does not distinguish fat from lean mass. BMI can underestimate body fat in older adults, because people tend to lose lean mass and accumulate fat mass with age; conversely, very lean individuals with high muscle mass, such as highly trained athletes, have less body fat than predicted by calculated BMI.[8] Next, as with any attempt to categorize a continuous phenomenon, the association with other disease risks in the lower ranges of abnormal BMI (ie, overweight) are not as consistent on an individual level.[7] In addition, BMI does not account for body fat distribution, which can alter risk associations. Visceral adipose tissue, most commonly found in

Table 1
BMI classification

Weight Classification	BMI (kg/m^2)
Underweight	<18.5
Normal weight	18.5–24.9
Overweight	25–29.9
Obesity class 1	30–34.9
Obesity class 2	35–39.9
Obesity class 3	40+

truncal/abdominal obesity, is metabolically active tissue and a promoter of systemic inflammation and insulin resistance via secretion of adipokines, which increases risk for cardiovascular disease, type 2 diabetes, and carcinogenesis.[9,10] Subcutaneous fat accumulation is generally associated with lower metabolic risk, although some evidence suggests that subcutaneous fat accumulation in the abdominal area may contribute to insulin resistance and inflammation.[11,12]

Several proposed obesity classifications combine anthropometric and clinical criteria to define obesity and obesity risk. These staging systems, such as the Edmonton Obesity Staging System and the American Association of Clinical Endocrinologists staging algorithm, include obesity comorbid conditions and functional limitations to provide a broader classification scheme of obesity[13,14] (**Table 2**). Preliminary data suggest that staging systems may have higher correlation with morbidity and mortality risk, compared with BMI alone, and therefore may aid clinicians in determining appropriate intensity of treatment strategies for each individual (ie, patients with higher stages of obesity are likely to be at greater risk of morbidity and mortality from obesity and thus may be more appropriate candidates for aggressive obesity treatment modalities, compared with lower stage patients), although further research is necessary.[15]

DIETARY STRATEGIES FOR OBESITY TREATMENT

Creating an Energy Deficit

Weight loss requires inducing and sustaining a state in which total energy expenditure is greater than energy intake (ie, an energy deficit), resulting in the use of stored fat as a source of energy. Although this principle is often communicated to patients in a message of eat less and exercise more, understanding the multifactorial contributions to weight gain and the rationale and nuances of evidence-based strategies can lead to more effective treatment and counseling. This article focuses on nutritional contributions to energy balance and other nutritional considerations for obesity management.

In adults, the primary components for total daily energy expenditure (TDEE) include resting metabolic rate (RMR), energy expenditure of activity (AEE), and thermic effect of food (TEF). For sedentary individuals, RMR represents roughly two-thirds of TDEE

Table 2
Edmonton Obesity Staging System

Stage	Obesity-related Medical Risk Factors/Comorbidities	Obesity-related Physical Symptoms/Comorbidities or Functional Limitations	Obesity-related Mental Health or Psychosocial Symptoms/Comorbidities
0	None	None	None
1	Mild/subclinical (eg, borderline hypertension, IFG)	Mild (eg, fatigue, dyspnea on exertion)	Mild
2	Established (eg, hypertension, type 2 diabetes)	Moderate	Moderate
3	End-organ damage (eg, CAD, CHF)	Significant	Significant
4	Severe/end stage	Severe	Severe

Abbreviations: CAD, coronary artery disease; CHF, congestive heart failure; IFG, impaired fasting glucose.

with AEE comprising 15% to 25% and the TEF contributing ~8% of TDEE. The energy balance equation is a thermodynamic process that incorporates both TDEE and energy intake. With a sustained positive balance (ie, energy intake greater than energy expenditure), overweight and obesity develop. In contrast, a prolonged negative energy balance with energy expenditure being greater than energy intake changes the energy balance to negative and leads to weight loss.

Reducing daily energy intake to create an energy deficit can be accomplished through several types of dietary changes. These changes include reducing portion sizes, using meal replacement products to reduce dietary choice and caloric intake, choosing more nutrient-dense and less energy-dense foods, or altering macronutrient composition, glycemic index/load, meal frequency, or eating pattern. Controlling portion sizes is often achieved through use of prepackaged foods, such as meal replacements. Prepackaged foods are commonly in the form of shakes or bars, but may also include meals of whole foods that are allocated in set portions (eg, frozen meals or preprepared meals). These foods are regularly promoted as a low-calorie product and several studies have shown their effectiveness for weight loss.[16–18] Altering food choices to limit high-energy foods, such as sugar-sweetened beverages and high-fat and high-sugar baked goods, and replacing these with foods that are lower in energy and higher in micronutrients, water, and fiber increases satiety and reduces energy density. The notion that humans eat a certain volume of food, independent of total energy content, led to the strategy to increase food volume through reducing energy density.[19–21] In the short term, consuming a food with a low energy density, such as soup or salad, before a meal reduces total energy intake for a single meal and for multiple meals when consumed over 1 to 2 days.[22–25] Furthermore, counseling to reduce energy density through increasing fruit and vegetable intake, along with decreasing fat intake, showed greater weight loss than was seen in a group that was only instructed on reducing fat intake.[26] This evidence formed the basis for the 2010 Dietary Guidelines recommendation to follow an eating pattern with a low energy density to manage body weight.

The role of macronutrients and other dietary factors

Unique combinations of macronutrient levels are often prescribed for weight loss. Because proteins, carbohydrates, and lipids have different effects on energy metabolism, appetite, and satiety, it is intuitive to consider that altering the proportion of macronutrients in diets with similar total calories will cause weight loss and body composition changes. Furthermore, the energy density of the diet may be changed in isocaloric diets differing in macronutrient composition. Because of the finite capacity for storing protein and carbohydrate in the body, and the nearly limitless capacity for fat storage, the body must have an ability to acutely regulate protein and carbohydrate balance.[27] How dietary macronutrient content affects the body's energy balance depends to some extent on the energy state of the body (ie, in a negative, positive, or neutral energy balance). In carefully controlled feeding studies, there is no significant difference in weight loss when reducing fat or carbohydrate content of the diet as long as there is similar total energy reduction. In contrast, during ad libitum intake, there are differences in weight loss between high-fat versus low-fat diets.[28–30] This difference is attributed to the higher diet-induced thermogenesis and lower energy intake with carbohydrates and proteins versus fat.[31,32]

Manipulating dietary protein levels (25%–35% of energy as protein) has been favored as a dietary strategy for weight loss and post–weight-loss regain. High-protein diets are thought to increase diet-induced thermogenesis, as well as reduce energy intake through altering satiety hormones, both of which promote a negative

energy balance.[33–36] In ecological studies and randomized controlled trials, high-protein diets have favorable weight management outcomes.[37–40] However, clinically meaningful weight loss can occur across a broad range of macronutrient compositions, particularly varying proportions of carbohydrates and fats, which are the most commonly varied among dietary recommendations and claims.[41] In a study that examined 4 diets that varied in content of fat (20%–40%), protein (15%–25%), and carbohydrates (35%–65%), there was similar weight loss among the interventions over a 2-year period. There were no differences in hunger and satiety ratings for all diets.

It is well known that there is a wide interindividual variation in weight loss between dietary strategies. The variation in response can potentially be mitigated by identifying factors that modify the effect of a given dietary intervention. For example, evidence from subgroup analyses suggests that the weight loss response on high-carbohydrate or low-carbohydrate diets is related to insulin sensitivity, with a better response seen with a low-carbohydrate versus a high-carbohydrate diet in insulin-resistant, but not insulin-sensitive, individuals.[42–44] Despite these findings, most of the current evidence suggests that the average weight loss responses to a wide range of dietary macronutrient patterns and other dietary manipulations are similar and generally a function of compliance and the energy restriction achieved.[7] One relevant example based on the recent popularization of the concept is the use of low-glycemic-index/low-glycemic-load diets for weight loss. Low-glycemic-index foods produce a lesser and more gradual increase in blood glucose levels, leading to less stimulation of insulin secretion.[45] Glycemic load is calculated as the total carbohydrate of the food (grams) multiplied by the glycemic index value of the food divided by 100. One of the CALERIE (Comprehensive Assessment of Long term Effects of Reducing Intake of Energy) trials assessed a high-glycemic-load diet compared with a low glycemic load diet in the setting of a 30% calorie restriction.[46] After a feeding period of 6 months, both groups self-administered assigned dietary plans for an additional 6 months. There were no differences in weight loss at 12 months for both groups (8% for high vs 7.8% for low).[46] Future research needs to address variable responses in the setting of different diet compositions and nutrient profiles, and in different genetic and biological makeups.

Ultimately, the future direction of obesity intervention will be to prescribe personalized nutrient profiles to match the specific needs of individual patients. Interindividual responses to specific foods create an opportunity to design prescriptions that lead to optimized outcomes compared with general guidelines.[47] The targets for individualization could include specific dietary patterns (eg, low glycemic load or decreased sugar intake), exclusion of certain nutrients (eg, gluten), specific dietary supplements, nutritional alteration of the microbiome, or consideration of biological factors (eg, degree of insulin sensitivity). Because the targets involved in energy homeostasis are myriad, the keys to unlocking the interaction between the nutrient environment and energy balance may ultimately include genotyping, metabolomics, and proteomics to direct nutrient therapy. However, these concepts are currently in the domain of potential future use as research and technology improve. At present, the most promising nutrition consideration for obesity is managing energy balance.

MODIFYING DIET COMPOSITION TO ADDRESS ASSOCIATED RISK FACTORS

Dietary patterns and compositions can be used to address specific cardiometabolic risk factors in the context of a weight-reducing diet. In this manner, a specific dietary pattern leads to a specific type of response in the cardiometabolic profile, allowing targeted intervention. For example, a low-carbohydrate, high-fat diet has been

associated with significant improvements in triglycerides, high-density lipoprotein cholesterol, and blood glucose levels in people with type 2 diabetes.[48,49] The DASH (Dietary Approaches to Stop Hypertension) dietary pattern, which features high intakes of fruits, vegetables, low-fat dairy, and whole grains, has been used as the basis of a weight reduction diet targeted for people with greater than normal blood pressure and stage I hypertension. In the Pounds Lost clinical trial, specific patterns of improvements in cardiometabolic risk factors were evident across 4 diets that varied in fat (20%–40%), protein (15%–25%), and carbohydrate (35%–65%) content.[41] The highest carbohydrate diet had the greatest decrease in low-density lipoprotein level, whereas the lowest carbohydrate diet had the greatest increase in high-density lipoprotein level. The high-protein diet had the largest decrease in fasting serum insulin level. Consistent with these results, Shai and colleagues[50] showed improvements in blood lipids with low-fat and low-carbohydrate dietary interventions, but the low-carbohydrate diet had a greater reduction in the ratio between total cholesterol and high-density lipoprotein. Note that they also found more favorable cardiometabolic effects in individuals with diabetes in patients on a Mediterranean diet pattern versus low-fat diet. Thus, specific dietary recommendations may have more to do with goals for improvements in obesity-associated comorbid conditions than any expected differences in average weight loss from the dietary pattern.

Consistent with these results, most weight loss claims of popular diets are unsubstantiated, as was recently codified by the obesity management guidelines led by the National Heart, Lung, and Blood Institute and published jointly by the American Heart Association, American College of Cardiology, and The Obesity Society.[7] As part of an in-depth systematic review process, a key question was included about which is the best diet for weight loss. Seventeen popular diets were reviewed, including the American Heart Association Step 1, ADA diet, low-carbohydrate and Atkins-type diets, low-fat diets, low-glycemic-index diets, vegetarian and vegan diets, DASH diets, Zone diets, and Mediterranean diets. There was no clearly superior dietary approach, beyond finding a pattern that leads to moderately reduced caloric intake. Importantly, the guidelines recommend respecting patients' preferences; thus, personal preference, rather than diet claims, are a key factor in macronutrient dietary prescription. Moreover, generally healthful dietary recommendations, and eliminating or minimizing sugar-sweetened beverages, should be considered for any dietary approach.

PROMOTING ADHERENCE WITH AN APPROPRIATE DIETARY PRESCRIPTION

Overall, trials comparing a wide variety of macronutrient distributions have found weight loss success in nearly all types of hypocaloric diets.[51] This finding suggests adherence to a reduced energy diet as the main driving force for weight loss success.[41,52,53] Thus, finding a diet that is palatable and fits with the lifestyle of the individual is a key to effective weight loss. For some, this may be achieved with a high-carbohydrate diet, whereas others may prefer a high-fat or high-protein diet. This approach is consistent with the Pounds Lost findings, by Sacks and colleagues,[41] discussed earlier, which showed that adhering to the macronutrient intake goal with a hypocaloric diet was associated with increased weight loss. In this study, group means for satisfaction with the diet, as well as satiety and hunger, were not different across 4 groups that had different target intakes for protein, fat, and carbohydrates. Importantly, there was a loss in dietary adherence over the 1-year follow-up period, showing the difficulty in long-term adherence to a dietary plan that is different from the person's habitual diet.

EXPECTED WEIGHT LOSS OUTCOMES

Similar to the management of many other chronic diseases, the goal of obesity treatment is to improve health and long-term risk, not necessarily to rid the body of obesity (eg, a treatment goal of diabetes management is to improve glycemic control to achieve a hemoglobin A1c level <7%, not necessarily to achieve a normal hemoglobin A1c level). There is strong evidence for health and comorbidity improvement with small weight losses. Sustained weight loss of 3% to 5% of initial body weight is likely to improve triglyceride levels, glycemic control, and risk of developing type 2 diabetes.[7] Sustained loss of 5% to 10% of initial body weight generally ameliorates or improves numerous other comorbid conditions and risk factors (eg, blood pressure, hepatic steatosis, urinary incontinence), although improvements in some risk factors and obesity-associated conditions (eg, low-density lipoprotein [LDL] cholesterol, sleep apnea, nonalcoholic steatohepatitis) may require greater weight losses for meaningful clinical improvement.[7,54–56]

As described earlier, reduction of body fat is accomplished by negative energy balance via changes in energy intake or expenditure. Expected rate of weight loss is traditionally estimated by reduced energy intake and/or increased energy expenditure by 3500 kcal to lose 450 g (1 pound). Thus, a 500 kcal/d energy deficit would theoretically lead to 450 g/wk of body weight loss. However, this general rule does not account for dynamic physiologic adaptations during weight loss, such as alterations in resting energy expenditure and increased muscle efficiency, thereby overestimating weight loss results.

These compensatory adaptations make evolutionary sense in that they counter sustained negative energy balance related to famine. More complex mathematical models have been developed that account for these metabolic adjustments during negative energy balance. In one such model, Hall and colleagues[57] predict greater than 10 kg difference in weight loss using the static linear model of the 3500-kcal rule versus their dynamic model, which incorporates energy expenditure changes with weight loss. Thus, when using the 3500-kcal/450 g value, patients typically experience less rapid weight loss and may fail to reach their expected weight loss goals, even for those strictly adhering to their target behavioral goals. On average, weight losses of up to 8 kg have been observed at 1 year in behavioral interventions that include a prescribed energy deficit diet combined with frequent behavioral counseling and a prescription for increased physical activity.[7] The weight loss nadir is generally observed at about 6 months of intervention with maintenance of weight loss achieved with continued intervention through 12 months. The nadir at 6 months is commonly observed as a weight loss plateau, and is, in part, attributed to these metabolic adaptations to energy expenditure in the setting of persistent low energy intake.

In light of these physiologic adaptations that occur with weight loss, in addition to the obesogenic environment that makes sustained decreases in dietary intake difficult to maintain over long periods, it is important to manage expectations and communicate realistic expectations for both the rate of expected weight loss and long-term weight loss goals. Several studies of individuals beginning weight loss programs show that weight loss expectations wildly exceed what is realistic. For example, in one study of 60 patients beginning a clinical trial of behavioral weight loss, subjects reported mean goal weight loss of 33% of initial body weight; an amount that exceeds the average weight loss with bariatric surgery.[58] At a minimum, health care providers should proactively work with patients to negotiate realistic weight loss and behavioral goals, informed by the type of strategy used (eg, very-low-calorie diets [VLCDs] using meal replacement products generally lead to faster initial rates of weight loss, whereas

a food-based deficit diet may require a longer period to achieve a similar weight loss) and life circumstances (ie, realistic weight loss may be lower during periods of life transition, such as job changes). Importantly, goal setting should include non–weight-specific goals (eg, improvements in physical functioning, risk factors, quality-of-life indices).

TROUBLESHOOTING AND COMMON COMPLICATIONS

Limited Weight Loss

Patients with less than their expected weight loss are a challenging consideration. The clinician's role is to systematically review key components of the intervention, with the goal of reinforcing consistent use of evidence-based tools that are effective for promoting sustained adherence to behaviors that promote a negative energy balance. With any behavioral intervention, it can be expected that the level of engagement and degree of adherence will decline over time on average.[59] However, brief and focused interactions can help patients refocus efforts and lead to modifications in the prescription that enhance weight loss.

Self-monitoring is the most common tool that can be easily used to help identify deviations from the dietary prescription or areas for adjustment. Patients should generally be encouraged to self-monitor dietary intake on a daily basis because this is one of the behaviors that are most commonly associated with achieving clinically meaningful weight loss.[60] A brief review of 1 to 2 weeks of food records can help the clinician identify deviations that might not be readily obvious to the patient. Deviations most often seen in clinical practice include skipping prescribed meals and snacks, longer intervals between eating episodes, and incorrect diet composition. A more thorough review can also reveal inadequate portion control and underestimation of calorie intake.

When none of these common patterns of deviation from the prescribed dietary intake is obvious, refining the dietary prescription may be necessary. Decreasing the calorie prescription is often the first consideration. Other than reducing portion sizes or eating episodes, calories can often be reduced by using meal replacements or substituting less-energy-dense food options for more-calorie-dense foods (eg, whole fruit for dried fruit snacks). These options preserve the nutrient density of the prescription while allowing maintenance of satiation. Altering macronutrient balance is a second level of adjustment that can be attempted in cases of limited weight loss. The food record can be the basis for making this adjustment; clinicians can recommend changes that are substantively different from the current macronutrient intake that is resulting in limited weight loss. For example, the clinician could recommend that a patient shift approximately 10% of calories from the group that represents the highest percentage of calorie intake into 2 other macronutrient groups (eg, shift 10% of carbohydrate calories into lean protein and unsaturated fat).

Weight Loss Plateau

As noted previously, many behavioral interventions for obesity have a weight loss nadir at approximately 6 months. When patients report maintenance of behaviors that previously resulted in weight loss but are no longer able to achieve reductions in weight, this represents a weight loss plateau. At this point, the negative energy balance is diminished largely because of metabolic adaptations in energy expenditure resulting from the previously discussed compensatory mechanisms designed to protect against loss of body mass. RMR decreases substantially with energy restriction, and, because it is the largest component of TDEE, this has a significant effect on the resulting energy balance.[61–63] RMR declines as body mass decreases, because less

energy is required for movement and maintenance. Furthermore, the decrease in RMR with weight loss can be attributed to alterations in hormones and the autonomic nervous system that conserve energy. Energy restriction also reduces physical activity energy expenditure in weight-dependent activities, resulting in fewer calories burned for a given task.[61] For example, a 100-kg patient who previously burned 100 calories when walking 1.6 km (1 mile) would now burn fewer calories after a 10% weight reduction because of improved exercise efficiency and decreased workload.

Basic Considerations for Dealing with a Weight Loss Plateau

Many of the same techniques used to address limited weight loss can also be implemented to help patients work through a weight loss plateau (eg, altering macronutrient balance, portion controls, meal replacements). Ultimately, the goal is to find the new combination of energy intake and activity energy expenditure that leads to an energy deficit that is sufficient to resume weight loss. Although further calorie restriction may seem an obvious target, this strategy has limitations. Further reduction of calories may only force more aggressive adaptation at this point, sending signals to the brain that the low-calorie environment is persistent and even more severe. Alternatively, clinicians typically elect to increase calories in small increments (~100 calories/d) along with alterations in the exercise program that circumvent the efficiencies recently gained with ongoing training. This approach leads to a higher energy flux state, which has been hypothesized to be more favorable for allowing expenditure of stored excess energy as heat; the primary adaptation that is altered in the weight loss plateau.[64]

Risks Associated with Weight Reduction Strategies

Although the benefits of weight reduction generally outweigh the risks, clinicians should be aware of potential complications and advise patients when precautions are necessary. Rapid weight loss, defined as greater than 1.5 kg/wk, has been associated with an increased risk of symptomatic gallstones.[65] VLCDs (ie, <800 kcal/d), which are associated with higher rates of weight loss, were thought to lead to gallstones in 10% to 25% of participants.[66] The largest report to date of 3320 consecutively enrolled patients in a VLCD commercial weight-loss program in Sweden showed that the incidence of gallstones was higher compared with matched controls on a low-calorie diet (LCD), but that the overall risk of gallstones requiring hospital care was low (152 per 10,000 person years for the VLCD compared with 44 for the LCD).[67] Differences in contemporary rates of symptomatic gallstones in people attempting to lose weight may be a result of higher dietary fat intakes in many modern weight loss strategies relative to the very low fat intakes that dominated in the 1980s and 1990s. These very low fat intakes may have contributed to bile stasis because fat intake decreased below a threshold needed to stimulate gallbladder contraction.[68]

Other medical concerns that are seen more frequently in high-risk patients include symptoms, such hypoglycemia and hypotension, resulting from the overtreatment of comorbid conditions. Individuals with type 2 diabetes and hypertension are at risk for adverse events if medication management is not done expectantly. Individuals on insulin or oral hypoglycemics such as sulfonylureas should have medications adjusted based on initial level of glycemic control and degree of calorie restriction. Antihypertensive medications can lead to postural hypotension along with symptoms of lightheadedness and dizziness if blood pressure decreases in response to the weight reduction intervention. In addition, antihypertensive regimens with significant amounts of diuretics can increase the risk of dehydration in patients with more rapid weight loss responses to calorie restriction, especially if sodium intake is decreased concomitantly.

Less serious but more commonly occurring side effects of weight loss and reduced calorie intake can include hair loss, changes in bowel patterns and habits, muscle cramping, and fatigue. Hair loss is generally a function of the duration and intensity of exposure to a low calorie intake. This type of hair loss, known as telogen effluvium, is a reactive response to lower energy intake and generally recovers spontaneously within 6 months of restoring energy balance (ie, during maintenance).[69] Changes in bowel habits are typically associated with changes in dietary fiber content and can be mitigated by supplementing fiber if the dietary plan is lower (eg, a lower-carbohydrate dietary plan). Cramping and fatigue are often related and can be associated with minor electrolyte disturbances such as low levels of sodium, calcium, or magnesium. These symptoms are more likely to occur when electrolytes are not replaced adequately after strenuous exercise routines, when the patient is taking diuretics, or when insensible losses are high because of warm temperatures.

WEIGHT MAINTENANCE STRATEGIES

The compensatory changes that occur in response to weight loss also make it more challenging to maintain weight loss long term. Ultimately, successful weight loss maintenance is a function of engaging in a consistent pattern of increased physical activity while maintaining a dietary pattern and energy intake that is appropriate for the new, lower body weight.

Benefits of Physical Activity in Weight Maintenance

Metabolic benefits occur from exercise training that facilitate weight loss maintenance. The preservation of lean body mass during dietary restriction is the most commonly mentioned factor that benefits weight loss maintenance. The level of calories burned during physical activity is related to weight loss at long-term (18–36 months) follow-up.[70,71] Women who achieved at least a 10% weight loss after 24 months of behavioral weight loss therapy reported activity energy expenditure of 1515 kcals/wk, compared with fewer than 500 kcals/wk in those achieving less than 0% to 5% weight loss at 24 months.[71] The recent 2014 obesity guidelines from American College of Cardiology/American Heart Association/The Obesity Society also suggest that exercise reduces weight regain with VLCDs.[7] These same guidelines prescribe at least 150 minutes of aerobic physical activity per week for weight loss with 200 to 300 min/wk for maintaining lost weight or reducing weight regain. However, most of these data are from secondary analyses from randomized controlled trials or from observational studies and do not fully answer the question of the role for physical activity in weight loss maintenance or the regain of lost weight. Several investigations have shown that, when programs are compared with varying combinations of low or high amounts of activity and exercise intensity, there is minimal impact on weight loss and weight loss maintenance.[71,72]

Role of Diet Composition in Weight Maintenance

Over the long-term, most individuals struggle with maintaining their lost weight. It has been theorized that diet composition may be critical in weight loss maintenance. Because the energy efficiencies of metabolic pathways vary, macronutrient content may influence energy expenditure, as well as dietary adherence.[73] This theory was tested in a crossover feeding trial of 3 isocaloric diets that varied in fat, carbohydrate, and glycemic load during the weight maintenance period following a 10% to 15% weight loss in overweight and obese young adults.[74] Reductions in energy expenditure (RMR and TDEE) from the pre–weight-loss period baseline were greatest in a

low-fat diet compared with a very-low-carbohydrate diet, with the low-glycemic-index diet being intermediate between the two. Furthermore, leptin and triiodothyronine (T3) levels were lowest, and insulin sensitivity was highest, in the very-low-carbohydrate diet compared with the low-fat diet. Moreover, the differences in energy expenditure with the diets are not from lower T3 levels, because the lowest T3 level was seen with the diet that had the least decline in energy expenditure.

The DIOGENES (Diet, Obesity and Genes) dietary study also comprehensively studied the impact of varying protein intakes and glycemic loads on weight maintenance following 8 weeks of weight loss induced by an 800 kcal/d diet.[38] Participants were provided with food for the first 6 months, followed by self-administered plans supported by a dietitian for the remaining 6 months. The high-protein groups (23%–28% of calories) regained 2 kg less at 12 months than the groups consuming low-protein diets (10%–15% of calories).[75] However, there was no consistent effect of the assigned dietary glycemic index on maintenance of weight loss. These results show that metabolic effects during weight loss maintenance differ based on macronutrient content, with protein intake showing the most consistent effects on promoting successful weight loss maintenance.

DIETARY SUPPLEMENTS FOR WEIGHT LOSS

Dietary supplements should be mentioned in any discussion of weight interventions. Herbal and dietary supplements for weight loss can be attractive, because they commonly promise near-miraculous benefits, seemingly without risk. Despite increasing sales and use of over-the-counter (OTC) weight loss products, there are minimal, if any, data supporting benefits for weight management.[76–78] Unlike US Food and Drug Administration (FDA)–approved treatments, dietary supplements are not required to be proved effective, and few have rigorous clinical trial evidence assessing efficacy and safety. When scientific studies are conducted, the results are disappointing. A 2004 systematic review of 25 clinical trials covering 10 popular supplements showed "no evidence beyond a reasonable doubt that any specific dietary supplement was effective for reducing body weight."[79] A 2010 review of published systematic reviews for 9 popular weight loss supplements concluded that none are supported by sound evidence.[80] However, there are 2 OTC options to consider for weight management. The first is the FDA-approved OTC version of orlistat, a prescription medication that was initially approved by the FDA in 1999. Several studies support the utility of orlistat for long-term weight management. One study showed that orlistat (at prescription dose of 120 mg, which is twice the dose available OTC) in combination with a behavioral weight loss intervention based on the Diabetes Prevention Program leads to 10% body weight loss over 1 year, maintenance of most of this weight loss through 4 years, and 45% decreased development of diabetes.[81] Various versions of fiber supplements may also be reasonable to use as dietary supplementation. Fiber-related supplements may support weight control by increasing satiety or slowing digestion. The most commonly used fiber supplement is psyllium, which has been shown to cause small weight losses and improvements in some cardiovascular risk factors.[82] At recommended levels, the risk of adverse effects is low.

SUMMARY

Obesity is an extremely common disorder with a complex cause. The ongoing epidemic has spurred significant advances in the understanding of nutritional approaches to treat obesity. Although the primary challenge is to introduce a dietary intake that creates an energy deficit, clinicians should also consider targeted

risk factor modification with specific manipulation of the nutrient profile of the weight-reducing diet. These strategies are broadly effective in producing clinically significant weight loss and associated improvements in cardiometabolic risk factors. Future research is needed to better understand how to personalize nutrient prescriptions further to promote optimal risk modification and maintenance of long-term energy balance in the weight-reduced state.

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