Weight Loss and the Prevention of Weight Regain: Evaluation of a Treatment Model of Exercise Self-Regulation Generalizing to Controlled Eating

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ABSTRACT

Context: For decades, behavioral weight-loss treatments have been unsuccessful beyond the short term. Development and testing of innovative, theoretically based methods that depart from current failed practices is a priority for behavioral medicine.

Objective: To evaluate a new, theory-based protocol in which exercise support methods are employed to facilitate improvements in psychosocial predictors of controlled eating and sustained weight loss.

Methods: Women with obesity were randomized into either a comparison treatment that incorporated a print manual plus telephone follow-ups (n = 55) or an experimental treatment of The Coach Approach exercise-support protocol followed after 2 months by group nutrition sessions focused on generalizing self-regulatory skills from an exercise support to a controlled eating context (n = 55). Repeated-measures analysis of variance contrasted group changes in weight, physical activity, fruit and vegetable intake, mood, and exercise- and eating-related self-regulation and self-efficacy over 24 months. Regression analyses determined salient interrelations of change scores over both the weight-loss phase (baseline-month 6) and weight-loss maintenance phase (month 6-month 24).

Results: Improvements in all psychological measures, physical activity, and fruit and vegetable intake were significantly greater in the experimental group where a mean weight loss of 5.7 kg (6.1% of initial body weight) occurred at month 6, and was largely maintained at a loss of 5.1 kg (5.4%) through the full 24 months of the study. After establishing temporal intervals for changes in self-regulation, self-efficacy, and mood that best predicted improvements in physical activity and eating, a consolidated multiple mediation model suggested that change in self-regulation best predicted weight loss, whereas change in self-efficacy best predicted maintenance of lost weight.

Conclusions: Because for most participants loss of weight remained greater than that required for health benefits, and costs for treatment administration were comparatively low, the experimental protocol was considered successful. After sufficient replication, physician referral and applications within health promotion and wellness settings should be considered.

INTRODUCTION

Approximately 69% of US adults are at a weight high enough to be considered unhealthy (body mass index [BMI], calculated as weight in kilograms divided by height in meters squared, ≥ 25 kg/m^2).[1] Approximately 36% of US women are obese (BMI ≥ 30 kg/m^2).[1] As degree of overweight increases, so do health risks such as diabetes mellitus, hypertension, heart disease, and certain cancers.[2] Although improving one's dietary behaviors (eg, increasing intake of fruits and vegetables; reducing the consumption of fats and sweets) and increasing physical activity will reliably reduce weight by at least the 5% required to obtain clinically important health benefits,[3] maintenance of those behaviors has been *very* difficult for almost all individuals.[4,5] It can reliably be predicted that weight lost over the first approximately 6 months will mostly (if not all) be regained within 1 to 3 years.[4,5] Even a more modest weight loss of at least 3% of original body weight sustained for 2 years, sometimes considered to be a marker of both weight-loss maintenance and some health-risk reductions,[6] has been difficult to attain.[7] Repeating the pattern of weight loss and regain may have adverse effects on both health risks and subsequent attempts at weight loss.[8,9]

Previous Behavioral Treatments

Interventions based on educating individuals on the need to lose weight by eating more healthfully and by being more physically active are the most common but have been ineffective.[4] Their absence of foundation in established behavior-change theories and research is a proposed reason for this lack of success.[10] Cognitive-behavioral methods consistent with Bandura's social cognitive[11] and self-efficacy[12] theories (eg, goal setting, cognitive restructuring) have occasionally had more favorable effects[13,14] and are presently considered to be state-of-the-art by many researchers. Several reviews, however, suggest that even those types of interventions simply defer weight regain.[4,5,15] Summaries of research also suggest that longer treatments (eg, 6 to 12 months, or longer) have had somewhat better effects than shorter treatments; but initial weight loss, energy-intake requirements, financial incentives, and focusing on fat vs kilocalories (kcal) do not affect the rate of weight regain after approximately 6 months.[5] Research has rarely sought to determine the psychosocial factors that predict weight-loss outcomes.[16]

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A group of behavioral researchers from Oxford University recently incorporated the extant theory and research to develop a highly structured Cognitive Behavioural Therapy protocol (Oxford CBT) in which maintenance of lost weight was targeted from the start.[17] Their intervention model is instructive because it embodies much of the current thinking on both obtaining and sustaining weight loss through evidence-based behavioral methods such as self-monitoring the time, location, kcal, and type of foods and drinks consumed;[18] regular self-weighing;[19] and actively countering lifestyle barriers.[20] Components of the Oxford CBT, which were administered by mostly clinical psychologists during individual 50-minute consultations, included "the role of body image in weight loss," "addressing barriers to weight loss," "encouraging acceptance," "common primary goals," and "developing long-term weight maintenance skills."[17] Tracking of foods, initially limiting to a 1500 kcal intake per day, and weighing and graphing weight changes were key elements of the modular protocol. The 24 sessions over 44 weeks designated the initial 24 to 30 weeks as a weight-loss phase, with the remainder devoted to weight maintenance. More in common with the available treatments, though, was that exercise was not emphasized. The treatment developers suggested that its minor impact on kcal totals render physical activity as being of minor concern for weight loss, and could possibly interfere with *dietary* compliance. Thus, initiating physical activity could be deferred by up to 6 months.[17] Although the Oxford CBT was expensive at an estimated professional cost of between US$3000 and US$4500 per participant, it proved to be no more effective than standard behavioral treatment.[21] With its sample of 49 women with obesity (ie, BMI of 30-40 kg/m^2) who were tested, approximately 68% of lost weight was regained at the 2-year point, and 91% was regained 3 years past treatment initiation. Possibly because even this strongly evidence-based and well-administered approach was judged by its developers to be ineffective at sustaining weight loss, they stated that it might be "ethically questionable to claim that psychological [behavioral] treatments for obesity 'work' in the absence of [favorable] data on their longer-term outcome."[21p712] In further consideration of their findings and the entire body of research on intervention outcomes, they pessimistically, yet possibly realistically, concluded their report by questioning whether continuing behavioral research in the area of weight management is even warranted any longer.[21]

Suggested Treatment Improvements

Other researchers disagreed with the above conclusions, but it was acknowledged that many of the presently held assumptions and methods around behavioral weight-loss treatments are ineffective and "fresh ideas are needed for attacking the problem."[5p14] Following from this suggestion, the National Institutes of Health commissioned a multidisciplinary working group on "Innovative Research to Improve Maintenance of Weight Loss" in 2014.[22] Its final report summarized that 1) although adherence issues need to be addressed first, exercise has promising implications for maintaining weight loss that go well beyond its obvious expenditure of energy; and 2) learning behavioral skills *before* starting on weight loss might be beneficial for weight-loss maintenance.[22] In an unrelated review of treatment results, Mann and her colleagues[4] also recommended further research on exercise as possibly being the "potent factor" (for long-term weight loss), in lieu of any additional work on dieting or composition of the diet.

Although a program of regular exercise has been shown to be the strongest predictor of success with maintaining weight loss for some time,[23-25] it remains difficult to maintain with an expected dropout rate of 50% to 65% within 3 to 6 months of its initiation.[26,27] On the basis of accelerometer data from both the 2003-2004 and 2005-2006 National Health and Nutritional Examination Surveys, less than 4% of US women complete the equivalent of at least 5 moderate-intensity walks per week,[28,29] which is considered to be the minimum threshold for health benefits.[30] Pilot research indicates that even when dropout from exercise is successfully countered, typical frequencies for formerly sedentary participants with obesity are only 2 to 3 sessions per week, with an estimated energy expenditure of less than 150 kcal per session (which amounts to only approximately 0.5 kg of weight loss every 9 to 10 weeks[31]). Although there have been advances in improving adherence to exercise through standardized cognitive-behavioral methods (eg, The Coach Approach protocol[32]), it was proposed that the relationship of exercise with maintained weight loss is more because of its association with improvements in psychological predictors of controlled eating than associated energy expenditures.[33] For example, if self-regulatory skills (eg, thought-stopping) could first be internalized within an intervention component designed to facilitate regular exercise, possibly treatment elements could be constructed to promote generalization of such behavioral skills to controlled eating.[33] This, however, runs in opposition to treatments such as the Oxford CBT[17] and some basic research[34] that suggests that self-regulation used for one behavior (here exercise) might deplete an individual's limited capacity of self-regulation for success with a second behavior (here reduced kcal eating). It was also proposed that self-efficacy, or one's feelings of ability and mastery, could be increased by demonstrating to one's self a better control of exercise behaviors through the use of newly learned self-regulatory skills to counter barriers.[33] Improved self-efficacy to control exercise might, in turn, also generalize to controlled eating, the other critical weight-loss behavior of interest.[33,35] Improvements in mood, a well-established by-product of initiating even manageable amounts of exercise,[33,36] might serve to counter the common problem (especially for women) of emotional eating,[37] and "… lead to a healthier psychological climate in which individuals have more cognitive and emotional resources, as well as motivation and energy, to sustain a long-term commitment to a weight-loss program."[35p320] Adherence to just 2 to 3 sessions per week of behaviorally supported exercise has been associated with significant improvements in self-regulation, self-efficacy, and mood,[38] which were found to be the most critical psychological predictors of improvements in eating and weight over 6 months, even when previously suggested factors such as self-concept and body image[35] were considered.[39] Additional studies are, however, required to determine psychological predictors of longer-term weight-loss *maintenance* that might inform both theory and the architecture of improved behavioral treatments. Although exercise is frequently incorporated into weight-loss interventions, we have found no longer-term research where its primary focus was on improving psychological predictors of controlled healthy eating.

Thus, as an extension to earlier research on short-term psychological, behavioral, and weight-loss effects,[33,40-42] the present study was conducted. It incorporated 1) an experimental treatment that initiated supported exercise 2 months before any changes in nutrition in attempts to improve targeted psychological and behavioral correlates of improved eating and weight loss, and 2) a comparison treatment of participants' use of a manual that simultaneously encouraged healthy eating, physical activity, and reasonable expectations, which was supplemented by telephone follow-ups. Both treatments were based on accepted behavioral theory, yet there were substantial differences. On the basis of a research consensus indicating that the initial approximately 6 months after treatment start is a time of weight loss, whereas beyond 6 months weight regain (often complete regain) can be reliably predicted,[4,5] the present study investigated 1) treatment-associated weight change, 2) behavioral predictors of weight change (ie, changes in healthy eating and physical activity), and 3) hypothesized psychological predictors of the behavioral changes (ie, self-regulation, self-efficacy, mood) during those 2 time frames. Data were measured at baseline and months 3, 6, 12, and 24. This allowed contrasts of dynamic changes in targeted variables by group, and analyses of which of the possible temporal intervals best predicted weight change and weight change-related behavioral improvements. Such findings could be instrumental for determining when, and to what degree, corresponding treatment processes should be emphasized. To enhance clarity, this report is expressed in 3 parts corresponding to the aforementioned 3 areas. Hypotheses and research questions are as follows.

Hypotheses

1. Reduction in weight from baseline-month 6 (weight-loss phase) will be greater, and regain in weight from month 6-month 24 (weight-loss maintenance phase) will be less, in the experimental group when contrasted with the comparison group.
2. Improvements in the targeted behaviors of physical activity and fruit and vegetable intake will be greater during both the weight-loss and weight-loss maintenance phases in the experimental group when contrasted with the comparison group.
3. Improvements in the targeted psychological variables of mood, self-regulation, and self-efficacy—related to both exercise and eating—will be greater during both the weight-loss and weight-loss maintenance phases in the experimental group when contrasted with the comparison group.

Research Questions

1. Was change in physical activity and fruit and vegetable intake from baseline-month 3, baseline-month 6, or month 3-month 6 the better predictor of weight change during the weight-loss phase? What temporal interval of change in physical activity and fruit and vegetable intake best predicted weight change during the weight-loss maintenance phase?
2. Was change in each psychological variable from baseline-month 3, baseline-month 6, or month 3-month 6 the better predictor of physical activity and fruit and vegetable intake change during the weight-loss phase? What temporal interval of change in each psychological variable best-predicted behavioral changes during the weight-loss maintenance phase?
3. Did changes in mood and/or aggregated (exercise- and eating-related) measures of self-regulation and self-efficacy significantly mediate relationships between treatment type (comparison and experimental) and changes in weight during the weight-loss and weight-loss maintenance phases?

Because participant characteristics, initial weight, cognitive-behavioral treatment orientation, and focus on weight-loss maintenance were designed to be similar to those of the previously published Oxford CBT study,[21] the present weight-change data were also contrasted with the Oxford CBT findings.

METHODS

Participants

Participant recruitment was through local print and electronic media. Inclusion criteria were 1) women of at least 21 years of age, 2) BMI ≥ 30 and < 40 kg/m^2, and 3) a self-reported goal of weight loss. Exclusion criteria based on self-report were 1) present or soon-planned pregnancy; 2) present use of medications for weight loss or a psychological/psychiatric condition; 3) current participation in a medical, commercial, or self-help weight-loss program; and 4) participation in a program of regular physical activity/exercise that averaged at least 20 minutes per week during the year before the start of the study. Treatments were administered at small, community-based wellness/fitness centers in the Eastern US. Because the chance of cross-contamination of participants through intergroup interactions within the same facility would have been high, randomization to either the comparison (COM) treatment (n = 55) or the experimental (EXP) treatment (n = 55) was by site (3 sites each). Institutional review board approval and written informed consent from each participant were received. The research was conducted in accordance with requirements of the Helsinki Declaration.

Independent t- and χ^2 tests indicated no significant group difference in age (mean$_{overall}$ ± standard deviation (SD) = 48.2 ± 7.8 years), BMI (35.3 ± 3.2 kg/m^2), or racial/ethnic make-up (overall 83% white, 11% African American, and 6% of other racial/ethnic groups). On the basis of self-reported family income, most participants were middle class (overall 11% below $24,999, 21% = $25,000-$49,999, 41% = $50,000-$99,999, and 27% = $100,000 or greater). Attrition from initial study acceptance to actual treatment participation was minimal at 7% and also did not significantly differ by group. This attrition was associated with either a reported illness, a newly arisen orthopedic issue, transportation issues, or an inability of study staff to make further contact after 3 attempts. There was no cost or financial compensation for participation.

Abbreviations Keys

FV = Fruit and vegetable intake
Mood = Overall negative mood
PA = Physical activity
SE-eating = Self-efficacy for controlling eating
SE-exercise = Self-efficacy for exercise
SR-eating = Self-regulation for controlled eating
SR-exercise = Self-regulation for exercise

Measures

The self-report measures used in this study were 1) physical activity (PA) through weekly energy expenditure, 2) healthy eating through daily fruit and vegetable intake (FV), 3) self-regulation for exercise (SR-exercise), 4) self-regulation for controlled eating (SR-eating), 5) self-efficacy for exercise (SE-exercise), 6) overall negative mood (Mood), and 7) self-efficacy for controlling eating (SE-eating). Descriptions of each of these measures, along with data on their reliability and validity, are presented below (Table 1). Body weight was measured in kilograms through the use of a recently calibrated scale (800KL; Healthometer, Buffalo Grove, IL).

Procedure

Participants initially received a group orientation to their assigned EXP or COM protocol. Wellness counselors administering treatments were trained in only one of the protocols and masked to the treatment differences and the study's research goals. Both the EXP and COM treatments were based on the social cognitive[11] and self-efficacy[12] theories of behavior where individuals are viewed as 1) directing their own actions through self-organization, 2) being able to manage their environments, and 3) possessing capabilities to be self-reflective of their internal abilities. Both the EXP and COM curricula incorporated cognitive-behavioral methods designed to empower participants with self-regulatory skills and abilities to deal with barriers to managing their weight effectively, while increasing their feelings of mastery and competence (ie, self-efficacy). Both treatment protocols informed participants of the recommended volume of weekly exercise to gain health benefits,[30] but also suggested that *any* amount was also likely to be beneficial. However, the administration formats and the proposed role of physical

Table 1. Description of study measures

Measure	Measurement instrument	Instrument description	Reliability and validity
Physical activity (PA)	Godin-Shephard Leisure-Time Physical Activity Questionnaire[43]	Requires entry of number of weekly sessions of strenuous (~ 9 METs; eg, running), moderate (~ 5 METs; eg, fast walking), and light (~ 3 METs; eg, easy walking) physical exertion for "more than 15 minutes." Incorporates METs, or the energy costs associated with specific physical activity intensities (1 MET approximates the use of 3.5 ml of O_2/kg/minute).[44]	Test-retest reliability (2 weeks) was 0.74.[45] Construct validity was indicated through strong correlations with both accelerometer and peak volume of oxygen uptake measurements.[46,47]
Healthy eating measured by fruit and vegetable intake (FV)	Self-report survey of FV[48]	Foods and beverages consumed "in a typical day over the past week" are based on examples and serving sizes of fruits (eg, apple, banana, peach [1 small or 118 mL or 4 ounces canned]; raisins, dates [0.59 mL or 2 ounces]; 100% fruit juice [118 mL or 4 ounces]) and vegetables (eg, broccoli, carrots, tomatoes, green beans [118 mL or 4 ounces]; raw spinach [236 mL or 8 ounces]) that correspond to both the US Department of Agriculture's current MyPlate and former Food Guide Pyramid.[49] Increases in FV were strongly associated with both weight loss and weight-loss maintenance,[50] and an increase in FV was a stronger predictor of weight loss than reduction in fat intake.[51] Previous research indicates that FV alone is a strong predictor of overall energy consumption and healthfulness of the diet.[52,53]	Test-retest reliability (3 weeks) was 0.77-0.83 for women.[33] Validated against comprehensive food frequency questionnaires,[54] in which pilot research indicated strong correlations (*r*-values = 0.70-0.85) with the full-length Block Food Frequency Questionnaire.[54,55]
Self-regulation for exercise (SR-exercise) and self-regulation for controlled eating (SR-eating)	Adaptation of a previously validated scale[56,57]	The 10 items for SR-exercise (eg, "I say positive things to myself about being physically active") and SR-eating (eg, "I make formal agreements with myself regarding my eating") assess the degree that barriers to those behaviors are addressed through the use of self-regulatory skills. Responses range from 1 (never) to 5 (often), and are summed. A higher score indicates a greater use of self-regulation.	Cronbach α-values for internal consistency were 0.75,[56] 0.83, and 0.80 for the present versions and sample, respectively. Test-retest reliability (2 weeks) was 0.77.[56]
Self-efficacy for exercise (SE-exercise)	Exercise Self-Efficacy Scale[58]	After beginning with the stem, "I am confident I can participate in regular exercise when ...," each of the scale's 5 items end with a possible barrier to overcome (eg, "I am tired," "I have more enjoyable things to do"). Responses range from 1 (not at all confident) to 7 (very confident), and are summed. A higher score indicates greater self-efficacy.	Cronbach α-values for internal consistency were 0.76-0.82. Test-retest reliability (2 weeks) was 0.90.[59] Cronbach α-value for internal consistency for the present sample was 0.80.
Overall negative mood (Mood)	Profile of Mood States Short Form scale of Total Mood Disturbance[60]	The 30 items (5 items per factor) assess feelings during the past week on depression (eg, "sad"), tension/anxiety (eg, "tense"), vigor (eg, "energetic"), fatigue (eg, "weary"), anger (eg, "angry"), and confusion (eg, "forgetful"). Responses range from 0 (not at all) to 4 (extremely) and are summed after reversing the scores of the vigor factor. A lower score indicates better mood.	Cronbach α-values for internal consistency were 0.84-0.95 across factors,[60] and 0.79-0.89 for the present sample. Test-retest reliability (3 weeks) averaged 0.69.[60]
Self-efficacy for controlling eating (SE-eating)	Weight Efficacy Lifestyle Scale[61]	The 20 items (4 per factor) assess feelings of ability to control eating when the following situations are present: negative emotions (eg, "I can resist eating when I am anxious [nervous]"), food availability (eg, "I can resist eating even when I am at a party"), physical discomfort (eg, "I can resist eating when I am uncomfortable"), positive activities (eg, "I can resist eating when I am watching TV"), and social pressure (eg, "I can resist eating even when I have to say 'no' to others"). Responses range from 0 (not confident) to 9 (very confident), and are summed. A higher score indicates greater self-efficacy.	Cronbach α-values for internal consistency were 0.70-0.90 across its factors,[61] and 0.74-0.81 for the present sample.

MET = metabolic equivalent; TV = television.

activity/exercise in facilitating changes in eating behaviors differed substantially between the EXP and COM treatments.

The EXP treatment incorporated The Coach Approach exercise-support protocol[32] paired with a nutrition behavior-change component developed for this research. It was based on 1) results from previous behavioral weight-management treatments,[14,17,33,62-64] 2) exploratory studies of psychosocial predictors of weight-loss behaviors,[33,39,57] 3) findings suggesting that behavioral mechanisms required to foster weight loss differ from those required to maintain lost weight,[16,65] and 4) the suggested benefits of targeting specific and measurable behaviors for change (eg, increasing FV rather than addressing numerous and detailed elements of the diet).[66] Beginning at baseline, The Coach Approach protocol[32] supported adherence to newly initiated exercise through six 45-minute meetings with a trained wellness counselor possessing at least 1 national certification (eg, American College of Sports Medicine). These were conducted in a private office over 6.5 months. Each participant's exercise plan, both initially and in revisions during subsequent meetings, was based on the participant's preferred type of physical activity and tolerance. Most of the meeting time was, however, spent on the development of specific self-regulatory skills such as long- and short-term goal setting paired with progress monitoring, dissociation from discomfort, cognitive restructuring, stimulus control, behavioral contracting, controlling behavioral prompts and triggers, and relapse prevention. Exercise-induced changes in mood (eg, anxiety, energy level) were assessed both in response to a single bout of physical activity and for 1 to 2 months, and displayed through responses to items embedded in the supporting computer application.

After 8 weeks of concentration exclusively on maintaining regular exercise, the components for eating behavior change were sequentially added. First, guidance and practice on methods for kcal tracking was individually provided in two 30-minute meetings over 2 weeks. Energy-intake goals were based on each participant's weight (eg, 1500 kcal/day for a weight range of 79-99 kg), and various methods for recording food and corresponding kcal intake were made available (eg, through an approved Web site, an approved application for hand-held devices, or a provided paper form and use of an approved "calorie counter" book). Next, 10 nutrition sessions of 60 minutes each focused on weight reduction were administered by trained wellness counselors (supported by a manual) at 2-week intervals in groups of 8-15 participants. Their primary aim was to generalize, adapt, and extend self-regulatory skills developed during The

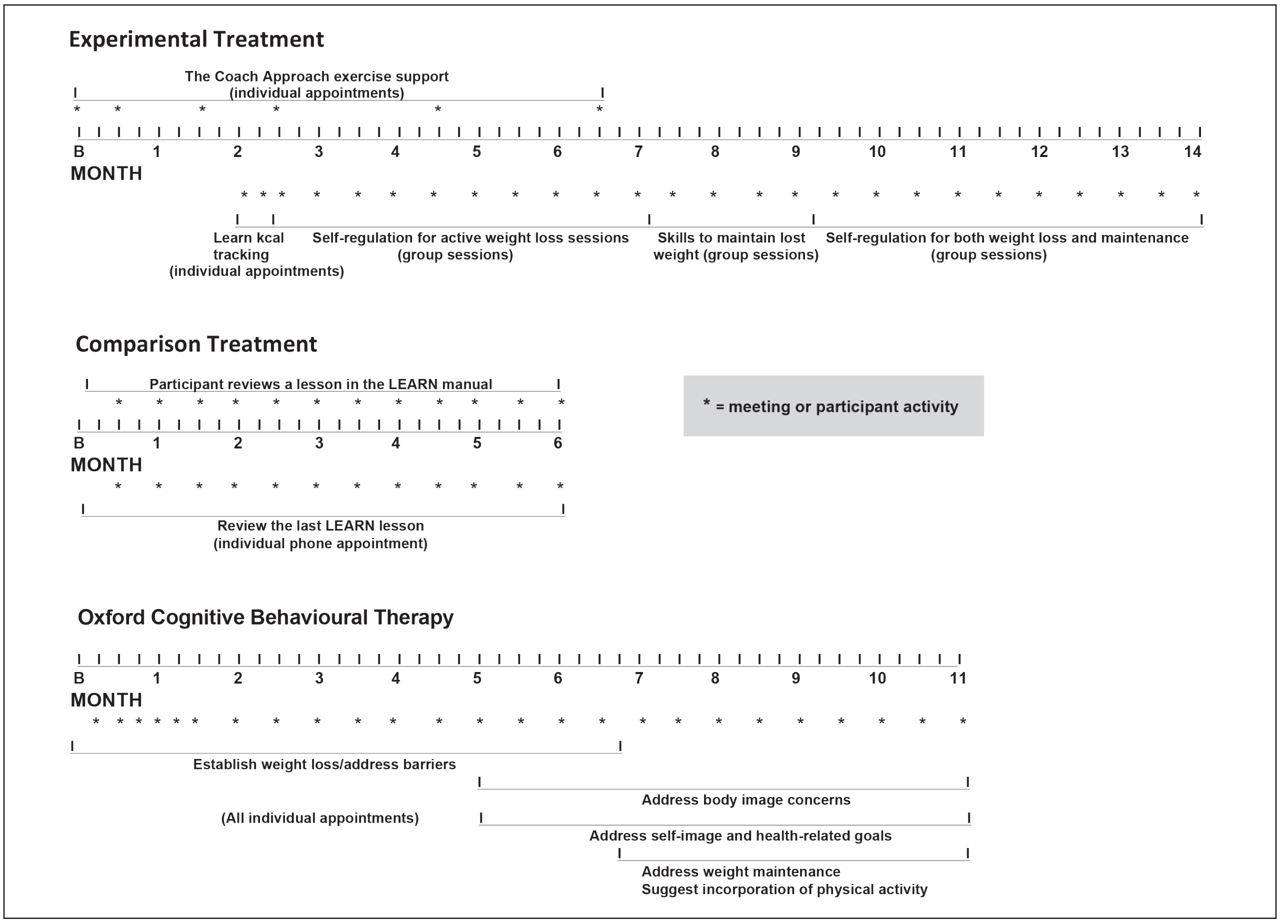

Figure 1. Timeline of the Experimental Treatment, Comparison Treatment, and Oxford Cognitive Behavioural Therapy.

B = baseline; kcal = kilocalories; LEARN = lifestyle, exercise, attitudes, relationships, nutrition.

Coach Approach exercise-support protocol,[32] to self-regulating eating behaviors (eg, dissociating from exercise-induced discomfort was generalized to dissociating from feelings of hunger; recovering from and rescheduling a missed exercise session was generalized to recovering from a day of excess kcal intake and immediately recommitting to the appropriate limit for the next day). There was a combination of brief lectures, individual tasks, and group activities within each session. The next component, now 28 weeks after baseline, was 4 group sessions in which self-regulatory skills were addressed in the context of *maintaining* lost weight. The final 10 sessions of the EXP treatment covered skills of self-regulation in both weight-loss and weight-loss maintenance contexts (Figure 1). Treatment content related to the diet was primarily concentrated on increasing FV intake, although there was a limited focus on minimizing the consumption of fat and sugar. Because meeting time was primarily centered on the development of self-regulatory skills and the ability to increase self-efficacy for controlling overeating, participants were referred to the ChooseMyPlate.gov Web site[67] for access to detailed, evidence-based information on nutrition.

The COM treatment replicated methods used previously in studies,[21,42] and consisted of participants reviewing 1 of the 12 "lessons" of a 265-page print manual entitled *The LEARN* (lifestyle, exercise, attitudes, relationships, nutrition) *Program for Weight Management* (10th edition)[68] every 2 weeks. Sections related to behavior change included "Dealing with Pressures to Eat," "Preventing Lapse, Relapse, and Collapse," "Interpreting Your Progress," and "Making Physical Activity Count." Sections related to diet included "Fast Foods," "Rating Your Diet," "Vegetables in Your Diet," and "Breads, Cereals, Rice, and Pasta in Your Diet." Each lesson was followed by a 15-minute phone conversation initiated by a wellness counselor to clarify chapter contents, review each participant's plans for carrying out behavioral changes, and answer the participant's questions. The process of participants reading chapters and obtaining telephone follow-ups started at baseline and lasted 24 weeks (Figure 1). The LEARN manual[68] suggested that women limit their energy intake to 1200 kcal per day. A paper monitoring form was provided for participants to record

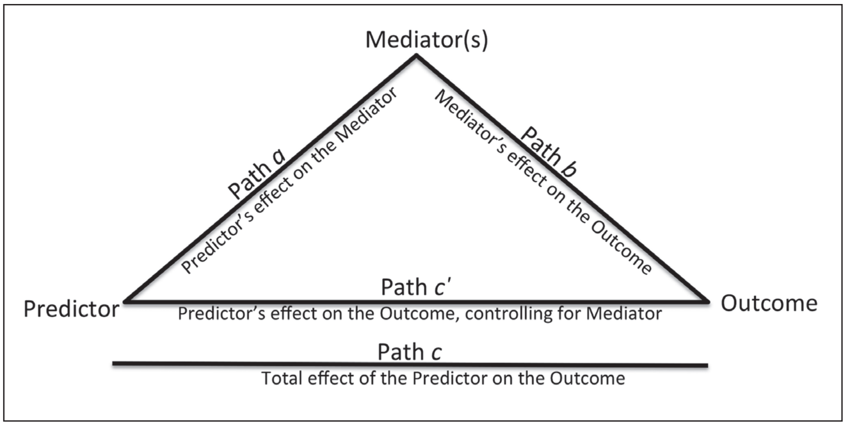

Figure 2. Representation of mediation models.

foods and drinks consumed, the amount consumed and their associated kcal, their corresponding food group categorization, and optional comments.

Fidelity checks were completed on approximately 15% of treatment components by study staff. Minor protocol violations were primarily related to adherence to required time frames within sessions and were easily rectified through study staff-instructor interactions. Surveys and weight measurements were completed in a private area.

Data Analyses

To avoid inappropriately inflated effect sizes such as those reported in the many studies where data from only weight-loss program "completers" were included, the conservative intention-to-treat approach was used, as suggested.[13] Thus, data were retained from *all* participants who engaged in treatment processes. The expectation-maximization algorithm[69] was used to impute data for the 14% of missing scores. The required criteria of missing at random (no systematic bias) was indicated because participants who were missing data at any assessment time did not significantly differ from the sample as a whole on demographic characteristics or any other study measure. On the basis of the planned multiple regression equations incorporating 3 predictor variables, and to detect the moderate effect of $f^2 = 0.15$ that was indicated in pilot research[33] at the statistical power of 0.90 ($\alpha = 0.05$), a minimum of 98 total participants was required.[70] In tests during the weight-loss phase, tolerances (0.60-0.82) and variance inflation factors (1.23-1.67) indicated a low degree of multicollinearity. During the weight-loss maintenance phase, tolerances (0.22-0.86) and variance inflation factors (1.16-4.58) indicated a low-moderate degree of multicollinearity.[71] Inspection of residual scatterplots indicated homogeneity of variances and linearity in the data. Both skewness and kurtosis values were < 2 standard errors. Consistent with previous suggestions for research within the present context, change scores were unadjusted for baseline values.[72] Statistical significance was set at $\alpha = 0.05$ (2-tailed) unless otherwise noted. Statistical analyses were conducted using SPSS, version 22 (IBM, Armonk, NY).

For all study measures, general linear model mixed-model repeated measures analyses of variance (ANOVAs) were computed to determine whether there were significant score changes across the 5 measurement times (baseline; months 3, 6, 12, and 24), and whether those changes differed between the EXP and COM groups. These were followed up by planned *t* tests to assess and contrast within-group changes during the weight-loss phase (using 1-tailed tests) and the weight-loss maintenance phase. Their associated effect sizes were computed as Cohen's d ($[\text{mean}_{post} - \text{mean}_{pre}]/SD_{pre}$). Effect sizes for ANOVA models were calculated using partial η-squared ($\eta^2_p = SS_{effect}/[SS_{effect} + SS_{error}]$). For d and η^2_p, 0.20, 0.50, 0.80; and 0.01, 0.06, 0.14 denote small, moderate, and large effects, respectively.

Part 1: Weight Change

After completing planned ANOVAs and follow-up tests on weight, and on the basis of research suggesting that ≥ 5% weight loss is the threshold for health benefits,[3] the percentage of participants attaining this criterion was reported for month 6 (end of the weight-loss phase) and month 24 (end of the study), by group. Because ≥ 3% loss has been the suggested criterion for maintained weight loss,[6] attainment of this change was also reported at month 24. Weight-change data previously published on the Oxford CBT[21] were also adapted for additional contrasting.

Part 2: Behavioral Predictors of Weight Changes

After completing planned ANOVAs and follow-up tests on PA and FV, data were aggregated across groups. The strengths of bivariate relationships between changes in PA and FV from baseline-month 3, baseline-month 6, and month 3-month 6, for the prediction of change in weight over the weight-loss phase, were then contrasted. Given the data collected, all possible temporal intervals of changes in PA and FV during the course of the 24-month investigation were similarly contrasted for predicting change in weight during the weight-loss maintenance phase. As was previously suggested,[73] wherever possible, behavioral changes occurring during the weight-loss phase were statistically controlled for.

Part 3: Psychological Predictors of Behavioral Changes

After completing planned ANOVAs and follow-up tests on the five psychological variables, data were aggregated across groups. Analyses of relationships of changes in the psychological variables using temporal intervals and methods identical to Part 2 were then completed. Data from the temporal intervals found to have the strongest relationships served as the predictors of PA and FV changes in multiple regression equations.

Because 1) the EXP treatment focus was on the carry-over of exercise-related self-regulation and self-efficacy to eating-related self-regulation and self-efficacy, 2) their strong interrelations had previously been supported,[33] and 3) previous theory suggested their interactions,[35,65] after normalizing (centering and standardizing) scores and confirming expected interrelations, the exercise- and eating-related self-regulation and self-efficacy measures were merged for further analyses. Multiple mediation models incorporating 20,000 bootstrapped resamples[74] were specified where the *predictor* variable was treatment

Table 2a. Descriptive statistics of study measures and analyses of their changes over 24 months, by group[a]

	Baseline (mean ± SD)	Month 3 (mean ± SD)	Month 6 (mean ± SD)	Month 12 (mean ± SD)	Month 24 (mean ± SD)	Effect for time[b] (F(4, 432) [η^2_p])	Time × group interaction (F(4, 432) [η^2_p])
Weight (kg)							
Experimental	94.95 ± 11.44	92.03 ± 11.84	89.21 ± 11.57	89.40 ± 11.86	89.84 ± 13.58	26.25[c] [0.196]	6.84[c] [0.060]
Comparison	95.36 ± 10.56	94.46 ± 10.63	93.27 ± 10.44	93.51 ± 11.07	94.11 ± 11.23		
Oxford CBT[d]	92.34 ± 8.81	NA	83.29 ± 10.39	84.33 ± 11.11	89.45 ± 11.48		
Physical activity (METs/week)							
Experimental	8.31 ± 7.30	28.65 ± 13.56	32.77 ± 15.47	32.44 ± 15.16	23.59 ± 15.15	89.01[c] [0.452]	9.50[c] [0.081]
Comparison	9.65 ± 8.14	23.51 ± 15.44	22.02 ± 12.82	23.20 ± 12.60	22.40 ± 12.26		
Fruit and vegetable intake (servings/day)							
Experimental	3.95 ± 1.97	5.81 ± 2.39	6.42 ± 2.14	6.23 ± 2.24	5.56 ± 1.90	38.92[c] [0.265]	4.55[e] [0.040]
Comparison	3.30 ± 1.81	4.25 ± 2.04	4.46 ± 2.23	4.73 ± 1.99	4.62 ± 1.98		
Self-regulation for exercise							
Experimental	22.53 ± 6.32	32.51 ± 4.36	33.04 ± 4.28	32.27 ± 4.59	29.87 ± 5.96	64.03[c] [0.372]	14.63[c] [0.119]
Comparison	23.07 ± 6.32	26.96 ± 6.12	26.58 ± 6.91	26.58 ± 6.75	26.56 ± 6.69		
Self-efficacy for exercise							
Experimental	25.87 ± 9.47	33.38 ± 10.08	34.98 ± 10.52	33.25 ± 11.73	29.36 ± 11.82	14.64[c] [0.119]	4.27[e] [0.038]
Comparison	22.36 ± 9.73	25.47 ± 10.89	25.29 ± 12.25	25.98 ± 11.22	25.49 ± 10.84		
Total mood disturbance							
Experimental	25.69 ± 15.45	9.17 ± 15.00	4.55 ± 11.54	7.96 ± 11.88	9.38 ± 13.87	53.56[c] [0.332]	8.62[c] [0.074]
Comparison	21.71 ± 11.50	12.25 ± 8.12	13.89 ± 11.50	12.78 ± 11.88	13.47 ± 11.51		
Self-regulation for controlled eating							
Experimental	23.75 ± 5.60	31.25 ± 4.57	32.51 ± 4.00	31.96 ± 4.19	29.82 ± 5.68	64.16[c] [0.373]	5.64[c] [0.050]
Comparison	22.05 ± 5.78	26.91 ± 5.54	26.78 ± 5.59	26.44 ± 5.23	26.29 ± 5.20		
Self-efficacy for controlled eating							
Experimental	87.82 ± 31.21	114.96 ± 26.95	126.48 ± 26.51	127.26 ± 26.90	124.69 ± 28.34	47.29[c] [0.305]	4.39[e] [0.039]
Comparison	88.24 ± 33.80	104.65 ± 27.17	108.00 ± 30.76	110.35 ± 30.45	108.18 ± 29.90		

[a] Experimental group, n = 55; comparison group, n = 55.
[b] Analysis of variance effects for time, and time × group interactions, contrast changes from baseline to month 24.
[c] $p < 0.001$.
[d] These data were adapted from previous research[21] for contrasting purposes.
[e] $p < 0.01$.
CBT = Cognitive Behavioural Therapy; MET = metabolic equivalent; SD = standard deviation.

type (0 = COM; 1 = EXP), the *outcome* variable was weight change during the weight-loss or weight-loss maintenance phase, and the possible *mediators* were changes in mood and the merged self-regulation and self-efficacy measures. In a multiple mediation model, significance of a mediator is identified when its corresponding 95% confidence interval for an indirect effect does not include 0. A graphical representation of mediation models is given in Figure 2.

Table 2b. Planned follow-up *t*-test results over the weight-loss phase (baseline-month 6) and weight-loss maintenance phase (months 6-12), by group[a]

	Group	$t(54)$	p vaue	d
Weight (kg) change				
Weight-loss phase	EXP	-11.18	< 0.001	0.50
	COM	-5.13	< 0.001	0.20
Weight-loss maintenance phase	EXP	0.61	0.274	0.05
	COM	1.87	0.033	0.08
Entire study period (baseline-month 24)	EXP	-4.59	< 0.001	0.45
	COM	-1.86	0.068	0.12
Physical activity change (METs/week)				
Weight-loss phase	EXP	11.83	< 0.001	3.18
	COM	8.89	< 0.001	1.52
Weight-loss maintenance phase	EXP	-4.42	< 0.001	0.59
	COM	0.30	0.764	0.03
Fruit and vegetable intake change (servings/day)				
Weight-loss phase	EXP	7.67	< 0.001	1.24
	COM	3.90	< 0.001	0.64
Weight-loss maintenance phase	EXP	-3.07	0.003	0.40
	COM	1.04	0.302	0.07
Self-regulation for exercise change				
Weight-loss phase	EXP	10.79	< 0.001	1.66
	COM	4.56	< 0.001	0.56
Weight-loss maintenance phase	EXP	-4.54	< 0.001	0.53
	COM	-0.03	0.974	0.003
Self-efficacy for exercise change				
Weight-loss phase	EXP	8.56	< 0.001	0.96
	COM	0.79	0.039	0.30
Weight-loss maintenance phase	EXP	-4.10	< 0.001	0.53
	COM	0.19	0.848	0.02
Total mood disturbance change				
Weight-loss phase	EXP	-9.21	< 0.001	1.37
	COM	-5.58	< 0.001	0.68
Weight-loss maintenance phase	EXP	2.86	0.006	0.42
	COM	-0.44	0.663	0.04
Self-regulation for controlled eating change				
Weight-loss phase	EXP	10.33	< 0.001	1.56
	COM	6.54	< 0.001	0.81
Weight-loss maintenance phase	EXP	-4.25	0.001	0.67
	COM	-1.25	0.218	-0.08
Self-efficacy for controlled eating change				
Weight-loss phase	EXP	8.15	< 0.001	1.24
	COM	4.37	< 0.001	0.58
Weight-loss maintenance phase	EXP	-0.46	0.646	0.07
	COM	0.13	0.899	0.01

[a] Experimental group (EXP), n = 55; Comparison group (COM), n = 55.
MET = metabolic equivalent.

If a significant mediator was found in the above analysis over the weight-loss phase, follow-up simple mediation models (eg, models with only a single mediator) were then specified to determine whether change in that psychological variable and weight demonstrated a reciprocal relationship. A reciprocal relationship is identified if, after reversing the position of the original outcome and mediator variable within a complementary mediation model, *both* equations demonstrate significant mediation.[42] Because the presence of a reciprocal relationship may not be assessed directly through multiple mediation, or with covariates, these analyses were possible during only the weight-loss phase.

RESULTS

There was no significant difference at baseline between the EXP and COM groups on any study measure. Table 2a provides descriptive statistics of data at baseline and at months 3, 6, 12, and 24. For all variables, there was a significant overall effect and a significant time × group interaction during the 24-month study (Table 2a). Results of follow-up, within-group *t*-tests, are given in Table 2b.

Part 1: Weight Change

During the weight-loss phase, although within-group reductions in weight in the EXP group (-5.73 kg) and COM group (-2.09 kg) were both significant, the EXP group had a significantly greater between-group reduction in weight, $t(108) = 5.56$, p < 0.001, $d = 1.07$. During the weight-loss maintenance phase, within-group weight regain in the EXP group (0.63 kg) was not significant, whereas it was significant in the COM group (0.84 kg). During the full 24-month duration of the study, reduction of weight was significant in the EXP group (-5.11 kg), but not significant in the COM group (-1.25 kg). Between-group reduction in weight was significantly greater over 24 months in the EXP group, $t(108) = 2.95$, p = 0.004, $d = 0.58$.

At month 6, ≥ 5% weight loss was found in 65.5% of EXP and 18.2% of COM participants. At month 24, ≥ 5% weight loss was found in 52.7% of EXP and 16.4% of COM participants. At month 24, ≥ 3% weight loss was found in 63.6% of EXP and 38.2% of COM participants. Figure 3 provides a graphic representation of percentages of weight change for 24 months, including data adapted from research on the Oxford CBT.[21]

Part 2: Behavioral Predictors of Weight Changes

Physical Activity

During the weight-loss phase, although within-group increases in PA in the EXP group and the COM group were both significant, the EXP group had a significantly greater between-group increase, $t(108) = 4.86$, $p < 0.001$, $d = 0.94$. There was a significant between-group difference in PA change during the weight-loss maintenance phase, $t(108) = -3.93$, $p < 0.001$, $d = 0.77$, with the EXP group demonstrating a significant within-group reduction and the COM group showing no significant change.

Eating

During the weight-loss phase, within-group increases in FV in the EXP group and the COM group were both significant, and significantly greater in the EXP group, $t(108) = 2.97$, $p = 0.002$, $d = 0.57$. There was a significant between-group difference in FV change during the weight-loss maintenance phase, $t(108) = -3.20$, $p = 0.002$, $d = 0.64$, with the EXP group having a significant within-group reduction and the COM group exhibiting no significant change.

Prediction of Weight Change

The temporal interval that was the strongest predictor of weight change during the weight-loss phase was baseline-month 6 for both PA and FV. β(standard error)-values were -0.38(0.05) and -0.30(0.33), respectively; p values < 0.001. The temporal interval that was the strongest predictor of weight change during the weight-loss maintenance phase was month 6-month 24 for both PA and FV. β(standard error)-values were -0.45(0.11) and -0.28(0.87), respectively; p values < 0.001 and 0.018, respectively.

Part 3: Psychological Predictors of Behavioral Changes

Self-Regulation for Exercise

During the weight-loss phase, within-group increases in SR-exercise in the EXP group and the COM group were both significant, and significantly greater in the EXP group, $t(108) = 5.64$, $p < 0.001$, $d = 1.09$. There was a significant between-group difference in SR-exercise reduction during the weight-loss maintenance phase, $t(108) = -3.51$, $p = 0.001$, $d = 0.67$, with the EXP group demonstrating a significant within-group reduction and the COM group showing no significant change.

Self-Efficacy for Exercise

During the weight-loss phase, within-group increases in SE-exercise in the EXP group and the COM group were both significant, and significantly greater in the EXP group, $t(108) = 2.94$, $p = 0.007$, $d = 0.52$. There was a significant between-group difference in SE-exercise change during the weight-loss maintenance phase, $t(108) = -3.39$, $p = 0.001$, $d = 0.65$, with the EXP group showing a significant within-group reduction and the COM group having no significant change.

Mood

During the weight-loss phase, within-group reductions in Mood score in both the EXP group and the COM group were significant, and significantly greater in the EXP group, $t(108) = -4.98$, $p = 0.002$, $d = 0.98$. There was a significant between-group difference in Mood change during the weight-loss maintenance phase, $t(108) = 2.70$, $p = 0.008$, $d = 0.54$, with the EXP group demonstrating a significant within-group score increase and the COM group exhibiting no significant change.

Self-Regulation for Controlled Eating

During the weight-loss phase, within-group increases in SR-eating in the EXP group and the COM group were both significant, and significantly greater in the EXP group, $t(108) = 3.64$, $p < 0.001$, $d = 1.08$. There was a significant between-group difference in SR-eating reduction during the weight-loss maintenance phase, $t(108) = -2.57$, $p = 0.012$, $d = 0.52$, with the EXP group having a significant within-group reduction and the COM group showing no significant change.

Self-Efficacy for Controlled Eating

During the weight-loss phase, within-group increases in SE-eating in the EXP group and the COM group were significant, and significantly greater in the EXP group, $t(108) = 2.88$, $p = 0.005$, $d = 0.55$. There was no significant between-group difference in SE-eating change during the weight-loss maintenance phase, $t(108) = -0.48$, $p = 0.635$, $d = 0.10$, with neither the EXP or COM group demonstrating a significant within-group change.

Prediction of Physical Activity Change

The temporal interval that was the strongest predictor of change in PA during the weight-loss phase was from baseline-month 6 for SR-exercise, SE-exercise, and Mood. β(standard error)-values were 0.58(0.15), 0.50(0.10), and -0.46(0.08), respectively; all p values < 0.001. The temporal interval that was the strongest predictor of change in PA during

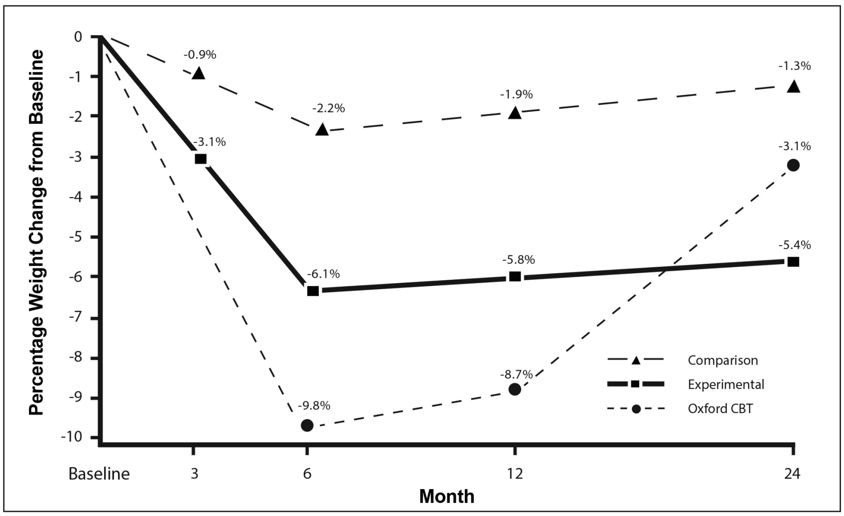

Figure 3. Percentage of body weight change over 24 months, by group.
CBT = Cognitive-Behavioural Therapy.

the weight-loss maintenance phase was baseline-month 24 for SR-exercise, SE-exercise, and Mood. β(standard error)-values were 0.65(0.24), 0.57(0.14), and -0.52(0.17), respectively; all p values < 0.001.

After incorporating the above temporal intervals into the following two models, the multiple regression equation predicting PA change during the weight-loss phase was significant. Changes in SR-exercise, SE-exercise, and Mood were each significant independent predictors (after controlling for one another). The prediction of PA change during the weight-loss maintenance phase was significant. Changes in SR-exercise and SE-exercise, but not Mood, were significant independent predictors (Table 3).

Prediction of Eating Change

The temporal interval that was the strongest predictor of change in FV during the weight-loss phase was the same for baseline-month 3 and baseline-month 6 for SR-eating, and was baseline-month 6 for both SE-eating and Mood. β(standard error)-values were 0.41(0.03), 0.45(0.01), and -0.37(0.08), respectively; all p values < 0.001. The temporal interval that was the strongest predictor of change in FV during the weight-loss maintenance phase was month 12-month 24 for SR-eating, and baseline-month 24 for both SE-eating and Mood. β(standard error)-values were 0.19(0.04), 0.47(0.01), and -0.31(0.02), respectively; all p values < 0.050.

After incorporating the above temporal intervals, the multiple regression equation predicting FV change during the weight-loss phase was significant. Changes in SR-eating, SE-eating, and Mood were each significant independent predictors (after controlling for one another) (Table 3). The prediction of FV change over the weight-loss maintenance phase was significant. Neither changes in SR-eating, SE-eating, nor Mood were significant independent predictors (Table 3).

Consolidated Model for Weight-Loss Effects

As expected, correlations of baseline, baseline-month 6, and month 6-month 24 scores between the exercise- and eating-related self-regulation measures (*r*-values = 0.61-0.66), and exercise- and eating-related self-efficacy measures (*r*-values = 0.40-0.48) were significant (all p values < 0.001). This further supported merging the exercise- and eating-related self-regulation (ie, SR-merged) and self-efficacy (ie, SE-merged) measures for the planned mediation analyses. The same Mood scale was used in both exercise and eating contexts so no such merger was needed.

In a consolidated model, the SR-merged, SE-merged, and Mood measures (changes from baseline-month 6) were entered as possible mediators of the relationship between treatment type (COM or EXP) and weight change during the weight-loss phase. The overall model was significant, $R^2 = 0.35$, $F(4, 105) = 14.23$, $p < 0.001$. Only change in SR-merged was a significant mediator within the equation (Table 4, Analysis I). In the planned simple mediation follow-ups, change in SR-merged significantly mediated the relationship between treatment type and weight change; and weight change significantly mediated the relationship between treatment type and change in SR-merged. This indicated a reciprocal relationship between increases in self-regulation and lost weight during the weight-loss phase (Table 4, Analysis I-a).

The SR-merged, SE-merged, and Mood measures (changes from month 6 to month 24) were entered as possible mediators of the relationship between treatment type and weight change during the weight-loss maintenance phase. The overall model was significant, $R^2 = 0.20$, $F(7, 102) = 3.61$, $p = 0.002$. Only change in SE-merged was a significant mediator within the equation (Table 4, Analysis II).

Post Hoc Tests

In post hoc analyses of only the EXP group, a significant quadratic (inverted-U) effect was found during the 24 months of the study in each of the psychological variables, which suggested a reduction in gains acquired during the initial 6 to12 months. Effect sizes (η^2_p) associated with those significant ANOVA models (all p values < 0.001) were stronger than for the corresponding linear relationship for SR-exercise (0.611), SE-exercise (0.417), Mood (0.504), and SR-eating (0.600); but not SE-eating (0.374).

DISCUSSION

Overall, findings associated with the EXP treatment were promising. The absence of significant regain of that group's weight loss of more than 6% was atypical, and represented a notable success (Figure 3).[4,5]

Table 3. Results of multiple regression analyses for the prediction of changes in physical activity and fruit and vegetable intake

Predictor	β	Standard error	R^2	*F*	*df*	p value
Δ Physical activity, baseline-month 6						
Model			0.42	25.96	3, 109	< 0.001
Δ Self-regulation for exercise	0.36	0.19				< 0.001
Δ Self-efficacy for exercise	0.21	0.11				0.028
Δ Overall negative mood	-0.25	0.08				0.003
Δ Physical activity, month 6-month 24						
Model			0.59	9.19	6, 109	0.006
Δ Self-regulation for exercise	0.42	0.28				< 0.001
Δ Self-efficacy for exercise	0.27	0.16				0.044
Δ Overall negative mood	-0.23	0.13				0.093
Δ Fruit and vegetable intake baseline-month 6						
Model			0.52	13.08	3, 109	< 0.001
Δ Self-regulation for controlled eating	0.20	0.04				0.048
Δ Self-efficacy for controlled eating	0.26	0.01				0.013
Δ Overall negative mood	-0.19	0.01				0.049
Δ Fruit and vegetable intake month 6-month 24						
Model			0.46	4.57	6, 109	< 0.001
Δ Self-regulation for controlled eating	0.12	0.04				0.202
Δ Self-efficacy for controlled eating	0.33	0.01				0.080
Δ Overall negative mood	-0.15	0.02				0.352

Δ = change in.

The experimental format not only elucidated psychological correlates of behavioral prerequisites to weight reduction, it highlighted temporal implications for their application within both weight-loss and weight-loss maintenance phases. Innovative treatment components and administrative formats were successfully incorporated within a practical setting that suggests potential for widespread application. The cost associated with implementation of the EXP treatment approximated US$400 per participant. This was about 10% to 15% of the cost estimated for both the Oxford CBT and an average of the 3 commercial weight-loss programs currently having the strongest market share.[75]

Specific Findings

Part 1 clearly demonstrated the superiority of the EXP treatment over the COM treatment for weight loss at all measured time points. Regain of weight in the EXP group was only a nonsignificant 0.7% of participants' original weight, which has not been observed in the great majority of treatment studies of individuals with obesity where a climb toward baseline weight (or higher) almost always occurred after about 6 months of loss.[4,5] When contrasted with the Oxford CBT (Figure 1), the EXP treatment had a far less acute slope of weight regain and a much larger proportion of participants who maintained ≥ 5% weight loss at month 24 (52.7% vs 38.8%) (Figure 3).[21] This suggested *substantial* improvements in health risks within the EXP group. In Part 2, effect sizes for increases in both PA and FV during the weight-loss phase were about twice as large in the EXP group. Those large behavioral improvements demonstrated a partial reversal during the second year. In Part 3, within the weight-loss phase, effect sizes of improvements on the psychosocial predictors of PA and FV within the EXP group were also double those in the COM group (all large effects with *d*-values of 0.96-1.66). However, an inversion of some of those gains appeared between month 12 and month 24. Because these trajectories could adversely impact participants' weight-management behaviors and weight in subsequent years, extensions of this research are presently evaluating noninvasive methods to lessen such "slippage" through periodic telephone and/or e-mail follow-ups after in-person treatment components conclude. These follow-up contacts will aim to bolster the use of previously addressed self-regulatory skills and feelings of control over behaviors associated with weight management. Part 3 of this study determined that changes in self-regulation, self-efficacy, and mood during the full 6 months of the weight-loss phase best-predicted increased PA and FV. Findings also suggested that changes in self-regulation applied to eating changes might be particularly important within the first several months of treatment. Changes in those 3 psychological factors over the entire weight-maintenance phase (months 6-24) best predicted a favorable direction for PA and FV. However, findings suggested that self-regulation for controlled eating is especially important during the second year. When the above results were consolidated, important findings also emerged. Data suggested that an emphasis on *self-regulation* during the weight-loss phase, and an emphasis on *self-efficacy* during the weight-loss maintenance phase, will optimize weight-management

Table 4. Results from multiple mediation and reciprocal effects analyses (N = 110)[a]

Predictor	Mediator[c]	Outcome	Path[b] *a* β ± standard error (p value)	Path *b* β ± standard error (p value)	Path *c* β ± standard error (p value)	Path *c'* β ± standard error (p value)	Indirect effect β ± standard error (95% CI)
Analysis I: Weight-loss phase (multiple mediation)							
Treatment type[d]	Δ Self-regulation	Δ Weight	1.13 ± 0.24 (< 0.001)	-2.13 ± 0.70 (0.002)	-8.03 ± 1.44 (< 0.001)	-4.61 ± 1.55 (0.004)	-2.42 ± 1.05 (-4.81, -0.65)
Treatment type	Δ Self-efficacy	Δ Weight	0.77 ± 0.24 (0.002)	0.20 ± 0.71 (0.780)	-8.03 ± 1.44 (< 0.001)	-4.61 ± 1.55 (0.004)	0.16 ± 0.71 (-1.27, 1.71)
Treatment type	Δ Mood	Δ Weight	-0.86 ± 0.17 (< 0.001)	1.35 ± 0.79 (0.093)	-8.03 ± 1.44 (< 0.001)	-4.61 ± 1.55 (0.004)	-1.16 ± 0.71 (-2.79, 0.06)
Analysis I-a: Weight-loss phase (simple mediation for reciprocal effects analysis)							
Treatment type	Δ Self-regulation	Δ Weight	1.13 ± 0.24 (< 0.001)	-2.27 ± 0.54 (< 0.001)	-8.03 ± 1.44 (< 0.001)	-5.46 ± 1.47 (< 0.001)	-2.56 ± 0.81 (-4.53, -1.23)
Treatment type	Δ Weight	Δ Self-regulation	-8.03 ± 1.44 (< 0.001)	-0.06 ± 0.15 (< 0.001)	1.13 ± 0.24 (< 0.001)	0.63 ± 0.25 (0.015)	0.51 ± 0.14 (0.26, 0.82)
Analysis II: Weight-loss maintenance phase (multiple mediation)							
Treatment type	Δ Self-regulation	Δ Weight	-0.17 ± 0.20 (0.415)	-5.91 ± 1.52 (< 0.001)	1.91 ± 2.88 (0.509)	1.42 ± 2.72 (0.604)	0.98 ± 1.21 (-2.20, 3.32)
Treatment type	Δ Self-efficacy	Δ Weight	-0.38 ± 0.20 (0.055)	2.87 ± 1.75 (0.104)	1.91 ± 2.88 (0.509)	1.42 ± 2.72 (0.604)	-1.09 ± 0.77 (-3.77, -0.10)
Treatment type	Δ Mood	Δ Weight	0.16 ± 0.14 (0.055)	3.81 ± 2.07 (0.068)	1.91 ± 2.88 (0.509)	1.42 ± 2.72 (0.604)	0.60 ± 0.60 (-0.14, 2.36]

[a] Analyses are based on a bootstrapping procedure for multiple mediation incorporating 20,000 resamples.[74]
[b] Path *a* = predictor→mediator; Path *b* = mediator→outcome; Path *c* = predictor→outcome; Path *c'* = predictor→outcome, controlling for the mediator.
[c] Δ = change from baseline-month 6 for Analysis I and I-a; or baseline-month 24, controlling for changes from baseline-month 6 (for Analysis II).
[d] For treatment type, 0 = comparison group, 1 = experimental group.
Δ change in; 95% CI = 95% confidence interval.

outcomes. During the weight-loss phase, changes in self-regulation and weight appeared to reinforce one another mutually. Overall, results supported the EXP treatment's ability to improve mood and increase self-regulation and self-efficacy related to both physical activity and healthy eating behaviors.

Fit with Previous Research

Although most weight-loss treatments employ an educational approach that focuses upon restricting energy intake, the use of cognitive-behavioral methods and exercise within weight-loss interventions is not novel. However, comprehensive reviews suggest that even the most state-of-the-art, theory-based approaches primarily targeting eating changes have been unsuccessful beyond the very short term.[4] Within this report, findings from a previously described[17] and tested[21] weight-loss/weight-loss maintenance protocol (Oxford CBT) was contrasted with the EXP treatment because of its theoretical similarity, similar research design, and seemingly strong cognitive-behavioral approach. As has been typical, however, exercise was treated as a favorable adjunct to nutritional change rather than a key component of that protocol, and its maintenance of weight loss was unsuccessful.[21] Guided by suggestions of the consistent relationship between exercise and maintained weight loss,[23-25] previous experimental research on (modifiable) psychosocial correlates of weight loss,[40-42,76] our own program of research on the generalization of exercise-induced psychological changes to eating changes during the short term,[33,77-85] and recommendations from the National Institutes of Health to address adherence to exercise and establish relevant behavioral skills before attempting weight loss,[22] we *substantially* modified and extended previous approaches. We incorporated assumptions that cognitive-behaviorally supported exercise can facilitate changes in eating and weight through associated psychological changes. Although the present data cannot determine precisely what treatment component(s) or implementation methods were most associated with the present positive results, future research designs might facilitate a more comprehensive decomposition of findings to determine the most salient treatment components and, thus, further enhance effects. We encourage future related research to also study weight-loss and weight-loss maintenance phases separately through behavioral changes and their psychological predictors, because processes within these phases appear to differ from one another. Continued evaluation of temporal aspects might facilitate a more precise process that further refines the benefits of emphasizing specific treatment components at specific times, which might also vary by personal characteristics (eg, initial weight, psychological profile). The present determination that weight loss might most benefit from a concentration on self-regulation, whereas weight-loss maintenance might most benefit from a concentration on self-efficacy, is a start in that direction. Although this research based the architecture of the EXP treatment and the selection and measurement of behavioral and psychological constructs on social cognitive and self-efficacy theory and the many studies following from those paradigms, additional theories (eg, self-determination theory, theory of planned behavior) might also serve as a basis in extensions of this research. The contrast of those results with the present findings will undoubtedly be instructive.

Study Limitations

To increase confidence in findings and assess their generalizability for application, present limitations such as the use of a homogeneous sample of primarily white and middle-class women who were motivated enough to volunteer for treatment require attention. Thus, replications with men, with other racial/ethnic and socioeconomic groups, and possibly with participants who were strongly referred by medical practitioners (to minimize effects of volunteerism) will be beneficial. Replications are also required with overweight participants and participants with a more severe degree of obesity (ie, class 3/morbid obesity). Other limitations of this research indicate a need for better controls for social support and expectation effects that are likely to bias results when interventions differ in length and amount of in-person contact, as was the case here.[86] Thus, the use of an attention-matched, or a wait-list, control group might also be useful in replications of this research. Although the repeated-measures design of this study was a strength, multiple administrations of the same self-report instrument increases its measurement error.[87] Although it is difficult to accomplish in field settings (that benefit the applicability of findings[88,89]), the use of more objective and comprehensive measures of exercise (eg, accelerometry) and dietary intake (eg, more extensive nutrition recall instruments) would increase accuracy of the behavioral outcomes. Within the present study, however, because of the length of time required for completion of the seven self-report surveys, any additional time burden placed on participants might have challenged the quality of their responses.[90]

CONCLUSION

Although the above limitations should be acknowledged, and replications are needed, the EXP treatment has considerable possibilities for dissemination. Its format allows for low-cost implementation in community-based health-promotion settings by staff members with general wellness credentials. It also has a strong potential for physician referral. Whereas pharmacologic and surgical interventions for obesity are available, improving physical activity and eating behaviors will effectively address obesity and their associated health risks for *most* affected individuals. Despite the fact that sustained improvements in eating and exercise have been difficult for behavioral medicine to effectuate, the present research introduced innovative behavior-change methods that empowered individuals to effectively deal with day-to-day barriers that consistently served as impediments to maintaining clinically important losses in body weight. The use of manageable amounts of exercise to build the self-regulatory skills and improvements in mood that promote a newfound sense of control over eating behaviors might prove to be one of the most viable solutions to the longstanding epidemic of obesity. ❖

Disclosure Statement

The authors have no conflicts of interest to disclose.

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