

## Strengthening Behavioral Interventions for Weight Loss: A Randomized Trial of Food Provision and Monetary Incentives

Robert W. Jeffery, Rena R. Wing, Carolyn Thorson, Lisa R. Burton, Cheryl Raether, Jean Harvey, and Monica Mullen

Behavioral treatments for obesity seek to modify eating and exercise behaviors by a change in their antecedents and consequences. More direct modification of antecedents and consequences by (a) the provision of food to patients and (b) the provision of financial rewards for weight loss was hypothesized to improve treatment outcomes. Two hundred two men and women were randomly assigned to no treatment, standard behavioral treatment (SBT), SBT plus food provision, SBT plus incentives, or SBT plus food provision and incentives. The major finding was that food provision significantly enhanced weight loss. Weight losses with SBT averaged 7.7, 4.5, and 4.1 kg at 6, 12, and 18 months, respectively, compared with 10.1, 9.1, and 6.4 kg, respectively, at the same intervals with the addition of food. Food provision also enhanced attendance, completion of food records, quality of diet, and nutrition knowledge. We conclude that the provision of food to weight-loss patients is a promising methodology that deserves further exploration.

When behavioral treatments for obesity were first introduced about 20 years ago (Ferster, Nurnberger, & Levitt, 1962; Stuart, 1971; Stunkard, 1975), they marked an important conceptual landmark in the field. A large body of intervention research was generated in response to these new ideas, and for a time there was renewed optimism about the potential for successfully treating this intractable disorder. The uniqueness of the behavioral approach was its emphasis on the environment. Behavioral theorists argued that body weight could be reduced by a change in eating and exercise behaviors and that the most effective way to modify these behaviors was to change the environmental factors that controlled them.

Environmental factors that precede behavior (antecedent stimuli) play a central role in the behavioral approach to weight control. Environmental antecedents are seen as determinants of the possible response options (e.g., what foods are available to eat), as factors that influence the response cost of behaviors that affect energy balance (e.g., the time and effort required to prepare foods or to engage in physical activity), and as prompts or cues for behaviors that otherwise might not be attended to (e.g., walking shoes placed next to the door may serve as a reminder to exercise). A number of specific intervention tech-

niques have been generated from the concept of antecedent environmental control. These include the restriction of the locations in which eating may occur, the limitation of activities associated with eating, and a change in the types of foods available in the home (Stuart, 1971).

A second set of environmental factors that are also emphasized in the behavioral conceptualization of weight control are the consequences of eating and exercise behaviors. Behavioral consequences with positive valence (e.g., pleasant taste or congenial social companions) are believed to increase the probability of a specific behavior over time, whereas unpleasant consequences (e.g., social criticism or an unappealing setting for eating) are expected to weaken response patterns. Intervention techniques based on the concept of behavioral consequences have focused especially on contingency contracting procedures in which obese patients contract with their therapists, their family, their friends, or themselves to obtain certain rewards contingent on changes in behaviors or body weight (Jeffery, Bjornson-Benson, Rosenthal, Kurth, & Dunn, 1984; Jeffery, Thompson, & Wing, 1978).

Unfortunately, the early optimism that behavioral interventions would solve the overall problem of obesity has not materialized. Since behavioral treatments for obesity were first introduced, treatment outcomes have slowly improved. Improvement has been noted in retention of patients in treatment and in the magnitude and durability of weight loss (Brownell & Jeffery, 1987; Wadden & Bell, 1990). Behavior modification techniques have been widely adopted as a standard component of many obesity intervention programs, and it has been argued that behavior modification is the preferred treatment for individuals with mild to moderate obesity. Nevertheless, consistent long-term success in weight control has not been achieved with behavioral methods. Large numbers of individuals, especially those with chronic weight problems, still have no reliable way to seek relief. In short, innovative methods to improve weight loss and maintenance are still needed.

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One approach to improve the results of behavioral treatment programs may be to more directly modify the environmental antecedents and consequences that control eating and exercise behaviors. Behavioral treatments are based on a theory that emphasizes environmental control, but the approach to change the environment is usually indirect. Treatment for obesity is typically done on an outpatient basis and consists of individual or group educational sessions in which the principles of environmental influence are explained and specific techniques to modify the environment are recommended. However, the implementation of the environmental manipulation is left up to the patients themselves, and documentation of the extent to which recommendations are carried out is seldom done. Thus, many patients may not implement these environmental changes and consequently may fail to control their weight.

The present research tested the hypothesis that a more direct approach to modifying behavioral antecedents and consequences would improve weight loss and maintenance. Suggestive evidence for the plausibility of a more aggressive approach to antecedent environmental change may be found in the research literature. The Diet-Heart Study (National Diet-Heart Study, 1968), for example, evaluated the efficacy of different diets to lower blood lipids. An ancillary study for this trial showed that the provision of foods consistent with participants' dietary recommendations produced greater dietary compliance and greater serum cholesterol changes than did the mere provision of instructions on how to purchase and prepare these same foods.

There is also evidence to support the usefulness of a more direct intervention on the consequences of behavior. Several studies evaluating the effectiveness of programs that required strong monetary contracts for weight loss or dietary compliance have shown that these procedures enhance weight loss in comparison with programs that have similar educational content but whose participants are encouraged to develop contracts on their own (Jeffery et al., 1978, 1984; Jeffery, Gerber, Rosenthal, & Lindquist, 1983).

The present study was a randomized trial to evaluate the effectiveness of intervention procedures that directly modify environmental antecedents, environmental consequences, or both in the treatment of obesity. To more directly manipulate environmental antecedents, interventionists provided appropriate foods to participants on a weekly basis. This procedure was expected to produce better compliance to dietary recommendations by an increase in environmental cues for appropriate eating and by a reduction in the response costs of making dietary changes. To more directly manipulate environmental consequences, interventionists provided participants with monetary payment for weight loss and maintenance. This direct reinforcement procedure was expected to enhance motivation for adherence to diet and exercise recommendations and thus to promote weight loss and maintenance. The trial used a factorial design and was carried out over a period of 18 months to allow for an evaluation of both short- and long-term effects. We hypothesized that direct manipulation of antecedents (food provision) and consequences (financial incentives) each would enhance weight loss and maintenance in comparison with stan-

dard behavioral therapy and that a combination of the two procedures would produce the best overall results.

## Method

### *Subjects*

Participants in this study were 101 men and 101 women recruited from two urban communities (Pittsburgh, PA, and Minneapolis-St. Paul, MN) through newspaper advertisement, radio announcement, and mailed invitation. To participate in the study, individuals were required to be between 14 and 32 kg overweight according to 1983 insurance industry standards, 25 to 45 years of age, nonsmokers, drinkers of fewer than three alcoholic beverages per day, not on a special diet or allergic to any foods, able to exercise, free of current serious diseases, not taking prescription medications including oral contraceptives, and agreeable to conditions of participation, including random assignment to treatment conditions. Study participants were randomized within center and sex to one of five treatment groups as described below.

### *Treatment Groups*

The first experimental group was a control group, which received no intervention. Individuals in this group could do whatever they wished to lose weight on their own and were asked to return for evaluations at 6, 12, and 18 months.

The second group was provided with standard behavioral treatment (SBT). This group participated in a state-of-the-art behavioral intervention program. Subjects received behavioral counseling in groups of approximately 20 individuals. Groups met weekly for the first 20 weeks and once a month thereafter. During the period of monthly group sessions, participants were also encouraged to attend weekly weigh-in sessions to monitor progress. Group sessions were led by trained interventionists with advanced degrees in nutrition or the behavioral sciences. These sessions included a weigh-in, presentations of information by the interventionist, group discussion, and a review of progress. Subjects were assigned an individualized caloric goal of either 1,000 or 1,500 calories per day on the basis of their baseline body weight. This goal was derived by multiplying baseline body weight by 12, subtracting 1,000 calories per day, and rounding to the closest caloric goal to produce an estimated weight loss of about 1 kg per week. Subjects selected a weight-loss goal (14, 18, or 23 kg) to try to achieve during the program; subjects who reached this goal during the course of the treatment program had their caloric goals adjusted upward to a level estimated to maintain this body weight. The primary dietary instruction emphasized the importance of remaining below caloric goals, but restriction of fat and an increase in consumption of complex carbohydrates were also stressed. Participants were asked to record their caloric intake in daily food records for the first 20 weeks and for 1 week each month thereafter. An exercise program based on walking or bicycling was also prescribed. Participants initially were instructed to walk or bike an amount equivalent to 50 calories per day for 5 days per week. Exercise goals were increased gradually to a final goal of 1,000 calories per week.

Participants recorded distances walked or duration of bicycling in their daily food records. Behavioral techniques emphasized in the program included (a) stimulus control techniques (e.g., reducing the visibility of food in the home, slowing the pace of eating, and imposing limits on where, when, and with whom participants ate); (b) problem-solving strategies (e.g., problem definition, brainstorming solutions, selecting the best solution, and evaluating success); (c) social assertion (e.g., role-playing interpersonal situations most likely to lead to increased food intake); (d) short-term goal-setting and reinforcement techniques for enhancing motivation; (e) cognitive strategies for replac-

ing negative thinking (e.g., perfectionism, pessimism, and self-doubt) with more positive and constructive self-statements; (f) relapse prevention (i.e., learning to recognize precursors and consequences of dietary lapses and to plan ways to deal with high-risk situations); and (g) social support (e.g., techniques for involving spouses and other members of the family in weight-loss efforts).

The third treatment group was given standard behavioral treatment plus food provision (SBT + FP). The standard behavioral treatment was identical to that described earlier. In addition, these participants were given prepackaged meals for five breakfasts and five dinners each week for the 18-month program. The prepackaged breakfasts primarily consisted of cereal, milk, juice, and fruit. Dinners typically consisted of lean meat, potato or rice, and vegetable. For 1 or 2 days a week, a frozen dinner, such as a Weight Watchers or Lean Cuisine meal, was provided. Along with the food, participants were given a meal plan that outlined what foods were to be eaten for which meals and were given recipes to guide their food preparation. Recommendations for lunches were also provided. Meals were prepared for the calorie level specific to each participant (1,000 or 1,500 kcal/day). All meals were prepared centrally by Nutrition Inc. in Pittsburgh and shipped weekly to Minneapolis–St. Paul by Air Express. All food was provided to participants free of charge.

The fourth treatment condition consisted of standard behavioral treatment plus incentives (SBT + I). Participants in this treatment condition received the behavioral treatment described earlier. In addition, participants in this group received a cash payment each week based on the amount of weight they had lost in relation to their weight-loss goal, which was determined in the same manner as described for the SBT group. The maximum payment was \$25 per week if participants reached and maintained their weight-loss goal. The minimum payment was \$2.50 per week if participants did not gain weight; weight losses of 50% of goal were reinforced with incentives of \$12.50. Incentives were paid weekly by check at the time of weigh-in.

The final treatment group, standard behavioral treatment plus food provision and incentives (SBT + FP + I), consisted of a combination of all of the treatment components described earlier.

To ensure standardization of intervention across treatment groups and centers, interventionists from Pittsburgh and Minneapolis–St. Paul attended a 2-day training session at the beginning of the study at which the behavioral component of the intervention was reviewed in detail. The two centers used identical instructional materials for participants and identical leader guidelines for interventionists throughout the study. Interventionists at the two centers conferred by conference call approximately once per week to coordinate activities. All food deliveries were completed on schedule throughout the study. Detailed records were kept at each center to ensure that incentives were administered appropriately.

### Dependent Measures

The primary outcome of interest in this study was change in obesity. Weight was measured on a balance beam scale with participants wearing their street clothes; height was measured with a stadiometer. Triceps and subscapular skinfolds were also measured. Body mass index (BMI; in kilograms per square meter) is the measure of obesity used in this article's analyses. Analyses based on body weight alone (unadjusted for height) and on skinfold thicknesses have also been done with similar results.

A number of process measures were assessed in an effort to identify mediators of weight change. These process measures included the following.

1. Attendance at group treatment sessions and weigh-ins was recorded.

2. For the completion of assigned food diaries, a 7-day diary was requested at each group treatment session. Number of completed days divided by number of assigned days was calculated to represent adherence.

3. Nutrient intake was assessed with the Block Food Frequency Questionnaire (Block, Hartman, Dresser, & Carroll, 1986) and with 3-day food records collected at 6-month intervals. Results were similar using either of these measures. This article reports data from the Block questionnaire and examines changes in total calories consumed per day and percentage of calories from fat.

4. Exercise was assessed using the Paffenbarger Physical Activity Recall (Paffenbarger et al., 1978). Estimated energy expenditure in exercise in the last week was used in the analysis.

5. Perceived barriers to adherence were derived from a 15-item questionnaire designed specifically for this study. The questions asked about practical barriers to adherence, such as subjects not being able to find appropriate foods in the store, and motivational barriers, such as subjects not having enough willpower. Each barrier was rated on a 5-point scale from *Not at all a problem for me* (1) to *A very important problem for me* (5).

6. The Eating Behaviors Inventory (EBI), a 26-item inventory of weight control practices (O'Neil et al., 1979), was used to assess the extent to which subjects adhered to behavioral weight control strategies.

7. Nutritional knowledge was assessed in two ways. The first method used a 15-item multiple-choice, true–false test relating to strategies for creating a negative energy balance. The second method consisted of a test in which subjects were asked to give quantitative estimates of the caloric content of 22 food items. The mean percentage of deviation from true values was used in the analysis.

On the basis of the conceptual rationale given earlier, we hypothesized that subjects in those groups using stronger environmental manipulations would perceive fewer barriers to adherence and would report greater dietary adherence (i.e., reduction in caloric intake, dietary fat intake, or both). We made no specific hypotheses about attendance, completion of assigned exercise, and knowledge.

### Design and Analysis

The study included five treatment groups. Dependent variables were assessed at baseline and at 6, 12, and 18 months. Statistical evaluation used a repeated measures analysis of variance (ANOVA). Factors included in the analysis were sex, center, treatment group, time, and their interactions. Planned orthogonal contrasts were also included to specifically test for treatment effects that were due to food provision, incentives, the interaction between food provision and incentives, and all active treatments versus the control group. Attendance and data on the completion of food records, which were collected on a weekly basis and only in the treatment groups, were analyzed somewhat differently. These data were expressed as a percentage of maximum values in three time periods: Weeks 1–20 (the initial period of weekly meetings), Weeks 21–52, and Weeks 53–78. These three time intervals were included in a repeated measures ANOVA that included terms for sex, center, food provision, incentives, time, and their interactions.

### Results

Characteristics of study participants at baseline are shown in Table 1 by treatment group. Subjects averaged between 35 and 40 years of age, were relatively well educated, were predominantly White, and averaged about 35% above insurance industry standards for height and weight (Metropolitan Life Insurance, 1983). A majority of subjects had participated in organized weight-loss programs in the past. Preliminary analysis

Table 1  
Baseline Characteristics of Study Participants by Treatment Group

| Item  | Control | SBT   | SBT + FP | SBT + I | SBT + FT + I | <i>p</i> <sup>a</sup> |
|---|---------|-------|----------|---------|--------------|-----------------------|
| <i>n</i>  | 40      | 40    | 40       | 41      | 41           | —                     |
| Age (years)   | 35.7    | 37.5  | 38.5     | 38.1    | 37.6         | .18                   |
| Non-college graduate (%)                            | 37.5    | 35.0  | 35.0     | 58.5    | 46.3         | .15                   |
| White (%)   | 92.5    | 87.5  | 97.5     | 90.2    | 92.7         | .56                   |
| Married (%)   | 72.5    | 65.0  | 67.5     | 75.6    | 73.2         | —                     |
| Previous weight program (%)                         | 50.0    | 57.5  | 62.5     | 63.4    | 58.5         | .75                   |
| Weight (kg)   | 88.2    | 89.4  | 88.1     | 92.3    | 91.1         | .18                   |
| Body mass index (kg/m <sup>2</sup> )                | 31.1    | 30.9  | 30.8     | 31.1    | 31.1         | .93                   |
| Nutrient intake                                     |         |       |          |         |              |                       |
| Kcal/day  | 2,004   | 1,982 | 1,766    | 1,803   | 2,075        | .34                   |
| Calories from fat (%)                               | 40.2    | 39.4  | 37.7     | 40.7    | 38.8         | .33                   |
| Exercise, past week (kcal/week)                     | 1,032.4 | 1,445 | 820      | 1,103   | 1,039        | .17                   |
| Total barriers to adherence                         | 36.5    | 36.4  | 33.9     | 35.7    | 36.1         | .51                   |
| Eating Behaviors Inventory                          | 66.4    | 68.4  | 69.0     | 65.0    | 66.7         | .37                   |
| Knowledge: total correct on 15-item test            | 12.9    | 13.1  | 13.1     | 12.6    | 12.9         | .91                   |
| Average absolute deviation of calorie estimates (%) | 47.9    | 48.3  | 43.9     | 50.0    | 55.1         | .44                   |

Note. SBT = standard behavioral treatment; SBT + FP = standard behavioral treatment plus food provision; SBT + I = standard behavioral treatment plus incentives; SBT + FP + I = standard behavioral treatment plus food provision and incentives.

<sup>a</sup> *p* values are derived from an analysis of variance for continuous variables and from a chi-square analysis for categorical variables.

found no significant differences between groups for any of the dependent variables, indicating that randomization was effective in producing comparable treatment groups.

Attrition of participants from the study over the 18 months of evaluation was relatively small. Eighty-nine percent of participants completed the 6-month follow-up evaluation, 87% completed the 12-month evaluation, and 85% completed the 18-month evaluation. Seventy-nine percent of participants provided data at all observation points. There were no differences among treatment groups at any individual follow-up point in the percentage of participants completing assessments. However, the percentage of participants who completed all three follow-ups differed by treatment group: control group (70%), SBT (65%), SBT + FP (90%), SBT + I (85%), and SBT + FP + I (83%),  $\chi^2(4, N = 159) 10.9, p = .03$ .

Two approaches for dealing with incomplete data were explored. One approach was to restrict the analysis to subjects who attended all assessment sessions. The other approach was to include all subjects who were present at the 18-month follow-up and to interpolate missing data from adjacent values. The results of analyses using these two approaches were very similar. Thus, the more conservative analyses, based on complete cases only, are presented below.

Mean changes in absolute body weight by treatment group are shown in Figure 1. The two groups that were provided with food had the largest weight loss at all time points studied (Table 2). Mean weight losses of the SBT groups, with or without incentives, were 7.7, 4.5, and 4.1 kg at 6, 12, and 18 months, respectively. In the groups provided with food, mean weight losses increased to 10.1, 9.1, and 6.4 kg, respectively, at these three time points.

An ANOVA computed on BMI data and body weight confirmed the data in Figure 1. Analyses on BMI (Table 3) showed

main effects for time and for Time  $\times$  Treatment, but not for sex, center, or their interaction. Examination of planned contrasts showed that the treatment effect was due to greater BMI changes in the food-provision groups than in the non-food-provision groups, and in the treatment groups than in the control group. There was no effect for financial incentives or for the interaction between incentives and food. Thus these results strongly support the hypothesis that the provision of food to participants improves weight loss through 18 months, but they give no support for an effect of financial incentives.

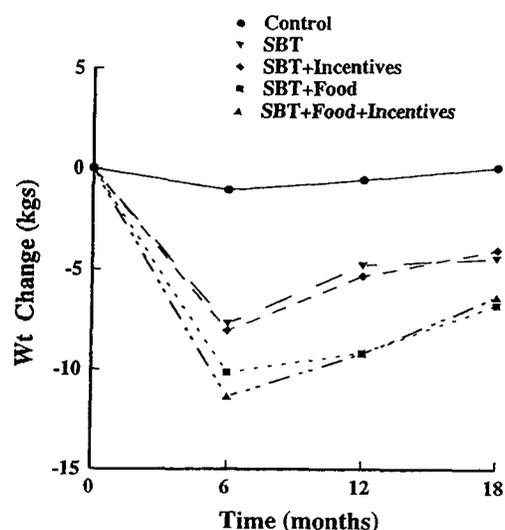


Figure 1. Weight change at 6, 12, and 18 months by treatment group. (SBT = standard behavioral treatment.)

Table 2  
Mean Body Mass Index by Time Interval and Treatment Group

| Group        | Time     |          |           |           |
|--------------|----------|----------|-----------|-----------|
|              | Baseline | 6 months | 12 months | 18 months |
| Control      | 30.88    | 30.48    | 30.38     | 30.67     |
| SBT          | 30.85    | 28.15    | 28.90     | 29.10     |
| SBT + FP     | 30.66    | 26.86    | 27.46     | 28.17     |
| SBT + I      | 30.77    | 27.94    | 28.92     | 29.28     |
| SBT + FP + I | 31.26    | 27.39    | 28.29     | 28.95     |

Note. SBT = standard behavioral treatment; SBT + FP = standard behavioral treatment plus food provision; SBT + I = standard behavioral treatment plus incentive; SBT + FP + I = standard behavioral treatment plus food provision and incentives.

The same analysis done on body weight produced the same results except that it also showed a significant effect for Time  $\times$  Sex, indicating that men lost more weight than women lost. The fact that no sex effect was present for BMI indicates that the sex difference in weight loss was primarily due to differences between men's and women's stature.

Subsequent analyses explored the possible mechanisms responsible for the observed treatment effects. Differences between treatment groups in weight loss were paralleled by differences in attendance at treatment sessions (Figure 2) and in completion of assigned food records (Table 4). At each time interval (Weeks 1–20, 21–52, and 53–78), attendance and completion of food records were greater in the two food-provision groups than in the SBT or SBT + I group. Attendance in the food-provision groups averaged 89% in the first 20 weeks, 76% in the next 6 months, and 64% in the final 6 months. By contrast, the SBT group averaged 66%, 33%, and 26%, respectively, for the three time periods; and the SBT + I averaged 80%, 54%, and 37% attendance, respectively, for the same periods. Thus, the food-provision groups showed higher attendance overall,  $F(1, 146) = 46.09, p < .0001$ , and less diminution of attendance with the passage of time,  $F(2, 292) = 12.95, p < .0001$ , than

did the non-food-provision groups. When we collapsed across treatment groups, the correlation between total attendance for the entire program and 18-month weight loss was  $r = .58, p < .0001$ . Examination of data on the completion of food diaries showed a similar pattern with greater adherence to self-monitoring in the food-provision groups at all time periods. There was a main effect of treatment condition,  $F(3, 146) = 4.51, p < .005$ , and the planned contrasts indicated a highly significant food effect,  $F(1, 146) = 11.05, p < .001$ . A modest main effect for sex was also observed,  $F(1, 146) = 4.02, p < .05$ , with men completing a higher percentage of their assigned food records than did women. Total food diary completion over 18 months was correlated significantly with attendance,  $r = .87, p < .001$ , and with weight loss,  $r = .58, p < .0001$ .

Provision of food also affected the percentage of calories from fat but did not affect total caloric intake. Analysis of caloric intake data showed main effects for time,  $F(3, 417) = 79.14, p < .0001$ ; for Time  $\times$  Sex,  $F(3, 417) = 6.54, p < .0003$ ; and for Time  $\times$  Treatment,  $F(12, 417) = 2.65, p < .003$ . The Time  $\times$  Treatment effect resulted from a difference between treatment versus control groups,  $F(3, 417) = 3.98, p < .01$ , and from the

Table 3  
Analyses on Body Mass Index and Planned Contrasts by Time, Treatment, Center, and Sex

| Source and contrast                                  | df  | F     | p     |
|--|-----|-------|-------|
| <b>Source</b>  |     |       |       |
| Time   | 3   | 139.6 | .0001 |
| Time $\times$ Treatment                              | 12  | 7.65  | .0001 |
| Time $\times$ Center                                 | 3   | 0.28  | .8414 |
| Time $\times$ Treatment $\times$ Center              | 12  | 0.28  | .7347 |
| Time $\times$ Sex                                    | 3   | 1.28  | .2594 |
| Time $\times$ Treatment $\times$ Sex                 | 12  | 1.72  | .1849 |
| Time $\times$ Center $\times$ Sex                    | 3   | 0.46  | .8663 |
| Time $\times$ Treatment $\times$ Center $\times$ Sex | 12  | 2.25  | .1129 |
| Error  | 417 | 1.07  | .3807 |
| <b>Contrast</b>                                      |     |       |       |
| Time $\times$ Food                                   | 3   | 6.56  | .0002 |
| Time $\times$ Incentive                              | 3   | 0.48  | .6941 |
| Time $\times$ Food $\times$ Incentive                | 3   | 0.04  | .9907 |
| Time $\times$ Treatment vs. Control                  | 3   | 22.57 | .0001 |

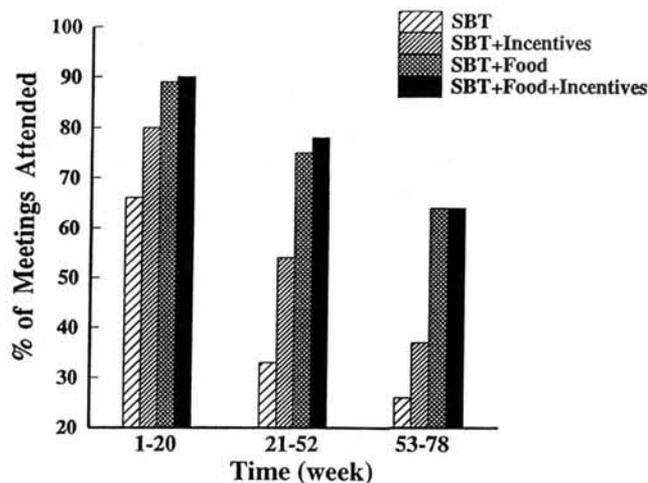


Figure 2. Attendance at group treatment sessions by treatment group. (SBT = standard behavioral treatment.)

Table 4  
Percentage of Food Days Completed

| Treatment group | Week    |          |          |
|-----------------|---------|----------|----------|
|                 | 1 to 20 | 21 to 52 | 53 to 78 |
| SBT             | 67      | 33       | 23       |
| SBT + FP        | 85      | 59       | 36       |
| SBT + I         | 81      | 48       | 24       |
| SBT + FP + I    | 89      | 63       | 38       |

Note. SBT = standard behavioral treatment. SBT + FP = standard behavioral treatment plus food provision. SBT + I = standard behavioral treatment plus incentives. SBT + FP + I = standard behavioral treatment plus food provision and incentives.

interaction between food and money,  $F(3, 417) = 3.98, p < .03$ . The interaction effect was caused by a combination of high baseline values for the SBT + FP + I condition and a very low caloric intake reported by this group at 6-month evaluation. The sex effect was caused by men reporting greater calorie reduction than did women (e.g., 32% vs. 24% reduction, respectively, from baseline to 18 months).

Percentage of caloric intake from fat in the two food-provision groups versus the two treatment groups not receiving food is shown in Figure 3. Analysis showed a significant time effect,  $F(3, 417) = 4.65, p < .0001$ , and a Time  $\times$  Sex effect,  $F(3, 417) = 4.07, p < .008$ . The time effect indicated a significant decrease in percentage of calories from fat over time: from 39% at baseline to about 34% at 18-month follow-up across all groups. The Time  $\times$  Sex interaction effect was because men had a higher percentage of calories from fat at baseline than did women (40.2% vs. 38.7%, respectively), but at each of the subsequent follow-up intervals men had a lower percentage of calories from fat than women had (e.g., 34.1% vs. 35.5%, respectively, at 18-month follow-up). Although there was no Time  $\times$  Treatment interaction effect, the more focused contrast analysis showed a

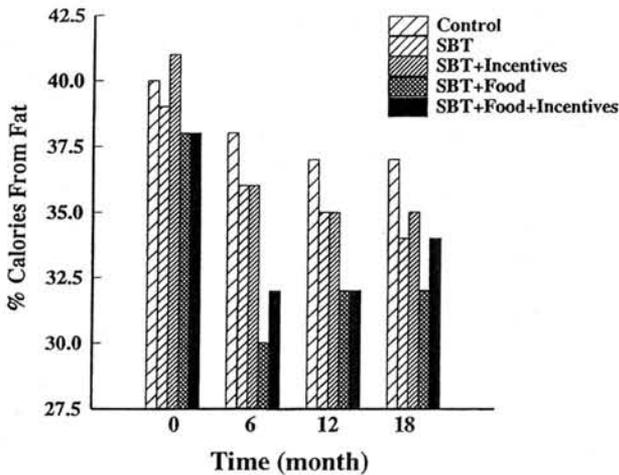


Figure 3. Percentage of calories from fat in treatment groups with and without food provision. (SBT = standard behavioral treatment.)

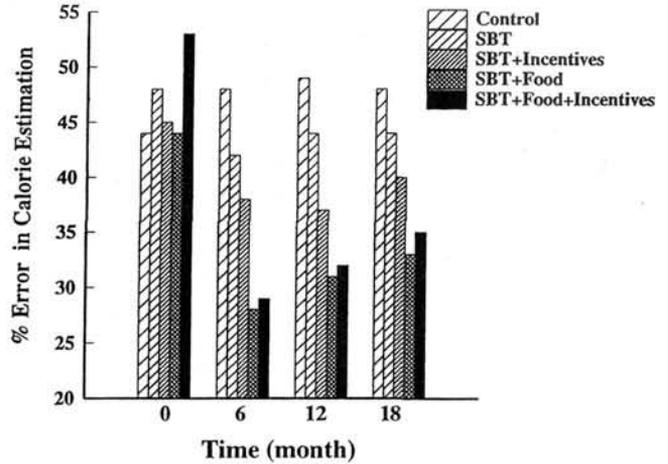


Figure 4. Accuracy of calories estimation in treatment groups with and without food provision. (SBT = standard behavioral treatment.)

significant effect for the food provision manipulation,  $F(3, 417) = 2.83, p < .04$ . As illustrated in Figure 3, this effect was caused by a larger reduction in percentage of calories from fat in the food-provision groups than in the treatment groups not receiving food. The extent to which changes in percentage of caloric intake from fat predicted changes in weight at an individual level was further evaluated by collapsing across treatment groups and by examining the correlations between percentage of fat change and weight change for each of the three time periods in the study (baseline to 6 months, 6 to 12 months, and 12 to 18 months). These correlations and their respective  $p$  values were  $r = .26, p < .01$ ;  $r = .03, p < .71$ ; and  $r = .21, p < .02$ , providing additional support for the causal contribution of dietary fat change to weight loss as well as to subsequent weight gain.

Analysis of the 15-item test on nutritional knowledge showed a time effect and a Time  $\times$  Treatment Group effect. The interaction was caused by increases in knowledge in the four treatment groups but not in the control group,  $F(3, 417) = 8.03, p < .0001$ . Analysis of the knowledge test on the basis of caloric estimation, however, showed a time effect and a Time  $\times$  Treatment Group effect. The treatment group effect included both a main effect for treatment versus no treatment,  $F(3, 411) = 8.11, p < .0003$ , with the treatment groups increasing in knowledge in relation to the control group, and an effect for food provision,  $F(3, 411) = 7.65, p < .0004$ . Participants in the food-provision groups increased knowledge (i.e., they were more accurate in estimating caloric values) to a greater extent than those in the non-food-provision groups. These results are illustrated in Figure 4. The individual-level correlations between change in this measure of knowledge and weight change at 6, 12, and 18 months were not statistically significant ( $r$ s of .07, .15, and  $-.03$ , respectively).

The other process measures showed no significant differences between groups. Analysis of exercise effects was done after a log transformation of the data because of highly skewed distributions (i.e., most participants were sedentary, but a few were

quite active). The only effect observed in this analysis was a main effect for time. All groups, including the control group, reported increasing levels of physical activity as the study progressed. None of the treatment interventions had an effect on exercise levels, at least as shown by data that were captured by this assessment tool.

Analysis of the perceived barriers to adherence showed only a main effect for time and for treatment versus no treatment,  $F(3, 417) = 12.13, p < .0001$ . Perception of barriers to adherence remained constant in the control group over the 18 months of the study and decreased in all of the treatment groups. Analogous results were observed for the EBI score. All groups reported higher EBI scores over time, indicating improved eating habits, with the greatest increases seen in the treatment groups,  $F(3, 417) = 12.31, p < .0001$ .

### Discussion

This study tested the hypothesis that a direct modification of the environmental conditions presumed to influence eating and exercise behaviors would produce better weight loss and maintenance than would standard behavioral modification approaches that rely on patients' initiative to make these changes. To more directly modify the antecedent environmental stimuli, interventionists provided study participants with a substantial portion of their food intake prepared in such a way as to guide portion sizes, caloric intake, and nutrient quality. To more directly modify the environmental consequences, interventionists provided financial incentives for weight loss and maintenance.

The results of the study strongly support the hypothesis that a more direct control of the antecedent environment through food provision enhances weight loss. Subjects who were provided with food lost substantially more weight at each evaluation time point than did those who received standard behavioral therapy with or without incentives for weight loss. At 6 months, patients in the food-provision group had lost approximately one-third more weight than did those in standard behavioral therapy; at 12 months their weight losses were 100% greater; and at 18 months their weight losses were about 40% greater. The effect was also robust because it was replicated in two different treatment centers and in both men and women. The only cautionary note is that both behavioral adherence and weight loss deteriorated from 6 months on in all groups equally so that the provision of food did not facilitate long-term weight-loss maintenance.

Analysis of process variables suggests several possible mechanisms by which food provision may have enhanced weight loss. First, food provision appears to have improved adherence to the treatment program. Participants in the food-provision groups attended meetings more regularly and completed a greater proportion of the assigned food and exercise diaries than did those in the non-food-provision groups. Second, food provision led to greater accuracy in estimating caloric values of foods. This finding suggests that the food-provision procedure, perhaps because it provided detailed nutritional information with each food shipment, instilled greater knowledge of the nutrient content of foods than did the more traditional procedure of patient evaluation of the nutritional content of their own diets by

their reference to a resource guide containing these values. Finally, food provision led to a lower fat intake. This lower intake may result from the difference in knowledge or self-monitoring described earlier, from the fact that the foods provided to subjects were very low in fat, or from both.

In contrast, the provision of monetary incentives to lose weight was not an effective weight-loss strategy. Monetary rewards had no effect on weight whether used singly or in combination with other therapies. These results seem to contradict the results of studies on financial contracting, several of which have reported enhanced weight losses from a procedure in which patients deposit their own money, which is then returned contingent on weight loss (Jeffery et al., 1978, 1983, 1984). One possible explanation of these conflicting results may be that deposit contracts operate through a different mechanism than the direct reward procedure used in this study. In addition to an incentive component, deposit contract procedures may include a stimulus control component, as Castro and Rachlin (1980) suggested, or may affect commitment or decision-making processes in ways that direct reinforcement procedures do not. It is also possible that one's own money has greater incentive value than external rewards of a similar magnitude have or that threatened losses have greater incentive value than potential gains have (Kahneman & Tversky, 1984). Although the present results do not necessarily imply that deposit contracts have no utility, they do suggest that \$25 per week is not a sufficient direct incentive to sustain weight-loss behaviors.

We believe that there are two important practical applications of the present findings. One application is in the area of dietary clinical trials research. Many recent studies have attempted to evaluate the effects of dietary change on clinical outcomes (e.g., Hypertension Prevention Trial Research Group, 1989). These trials have been difficult to conduct because of problems in achieving dietary adherence. The results of this study support the observations of investigators in the Diet-Heart Study that food provision is superior to dietary instruction. Individuals conducting clinical trials in the future should seriously consider the provision of food to study participants as a method to enhance their dietary adherence and thus increase the power of the studies. The present findings may also have important implications for clinical interventions for weight loss. Although the procedures used in this study differ from those used in clinical practice, especially because participants did not have to pay for their food, further investigation of this methodology in clinical settings is clearly warranted.

Additional research is needed to determine the mechanisms responsible for the effectiveness of food provision. The food-provision procedure used in this study involved a number of components that differ from standard therapy, including (a) a detailed and structured diet; (b) provision of free food, which may have been an incentive for attendance and completion of homework assignments; and (c) packaging of food in appropriate combinations and portion sizes, which may have had a direct cuing effect on eating behavior. Further evaluations of the necessary and sufficient conditions for the creation of the food-provision effect are warranted. Another possible avenue for future research may be to evaluate whether food-provision procedures could be used to enhance other dietary changes, such as

intake of dietary salt or dietary fat. In addition, antecedent control principles might also be explored to enhance exercise, one area in which the present study was not successful. Finally, this study reinforced the pressing need for additional investigation of methods to increase long-term maintenance of weight loss. Participants in all treatment conditions showed a deterioration in behavioral compliance and a gradual weight gain after 6 months of treatment, despite ongoing counseling support and direct environmental intervention. Improved maintenance of weight loss remains the greatest single challenge for weight-control research.

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