

Efficacy of Lifestyle Modification for Long-Term Weight Control

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Abstract

WADDEN, THOMAS A., MEGHAN L. BUTRYN, AND KIRSTIN J. BYRNE. Efficacy of lifestyle modification for long-term weight control. *Obes Res.* 2004;12:151S–162S. A comprehensive program of lifestyle modification induces loss of ~10% of initial weight in 16 to 26 weeks, as revealed by a review of recent randomized controlled trials, including the Diabetes Prevention Program. Long-term weight control is facilitated by continued patient-therapist contact, whether provided in person or by telephone, mail, or e-mail. High levels of physical activity and the consumption of low-calorie, portion-controlled meals, including liquid meal replacements, can also help maintain weight loss. Additional studies are needed of the effects of macronutrient content (e.g., low-fat vs. low-carbohydrate diets) on long-term changes in weight and health. Research also is needed on effective methods of providing comprehensive weight loss control to the millions of Americans who need it.

Key words: lifestyle modification, weight loss, diet, exercise, behavior therapy

Introduction

The Diabetes Prevention Program (DPP)¹ recently provided definitive evidence of the health benefits of lifestyle intervention for weight control (1). This 4-year study examined >3200 overweight or obese individuals with impaired glucose tolerance and found that a lifestyle intervention designed to induce a 7% reduction in initial weight and increase physical activity to 150 min/wk reduced the risk of developing type 2 diabetes by 58% compared with placebo.

The intervention was also more effective than metformin, a medication for type 2 diabetes (Figure 1). A Finnish study yielded the same results: individuals who lost 4.3 kg with diet and exercise reduced their risk of developing type 2 diabetes by 58% compared with a control group (2). These two studies, together with trials on the management of hypertension (3,4), leave little doubt of the efficacy of lifestyle modification in facilitating long-term improvements in weight and health.

In the DPP, lifestyle-treated participants lost ~7 kg at the end of the 1st year and then regained ~1 kg a year in the ensuing 3 years (Figure 2). Such weight regain is common after behavioral treatment of obesity and has led some to question the benefits of this approach (5). Thus, it is worth noting that participants experienced a significant reduction in diabetes risk, despite regaining about one-third of their lost weight. These findings suggest, with regard to health, that it is better to have lost and regained than never to have lost at all (6).

This article briefly describes lifestyle modification for obesity and reviews its short- and long-term results. Our principal objective is to examine behavioral methods for improving long-term weight control.

Lifestyle Modification for Weight Control

The terms lifestyle modification, behavioral treatment, and behavioral weight control are often used interchangeably (7). They all encompass three principal components: diet, exercise, and behavior therapy. The last term refers to a set of principles and techniques for modifying diet and exercise (7–9). It teaches patients how to achieve their eating and exercise goals by methods such as keeping records of their physical activity (and food intake) or modifying cues that elicit unwanted eating (e.g., the sight of food on the kitchen counter). Lifestyle modification programs typically encourage patients to eat conventional foods (of their liking) but to reduce their energy intake by 500 to 1000 kcal/d. This historically has been achieved by reducing portion sizes and eliminating fat and sugar (9). These were the general dietary goals of the DPP, although

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¹ Nonstandard abbreviation: DPP, Diabetes Prevention Program.

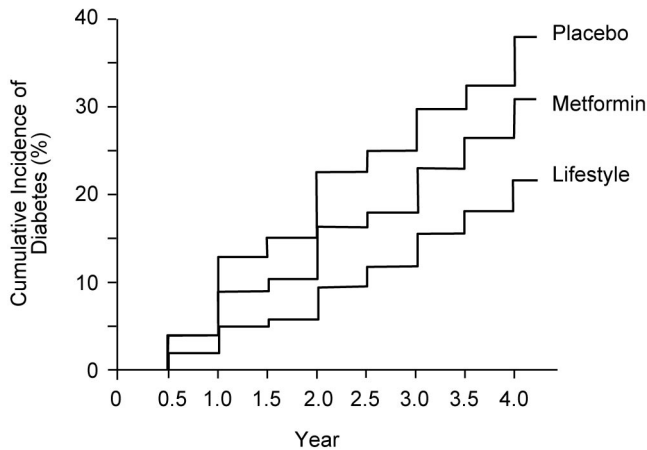


Figure 1: Cumulative incidence of diabetes over a 4-year period in participants who received placebo, metformin, or lifestyle modification (1). Reproduced with permission by the *New England Journal of Medicine*.

specific targets were given for each of the macronutrients (including limiting the intake of saturated fat). Patients also are encouraged to exercise 30 minutes a day, five to six times a week. Walking, the activity most frequently recommended, was prescribed in the DPP (1).

Regularly scheduled treatment visits and homework assignments are two critical components of lifestyle modification (7,8). Patients usually attend treatment sessions weekly for an initial 16 to 26 weeks. Sessions begin with a weigh-in, followed by a review of participants' food and activity records. Interventionists often introduce a new topic at each session, but the majority of time is devoted to discussing methods to help participants adhere to their eating and activity regimens.

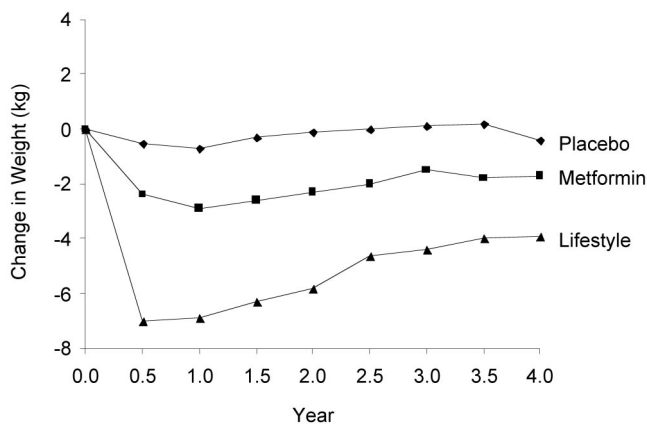


Figure 2: Changes in weight over 4 years in participants who received placebo, metformin, or lifestyle modification (1). Reprinted with permission by the *New England Journal of Medicine*.

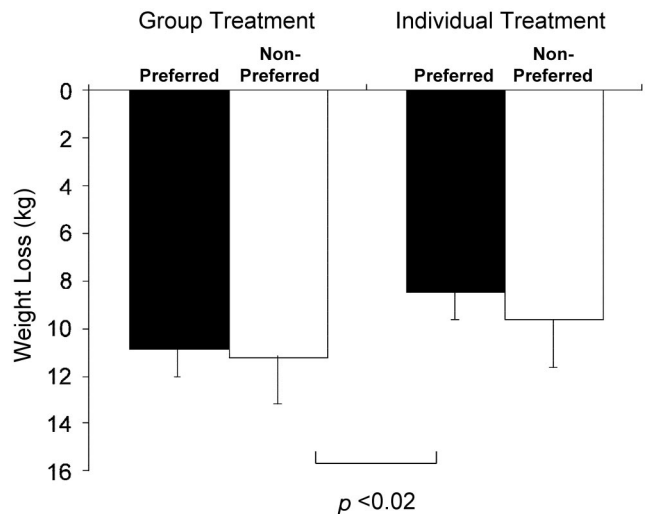


Figure 3: Weight loss at the end of 6 months in patients assigned to group vs. individual treatment. Participants first were divided into those who preferred group vs. individual care. They were then randomly assigned to treatment, yielding four groups: preferred group treatment and received it; desired individual treatment but received group; preferred individual care and received it; or preferred group treatment but received individual. Data adapted from Renjilian et al. (10).

In academic medical centers, lifestyle modification is typically provided to groups of 10 to 20 participants (during 60- to 90-minute sessions) by registered dietitians, psychologists, or exercise specialists (7,8). Treatment can be provided on an individual basis, as it was in the DPP, but this is more expensive than group treatment. In addition, individual counseling may be less effective than group care. In a recent study, participants were selected on the basis of whether they preferred group vs. individual treatment and were then randomly assigned to one of four conditions: those who preferred and received group treatment; those who preferred individual care but received group treatment; those who preferred and received individual treatment; or those who preferred group care but received individual treatment (10). As shown in Figure 3, group treatment induced a significantly greater weight loss than individual care after 6 months of treatment. This was true even in patients who preferred individual treatment but were assigned to group treatment; they lost more weight than persons who preferred individual treatment and received it. We believe that group treatment is more effective because it provides empathy, social support, and a healthy dose of competition (7). Further accounts of lifestyle modification are available (7-9), as is the protocol used in the DPP (11).

Short- and Long-Term Results of Lifestyle Modification

Table 1 summarizes the results of lifestyle modification from 1974 to 2002, as determined from randomized con-

Table 1. Lifestyle modification for obesity, 1974 to 2002

	1974	1985 to 1987	1991 to 1995	1996 to 2002*
Number of studies	15	13	5	9
Sample size	53.1	71.6	30.2	28.0
Initial weight (kg)	73.4	87.2	94.9	92.2
Length of treatment (weeks)	8.4	15.6	22.2	31.4
Weight loss (kg)	3.8	8.4	8.5	10.7
Loss per week (kg)	0.5	0.5	0.4	0.4
Attrition	11.4	13.8	18.5	21.2
Length of follow-up (weeks)	15.1	48.3	47.7	41.8
Loss at follow-up (kg)	4.0	5.3	5.9	7.2

All studies sampled were published in the following four journals: *Addictive Behaviors*, *Behavior Therapy*, *Behavior Research and Therapy*, and *Journal of Consulting and Clinical Psychology*. All values, except for number of studies, are weighted means; thus, studies with larger sample sizes had a greater impact on mean values than did studies with smaller sample sizes.

* Studies included in the 1996 to 2002 sample are found in Perri et al. (28), Wadden et al. (49), Meyers et al. (88), Fuller et al. (89), Perri et al. (56), Harvey-Berino (90), Sbrocco et al. (91), Wing and Jeffery (92), and Ramirez and Rosen (93). Reproduced with permission by *Endocrinology and Metabolism Clinics of North America* (7).

trolled trials published in four journals: *Addictive Behaviors*, *Behavior Research and Therapy*, *Behavior Therapy*, and *Journal of Consulting and Clinical Psychology*. Only studies representative of standard behavioral treatment are included. No interventions prescribed a diet providing fewer than 900 kcal/d (7).

The data show that patients treated by group lifestyle modification lost ~10 kg (~10% of initial weight) in 30 weeks of treatment. In addition, ~80% of patients who began treatment completed it. Thus, this approach yields very favorable results as judged by criteria for success proposed by the NIH/National Heart Lung and Blood Institute (12) and the World Health Organization (13).

A comparison of early (i.e., 1974) and more recent (1996 to 2002) studies shows that weight loss has nearly tripled over the past 30 years as treatment duration has increased more than 3-fold. For instance, in 1974, treatment for 8.4 weeks produced a mean loss of 3.8 kg, whereas treatment from 1996 to 2002 averaged 31.6 weeks and induced a loss of 10.7 kg. Although several new components (e.g., cognitive restructuring, relapse prevention) have been added to the behavioral approach since 1974, the most parsimonious explanation for today's greater weight loss is the longer duration of treatment. The rate of weight loss has remained constant at ~0.4 to 0.5 kg/wk (7).

Long-Term Results

Weight regain is a problem after virtually all dietary and behavioral interventions for obesity (7,8,14,15). As shown

in Table 1, patients treated by group lifestyle modification for 20 to 30 weeks regain ~30% to 35% of their lost weight in the year after treatment. Weight regain slows after the first year, but by 5 years, 50% or more of patients are likely to have returned to their baseline weight (16). This is very disheartening for patients, particularly when they have worked hard and spent substantial funds to achieve their weight loss goals (17). Patients need to know that, even with weight regain, they still may have improved their long-term health, as suggested by results of the DPP (1).

Contributors to Weight Regain

Remarkably little is known about factors responsible for weight regain, despite the frequency with which this problem is observed. Contributors are likely to include compensatory metabolic responses to weight loss that include reductions in resting energy expenditure (18) and leptin (19) and increases in ghrelin (a gut peptide associated with reports of hunger) (20). These physiological responses to both energy restriction and weight loss protect humans against the adverse effects of starvation (21). In addition, once patients leave treatment, they are confronted daily by an environment that explicitly encourages them to consume large quantities of foods, high in fat and sugar (22). Weight regain appears to be a nearly inevitable response to this environment, as witnessed by our nation's epidemic of obesity (23).

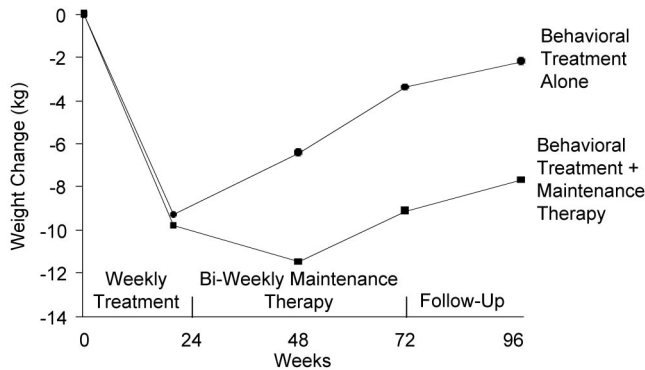


Figure 4: Long-term changes in weight for patients who received standard behavioral treatment, with or without biweekly maintenance therapy. Data adapted from Perri and colleagues (27–29). Data for week 96 are from Perri and colleagues (27,29).

Inadequate Treatment

Inadequate treatment also contributes to weight regain. Short-term treatment of 16 to 26 weeks clearly is no match for what is a chronic disorder for most obese individuals (7). Obesity cannot be cured by 6 months of therapy, any more than type 2 diabetes or hypertension can be cured by such a brief intervention. The long-term results of obesity management have begun to improve with the recognition that obesity is a chronic disorder that, like hypertension and diabetes, requires long-term care (24).

The remainder of this article describes interventions that hold promise for improving long-term weight control by facilitating long-term adherence to appropriate diet and activity regimens.

Long-Term Behavioral Treatment

Several studies have revealed the benefits of continuing to attend weight maintenance classes after completing an initial 16- to 26-week weight loss program (24–27). For example, Perri and colleagues found that individuals who attended every-other-week group maintenance sessions for the year after weight reduction maintained 13.0 kg of their 13.2 kg end-of-treatment weight loss, whereas those who did not maintained only 5.7 kg of a 10.8-kg loss (27). The benefits of extended contact are illustrated in Figure 4, which displays the results of this study (27), as well as two others with similar designs (28,29). In reviewing 13 studies on this topic, Perri and Corsica found that patients who received long-term treatment, which averaged 41 sessions over 54 weeks, maintained 10.3 kg of their initial 10.7-kg weight loss (24). Maintenance sessions seem to provide many patients with the support and motivation they need to continue to practice weight control behaviors, such as keeping food records and exercising regularly (7).

Limitations of Long-Term On-Site Treatment

Despite these favorable results, long-term on-site treatment has limitations. As Figure 4 shows, this approach

appears only to delay rather than to prevent weight regain. Patients maintain their full end-of-treatment weight loss as long as they participate in biweekly maintenance sessions. In fact, they lose additional weight during the first 6 months of extended treatment but regain the additional loss during the second 6 months of therapy. Weight gain continues with the termination of maintenance therapy.

Patients also tire of attending treatment sessions twice monthly, and 50% eventually drop out (26,30). Reasons for attrition are not well understood but are likely to be associated with two factors. The first is the lack of weight loss or other gratification after the first 6 months of maintenance therapy (27–29). Most individuals who receive lifestyle modification (25,26) or pharmacotherapy (31,32) cannot lose >15% of their initial weight, even if treated continuously for 2 years or more. This barrier may be attributable to compensatory biological responses (discussed earlier) or to behavioral fatigue (i.e., participants tire of restricting their food intake and exercising vigorously) (33). Weight loss plateaus are frustrating to patients, most of who remain obese after 1 year of treatment and continue to want to lose 25% of their initial weight, despite therapists' efforts to convince them otherwise (34). As shown in Table 2, maintaining a reduced body weight requires as much (if not more) effort as losing weight but provides few rewards (35). Many individuals seem to conclude that the benefits of weight maintenance—weight stability when weight loss is desired—are not worth the costs (i.e., time, money, continued monitoring of eating and activity habits).

The second factor associated with attrition from therapy concerns complaints that treatment is monotonous and sometimes demoralizing (26). Patients often feel that they do not acquire new information or skills after the first 6 to 12 months of therapy. In addition, weight maintenance sessions give greater attention to individuals who suffer lapses and regain weight than to persons who are successful. Thus, group social interactions that were gratifying during weight loss often lose their appeal during weight maintenance classes (26).

As described in the next sections, the use of telephone, mail, or e-mail could decrease the burden of participating in weight maintenance therapy. However, additional research is needed to determine the optimal frequency of on-site weight maintenance visits and the benefits of using individual vs. group treatment. Study also is needed of the possible benefits of scheduling periodic breaks in maintenance therapy (36) and of increasing opportunities for learning by introducing new lifestyle interventions or additional treatment venues, such as a health club or an instructional kitchen.

Telephone and Mail Contact

Long-term patient-provider contact may be provided by telephone or mail. Perri and colleagues demonstrated that

Table 2. Comparison of behaviors and reinforcement associated with losing weight vs. maintaining a weight loss

Weight loss	Maintenance of weight loss
The goal of treatment is to lose a large amount of weight, after a prolonged period of weight gain	The goal of treatment is to lose small amounts of weight, as small increases in weight occur
The dieter's principal strategy is to avoid eating all of the foods that have caused the weight problem	The dieter's principal task is to learn to eat troublesome foods in a controlled fashion (mastery) and to eat new foods, low in fat and calories
Treatment is time-limited, usually 15 to 25 weeks	Treatment is ongoing and life-long
The dieter receives support from the diet program and from family and friends	The dieter receives little or no support from professionals or family members
Weight loss is highly reinforcing; it is very noticeable and pleasing to dieters and their families	Maintenance of weight loss is not reinforcing; dieters forget about their accomplishments, as do their family members
Dieters do not have to exercise to lose weight	Exercise appears to be critical to maintenance of weight loss

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therapist contact by either of these modalities significantly improved weight maintenance, compared with no further intervention (37). When scheduling telephone calls, the same therapist should contact the patient on each occasion. A study in which patients were contacted by staff members unknown to them failed to produce weight maintenance results superior to those of a no-contact group (38).

Internet and E-Mail

More recently, investigators have explored the Internet and e-mail as methods to provide behavioral treatment, both short- and long-term. In an initial study, Tate and colleagues (39) assigned participants to one of two 6-month weight-loss programs delivered over the Internet. The educational intervention provided a directory of Internet resources for weight control. The behavior therapy intervention included this component and 24 weekly lessons conducted by e-mail. Patients submitted their self-monitoring diaries electronically and received feedback the same way. The behavior therapy participants lost significantly more weight at 6 months (4.1 vs. 1.6 kg, respectively). In a 1-year study, Tate and colleagues (40) randomly assigned individuals at risk for type 2 diabetes to an Internet weight loss program or to the same intervention with the addition of weekly behavioral counseling, delivered by e-mail. Participants in the latter group lost significantly more weight at 1 year (4.4 vs. 2.0 kg, respectively). These studies, taken together, underscore the importance of participants keeping records of their food intake and physical activity, as well as completing other behavioral assignments. Educational instruction alone is not sufficient to induce clinically significant weight loss.

Two additional studies examined the use of the Internet to facilitate weight maintenance after participation in a tradi-

tional lifestyle modification program. Harvey-Berino and colleagues (41) randomly assigned patients to one of three 22-week maintenance programs: an on-site therapist-led intervention; an Internet therapist-led program; or a control condition. Weight loss at the end of the initial 15-week behavioral program averaged 6.5 kg. Most participants continued to lose weight during the maintenance programs, so that total weight loss at the end of maintenance averaged 8.0 kg. There were no significant differences among the three maintenance groups in total weight loss. However, participants in the on-site program were more satisfied with their treatment and attended more sessions than those in the Internet program. In a second study from this team, participants received one of three maintenance interventions: on-site biweekly sessions for 12 months; on-site monthly sessions for the first 6 months only; or 12 months of biweekly Internet video and chat sessions, combined with e-mails from a group therapist, on-line submission of self-monitoring forms, and an e-mail discussion group (42). Weight loss at the end of the initial 6-month behavioral program averaged 9.5 kg. At 1-year follow-up, participants in the frequent and minimal on-site treatment programs had significantly greater total weight loss than patients in the Internet program (10.4, 10.4, and 5.7 kg, respectively). Participants in the Internet program attended fewer (virtual) sessions and were less satisfied with their intervention plan than were patients in the on-site program who had biweekly visits.

Internet-delivered interventions, for either the induction or maintenance of weight loss, generally are not as effective as traditional on-site programs. Nonetheless, Internet-based behavioral programs do induce clinically significant weight loss and could be provided to millions of overweight Amer-

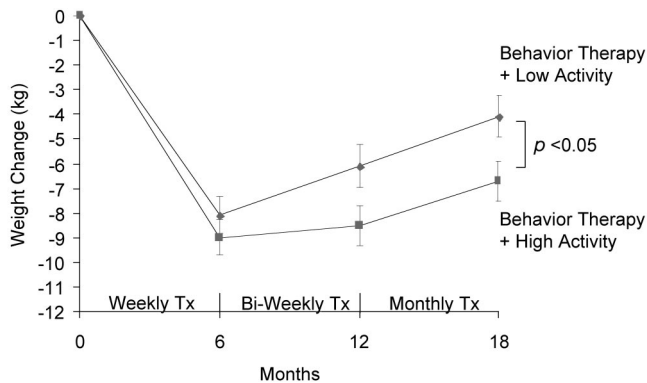


Figure 5: Weight change over 18 months in patients treated by behavior therapy combined with low physical activity (i.e., 1000 kcal/wk) or behavior therapy with high physical activity (i.e., 2500 kcal/wk). Participants received weekly treatment (Tx) for the first 6 months, which declined to twice monthly from months 7 to 12, and monthly thereafter.

icans who do not have access to treatment at an academic medical center. Further research is likely to improve on these initial, promising findings.

High Levels of Physical Activity

Data from case studies (43,44), correlational investigations (45), and randomized trials (46,47) all have concluded that high levels of physical activity facilitate long-term weight control. Findings from the National Weight Control Registry, for example, clearly underscore this point (43). Members of the Registry have lost an average of 32.4 kg and maintained their loss for 5.5 years. Women report expending ~2825 kcal/wk, the equivalent of walking ~28 miles/wk (or 75 to 90 min/d) (43).

Based on these findings, Jeffery and colleagues (47) recently compared the benefits of low vs. high levels of physical activity in a randomized controlled trial. Participants in the high-activity group were instructed to expend 2500 kcal/wk, whereas those in the low group were prescribed a goal of 1000 kcal/wk. As shown in Figure 5, weight loss in the two groups did not differ significantly at the end of 6 months, during which participants attended weekly group meetings. However, participants in the high-activity group maintained their weight loss significantly better than did patients in the low-activity group at both the 12- and 18-month assessments. Jakicic and colleagues (48) similarly found, in secondary analyses of results of a randomized trial, that obese individuals who exercised 200 or more min/wk achieved significantly greater weight loss at 18 months than did persons who exercised fewer than 150 min/wk.

Mechanism of Action

The mechanisms by which exercise facilitates weight maintenance are not well understood (49,50). The simplest

explanation is that increased physical activity helps to keep patients in energy balance. Walking 3 to 4 miles a day may help to compensate for occasional dietary indiscretions that are associated with weight regain (in persons who do not exercise regularly). Alternatively, exercise spares the loss of fat-free mass during diet-induced weight loss (51), an occurrence that could help minimize undesired reductions in resting-energy expenditure (49). Increased physical activity also could be associated with improved mood that, in turn, could facilitate long-term adherence to a low-calorie diet (49). Regardless of the mechanism of action, the message is the same: Patients should increase their physical activity by whatever means possible.

Programmed vs. Lifestyle Activity

Patients can increase their energy expenditure in two ways—programmed or lifestyle activity (52,53). Programmed activity (e.g., walking, biking, swimming) is typically planned and completed in a discrete period of time (i.e., 30 to 60 minutes) at a relatively high-intensity level (i.e., 60% to 80% of maximum heart rate). Lifestyle activity, by contrast, involves increasing energy expenditure while completing everyday tasks. Patients may, for example, increase their lifestyle activity by parking further away from building entrances, taking stairs rather than escalators, or even by discarding the remote control to the television (52). Epstein et al. (53) found that lifestyle activity was superior to programmed exercise in facilitating the maintenance of weight loss in obese children. Andersen and colleagues, in a study of obese women, found that both types of activity, when combined with a 1200 kcal/d diet, induced a loss of ~8 kg in 16 weeks (54). There was a trend ($p = 0.06$) for lifestyle activity to be associated with less weight regain than was programmed exercise 1 year after treatment (0.1 vs. 1.6 kg, respectively). Results of this study await replication in a larger sample that includes men. Initial findings, however, suggest that lifestyle activity is an ideal alternative for patients who report they hate to exercise.

Long- vs. Short-Bout Activity

Jakicic and colleagues (48,55) have investigated the effects of prescribing exercise in multiple short bouts as compared with a single long bout. In one study, all patients were instructed to exercise for 40 min/d. Those who were encouraged to complete their activity in multiple 10-minute bouts exercised on more days over 20 weeks than did patients who were encouraged to exercise in a single bout (87.3 vs. 69.1 days, respectively) (55). There was a trend ($p = 0.07$) toward greater weight loss in participants who exercised in multiple short bouts (8.9 vs. 6.4 kg, respectively). The superiority of short bouts of exercise was not replicated in a follow-up study of 18 months' duration (48). Nonetheless, the finding that multiple short bouts of activity are as effective as one long bout should facilitate patients'

efforts to increase their activity. They do not need to set aside a 30- to 60-minute block of time in which to exercise. Several brief walks during the day are equally beneficial.

Supervised Activity and Incentives

Researchers also have studied whether increasing the structure of physical activity (56,57) or providing incentives (57) is associated with better exercise adherence and greater weight loss. Perri and colleagues (56) randomized obese patients to receive 12 months of behavioral weight control that included on-site supervised exercise or a comparable program of home-based activity. They found during the first 6 months that the two groups exercised approximately the same number of minutes per week (107 to 120 minutes) and lost comparable amounts of weight (10.6 to 10.9 kg). At 15 months, however, those who exercised at home engaged in more minutes of activity and lost significantly more weight than persons who exercised on-site (11.9 vs. 9.2 kg, respectively). King et al. (58) obtained similar findings in an earlier study.

Wing and colleagues (57) found that providing participants with a personal trainer (who met participants at home or work and led them on a walk), in addition to having three on-site supervised activity sessions per week, did not improve weight loss over the on-site activity sessions alone. In another study in the same article, the authors provided 24 weeks of lifestyle modification and three supervised exercise sessions weekly. In addition, patients were randomized to receive either no incentives or to be eligible for a lottery drawing that rewarded more frequent attendance at exercise sessions. The two groups did not differ significantly in weight loss or exercise adherence at the end of the 24-week period.

Less structured exercise plans seem to facilitate long-term adherence and weight control (53,54,56,58). Lifestyle activity and at-home exercise potentially remove common barriers to physical activity, such as travel time, cost, the need for child care, or embarrassment about weight or shape. The failure of structure and incentives to improve exercise adherence suggests that internal motivation and intrinsic reinforcement also may be critical to increasing physical activity (59). Further research is needed on this topic.

Dietary Options for Long-Term Weight Control

America's media worked overtime last year, providing consumers daily updates on the low-fat vs. low-carbohydrate controversy that is still sweeping our nation (and others). Four randomized controlled trials (published in 2003) found that dieters achieved significantly greater short-term weight losses on a high-protein, low-carbohydrate diet than on a conventional, low-fat diet (15,60–62).

The single study that included a 1-year evaluation found no differences in weight loss between the two approaches at the end of this time (15). Long-term studies (i.e., ≥ 2 years) clearly are needed to assess the ultimate health benefits (and risks) of low-carbohydrate diets. In the absence of such data, other dietary approaches hold promise of facilitating long-term weight control.

Findings from the National Weight Control Registry

Members of the National Weight Control Registry, described in the previous section, clearly belong to a highly select group (43). Investigators have not identified the specific factors that helped these individuals lose weight (and keep it off after several previous failed attempts) (63). Nevertheless, participants' reports of their physical activity, food intake, and eating habits are informative of the types of behaviors that other obese individuals need to adopt to achieve long-term weight control. As shown in Table 3, women in the Registry consumed only 1296 kcal/d, and men ate only 1724 kcal/d (43). Macronutrient analyses suggest that these individuals ate a low-fat, high-carbohydrate diet. In addition, they limited meals eaten out of the home, particularly at fast food restaurants.

Portion-Controlled Servings

Obese individuals generally underestimate their food intake by 30% to 50% when eating a diet of conventional foods (64). This is attributable to misjudging portion sizes, failing to recognize hidden sources of fat or sugar, or forgetting some foods eaten. Jeffery and Wing (65) have shown that consuming portion-controlled servings of conventional foods improves the maintenance of weight loss. Participants who were prescribed a 1000 kcal/d diet and were provided five prepackaged breakfasts and dinners a week lost significantly more weight during 6 months than patients who were prescribed the same number of calories but consumed a diet of self-selected table foods. The continued provision of portion-controlled foods also was associated with significantly greater weight loss at 18 months. A follow-up study by this team showed that structure alone, provided by detailed meal plans, was sufficient to improve weight loss, at least in the short term (66).

Portion-controlled servings, such as frozen food entrees, eliminate the need to weigh and measure foods, save time planning and preparing meals, and reduce contact with problem foods (67). To the extent that they reduce dietary variety, portion-controlled meals also may better satisfy appetite (68,69). A comprehensive review of 39 studies of this issue found that reduced dietary variety was associated with reduced food intake (70).

Meal Replacements

Liquid meal replacements are a popular form of a portion-controlled diet. Shakes and meal bars provide patients

Table 3. Eating habits of National Weight Control Registry members

	Women (n = 629)	Men (n = 155)
Maximum weight (kg)	94.6	121.0
Maximum BMI (kg/m ²)	34.6	37.2
Current weight (kg)	66.0	85.6
Current BMI (kg/m ²)	24.1	26.4
Energy intake (kcal/d)	1296	1724
Energy from fat (%)	24	23
Energy from protein (%)	19	18
Energy from carbohydrate (%)	55	56
Number of meals or snacks per day	5.0	4.5
Number of meals at fast food restaurants per week	0.7	0.8
Number of meals at non-fast food restaurants per week	2.4	2.9

Data adapted from Klem et al. (43).

a fixed quantity of food with a known calorie content (i.e., 160 to 220 kcal/d). A meta-analysis of six randomized controlled trials found that after 1 year of treatment, participants who used meal replacements maintained a loss 2.4 to 3.4 kg greater than persons who consumed a diet of conventional foods with the same calorie target (71). In the most impressive study to date, Ditschuneit et al. (72) found that patients who replaced two meals and two snacks a day with liquid shakes (and snack bar) lost 7.8% of their initial weight during 3 months of treatment, compared with a loss of only 1.5% for patients who were prescribed the same number of calories (1200–1500 kcal/d) but consumed a self-selected diet of conventional foods. Thereafter, participants in both groups replaced one meal and one snack a day with a liquid shake or meal bar (73). As shown in Figure 6, individuals in the original (3-month) meal replacement group maintained a loss of 11.3% of initial weight 2 years after treatment and 8.4% at a 4-year follow-up (73). Patients who were originally treated by the conventional diet but were switched to meal replacements maintained a loss of 3.2% of initial weight at 4 years.

These are the most successful long-term findings, to date, for the dietary management of obesity. The study has limitations, including the use of a nonrandomized design after the first 3 months and the examination of a relatively small sample (i.e., 100 participants). If, however, the results were replicated in a large randomized controlled trial, they would have major implications for the long-term management of

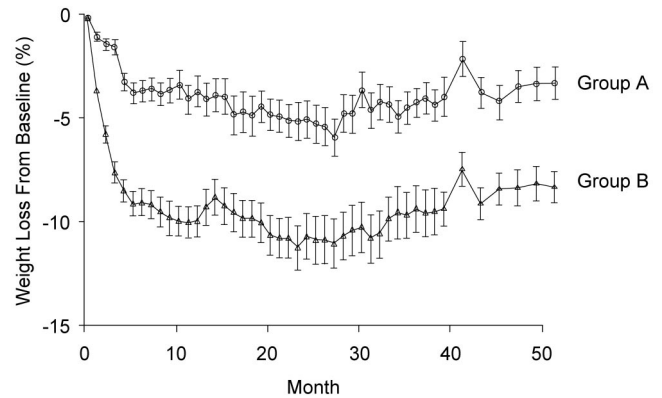


Figure 6: Long-term changes in weight in participants who were instructed to replace one meal and one snack a day with shakes or bars. During the first 3 months, patients in one group were prescribed a 1200 to 1500 kcal/d diet of conventional foods. Those in the second group had the same calorie goal but replaced two meals and two snacks with shakes and bars. After 3 months, both groups followed the modified meal replacement strategy described.

obesity. Studies also are needed of factors that contribute to the apparent success of this approach, including the effects of meal replacement on hunger and satiation (67).

Dietary Composition

As noted previously, further study is needed of the long-term effects of high-protein, low-carbohydrate diets (15). Similarly, research is needed on more traditional low-fat, high-carbohydrate regimens, as consumed by members of the National Weight Control Registry (43). In a randomized trial, Toubro and Astrup (74) found that, after achieving an initial weight loss of 13.6 kg, participants who were instructed to consume a low-fat, ad libitum carbohydrate weight maintenance diet regained significantly less weight than those prescribed a low-calorie weight maintenance diet. Differences in weight regain were significant both 1 (0.3 vs. 4.1 kg regained, respectively) and 2 (5.4 vs. 11.3 kg regained, respectively) years after initial weight loss. However, two other studies found that long-term weight loss with a low-fat, ad libitum diet did not differ significantly from that of a low-calorie diet (75,76).

Low-energy density diets present another option for weight control. The underlying principle of this approach is that the volume of food consumed, not calorie content, influences satiety (77,78). Low-energy density diets aim to minimize the amount of energy in a given weight (grams) of food. Energy density can be reduced by replacing fat (i.e., 9 kcal/d) with carbohydrate or protein (i.e., each 4 kcal/d) or by increasing the fiber or water content in foods. Short-term studies have shown that persons who consumed ad libitum low-energy density diets lost a small amount of weight as a result of consuming only ~70% of the calories as persons

on high-energy density diets (79). Long-term studies currently are being conducted to determine whether low-energy density diets facilitate the maintenance of weight loss (80). Studies also are being conducted on the glycemic index, a classification system originally developed by Jenkins et al. (81) to help patients with type 2 diabetes select foods that would confer optimal control of glucose and insulin. Results of a 1-year trial in obese adolescents without diabetes showed promise (82).

Summary

There currently are not definitive data to recommend the use of one dietary approach over another for long-term weight control. The choice of a particular approach depends, in large measure, on personal preference, although the diet certainly should promote good health. The use of portion-controlled servings, including meal replacements, currently has the strongest evidence of long-term efficacy. This approach focuses more on limiting energy intake than modifying the consumption of a specific macronutrient.

Looking Ahead

This review has shown that a comprehensive program of lifestyle modification clearly is efficacious in inducing a loss of ~10% of initial weight and that losses of this size are associated with significant improvements in health, as revealed by the DPP (1). The NIH is conducting a follow-up investigation to determine whether a weight loss of $\geq 7\%$ of initial weight, combined with ≥ 175 min/wk of physical activity, will decrease morbidity and mortality in overweight individuals who already have type 2 diabetes (83). Participants in the lifestyle intervention will receive a 4-year behavioral program that incorporates many of the components described in this review, including long-term use of a meal replacement, monthly on-site weight maintenance visits, and the prescription of both programmed and lifestyle activity. This Look AHEAD (i.e., Action for Health in Diabetes) study will provide the most definitive assessment, to date, of the health consequences of intentional weight loss (83).

Translational Research

Lifestyle modification for obesity faces several challenges. First among these is making treatment available to the millions of Americans who need it. Most of what investigators know about the behavioral treatment of obesity comes from randomized controlled trials conducted at academic medical centers in which experienced therapists treat highly motivated patients. Treatment is efficacious under these optimal circumstances (in which cost is not a factor). Research now is needed to find effective methods of providing treatment in primary care and community practice (in a practical and affordable manner). Some self-help (84)

and commercial programs—particularly Weight Watchers (85)—may be an effective means of increasing the availability of lifestyle modification.

Tackling the Toxic Environment

Far greater resources and efforts must be devoted to the prevention of obesity if we are to halt the progression of this epidemic, let alone reverse it (86). Our best hope for prevention may lie with children (22). Efforts should be directed toward improving the quality and monitoring the quantity of meals and snacks served at schools, providing more opportunities for physical activity at school and at home, and educating youth about the importance of diet, activity, and a healthy body weight (22). Ultimately, we must tackle what Brownell (22) has referred to as a “toxic environment” that explicitly encourages the consumption of super-sized servings of high-fat, high-sugar foods, while implicitly discouraging physical activity, as a result of sedentary work and leisure habits. Changing this environment will require public policy initiatives, such as those that were needed to reduce cigarette smoking and to increase seat belt use (87). Although behavioral treatment can assist those who already are obese, there is a pressing need for wide-scale environmental interventions to reduce the number of individuals who require such treatment.

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