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Supported Exercise Improves Controlled Eating and Weight Through Its Effects on Psychosocial Factors: Extening a Systematic Research Program Toward Treatment Development

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Supported Exercise Improves Controlled Eating and Weight through Its Effects on Psychosocial Factors: Extending a Systematic Research Program Toward Treatment Development

James J Annesi, PhD

Abstract

Background: Behavioral weight-loss treatments have been overwhelmingly unsuccessful. Many inadequately address both behavioral theory and extant research—especially in regard to the lack of viability of simply educating individuals on improved eating and exercise behaviors.

Objective: The aim was to synthesize research on associations of changes in exercise behaviors, psychosocial factors, eating behaviors, and weight; and then conduct further direct testing to inform the development of an improved treatment approach.

Methods: A systematic program of health behavior-change research based on social cognitive theory, and extensions of that theory applied to exercise and weight loss, was first reviewed. Then, to extend this research toward treatment development and application, a field-based study of obese adults was conducted. Treatments incorporated a consistent component of cognitive-behaviorally supported exercise during 26 weeks that was paired with either standard nutrition education (n = 183) or cognitive-behavioral methods for controlled eating that emphasized self-regulatory methods such as goal setting and caloric tracking, cognitive restructuring, and eating cue awareness (n = 247).

Results: Both treatment conditions were associated with improved self-efficacy, self-regulation, mood, exercise, fruit and vegetable consumption, weight, and waist circumference; with improvements in self-regulation for eating, fruit and vegetable consumption, weight, and waist circumference significantly greater in the cognitive-behavioral nutrition condition. Changes in exercise- and eating-related self-efficacy and self-regulation were associated with changes in exercise and eating (R^2 = 0.40 and 0.17, respectively), with mood change increasing the explanatory power to R^2 = 0.43 and 0.20. Improved self-efficacy and self-regulation for exercise carried over to self-efficacy and self-regulation for controlled eating (β = 0.53 and 0.68, respectively).

Conclusions: Development and longitudinal testing of a new and different approach to behavioral treatment for sustained weight loss that emphasizes exercise program-induced psychosocial changes preceding the facilitation of improved eating and weight loss should be guided by our present research.

Introduction

The most current data from the US government indicates that 34% of adults (77 million) are obese (body mass index [BMI] ≥ 30 kg/m^2),[1] causing increased propensities for Type 2 diabetes, hypertension, heart disease, and stroke as degree of overweight increases.[2,3] The rate of obesity has steadily risen over the last several decades,[4] with the more severe levels of obesity (BMI 40 and above) rising 3 times that of class I obesity (BMI 30 to 35 kg/m^2).[5] At any given time, approximately 70% of adults report trying to manage their weight.[6] Weight loss of even less than 5% can result in clinically important improvements in health risks.[7] Although a reduction in caloric intake and an increase in physical activity will reliably reduce excess weight, results of behavioral weight-loss treatments have, overwhelmingly, been poor.[8] When significant weight *is* lost, with very few exceptions, it is regained in short order.[8,9] A pattern of repeated weight loss and regain is associated with increased health risks,[10] and makes weight loss even more difficult in the future.[11,12] Findings suggest that even the most current behavioral methods focused on reduction in caloric intake are largely inadequate,[13] and innovative techniques, possibly through the use of exercise as the central component,[8] should be investigated.[9] On the basis of this present state-of-affairs, this article has 3 aims:

1. To review limitations in the extant research on behavioral weight-loss treatment and describe a systematic program of research that was intended to address some of those limitations
2. To design and carry out a field study based on a new model suggesting a relationship between supported exercise and weight loss through psychosocial channels
3. To inform construction of a treatment, based on present findings, that may be appraised for effect over the long term.

Limitations of Previous Research

One problem with existing treatments is that they typically fail to address methods to sustain weight loss beyond the initial weeks or months. Although research indicates that exercise is the strongest predictor of long-term success with weight loss,[14-16] adherence is usually not sufficiently considered, as attrition from programs is high.[17,18] In many cases, the inclusion of physical activity is either deferred or minimized because it is feared that participants' self-regulation for maintaining an exercise program may dilute their self-regulatory resources for managing their eating.[19] This is understandable because research has suggested self-regulation to be a limited resource that is subject to depletion.[20] Minimal caloric expenditures possible from deconditioned and obese participants[21,22] may also lessen the perceived importance of

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exercise because of its minimal direct impact on weight. Although a "clustering" of improvements in exercise and eating behaviors has been suggested, explanatory mechanisms that may lead to intervention development has been lacking, and cited as a limitation.[23-25]

… less than 4% of adults in North America complete recommended minimum amounts of physical activity, and most consume well in excess of their caloric needs …

Integration of accepted behavioral theory into weight-loss treatment has been sporadic.[26] Treatments often are based on the assumption that providing education in desired behaviors and their beneficial outcomes will alone be sufficient to induce a reduction in caloric consumption and, possibly, an increase in physical activity. This is inconsistent with most theories of behavioral change as well as the realization that, although most adults absolutely know the value of exercise, healthy eating, and an appropriate weight,[27,28] less than 4% of adults in North America complete recommended minimum amounts of physical activity,[29-31] most consume well in excess of their caloric needs,[32] and approximately two-thirds are now at an unhealthy weight.[1]

Interventions that claim a theoretical basis generally have been influenced by established behavioral models in only broad and general terms.[33] Relations of specific psychological variables associated with changes in exercise, eating, and weight loss have not been sufficiently tested in a manner that could easily be translated into practical treatments. Possibly, this is because researchers typically test a proposed set of relationships emanating from a nuanced adaptation of theory that is of interest to them, report on its strengths, weakness, and needs for replication and extension, and move on.[34] Further compromising matters is that specific treatment techniques used have not typically been annotated through a standard taxonomy that could facilitate comparative evaluation of efficacy—especially through their relationship with theory.[35] Thus, conclusions do not often go beyond whether a set of findings might hold promise for predicting or explaining exercise and weight-loss phenomena in future research. There has been minimal concern for systematically evolving their line of inquiry in a manner where treatment, as well as theory, may simultaneously benefit. Albert Bandura referred to this as a paradigm's, "… operative power to guide psychosocial change."[36p248] This is problematic because practitioners are bound by practical constraints when attempting to translate abstract findings into day-to-day use, whereas researchers may have little concern for advancing treatments in real-life settings. What remains is a preponderance of intuitively based treatments, and concerns from the academicians that such treatments are not sufficiently guided by theory and rigorous research.[37]

Systematically Progressing

Since 2000, I, along with a team from varied disciplines from the YMCA of Metropolitan Atlanta, have attempted to address some of the above-stated limitations. Within our research program, the relations of exercise with psychosocial changes and changes in eating behaviors and weight have been evaluated in a systematic manner while maintaining a focus on the practical application of findings. Out of heuristic necessity, issues such as adherence to exercise, exercise and mood change, and effects of exercise on weight loss through psychosocial channels were sequentially addressed. Incorporating recent suggestions,[38,39] much of the research was, accordingly, completed in practical settings. Our research produced a structured exercise support protocol entitled The Coach Approach,[16,40-42] incorporating an array of self-regulatory methods (eg, self-talk, relapse prevention) where manipulation of variables based on social cognitive theory (a theory viewing individuals as directing their own behaviors through self-reflection and self-organization[43-44]) and self-efficacy theory (a theory viewing behaviors as being directed by individuals' feelings of ability[45]) (eg, physical self-concept, barriers self-efficacy[46]) were used to reliably and meaningfully increase adherence to exercise in obese and formerly sedentary adults by an average of 52% over 53 trials.[47] Consistent with previous research,[48] mood also improved and was, additionally, found to be associated with adherence.[47,49,50] Because the research clearly and strongly relates exercise to success with sustained weight loss,[51] we judged this adherence component to be an essential initial step in a progression toward development of effective weight-management treatment. Nutrition components, which were also included in much of the research, incorporated traditional educationally based approaches. This allowed us to probe for and identify salient relationships among psychosocial variables, associated with behaviorally supported exercise, which might ultimately lead to an effective and reliable intervention.

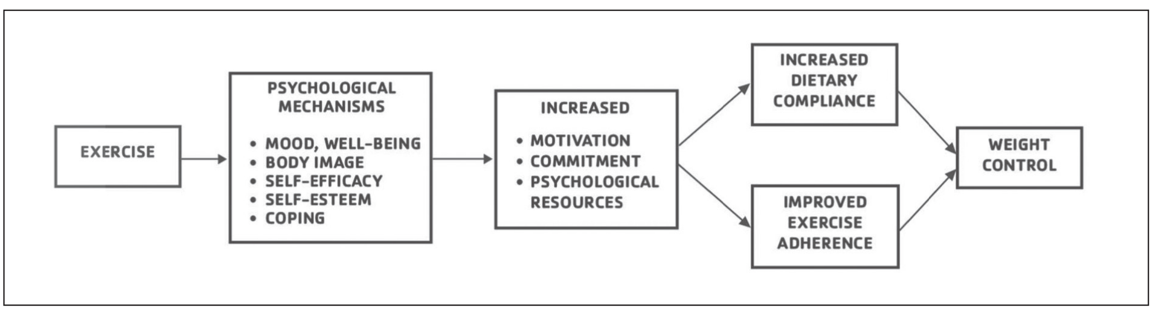

Figure 1. Proposed psychological pathways linking exercise and weight control within the Baker and Brownell model.[1]

[1] Adapted, with permission, from Baker CW, Brownell, KD. Physical activity and weight loss: physiological and psychological mechanisms. In: Bouchard C, editor. Physical activity and obesity. Champaign, IL: Human Kinetics; 2000. p 315.

Thus, through the use of an overarching framework of social cognitive and self-efficacy theory,[43,44] our program of research progressively built upon findings, suggesting the following:

1. There is empirical strength in the basic social cognitive model proposed in 2000 by Baker and Brownell (Figure 1),[52] particularly as in the contribution of exercise program-induced changes in mood, body image, self-efficacy, and coping leading to increased physical activity, improved eating, and weight loss.[47,50,53-58]
2. Self-efficacy and self-regulation for both exercise and controlled (well-managed) eating are distinct[59] and essential constructs in the prediction of physical activity and eating changes, and weight loss.[60-64]
3. There are significant effects of exercise-induced mood change on weight loss and psychosocial predictors of weight loss[55,64-69]—especially in the effect that mood change has in enhancing and/or undermining self-efficacy and self-regulation (such as with emotional eating [emotion-triggered eating]).[62,70]
4. There is a carry-over effect from improvements in self-efficacy and self-regulation for exercise to self-efficacy and self-regulation for controlled eating,[60,64,70] which is consistent with recent research on women from Portugal,[71,72] Finland,[73] and Baker and Brownell's model.[52]

The strong positive relationship between changes in self-regulation for exercise and self-regulation for eating[60,64,70-72] was especially noteworthy because laboratory research suggested, quite definitively, that self-regulation for exercise would deplete self-regulation for eating when these behaviors are attempted in close temporal proximity (viewing self-regulation as a limited resource that is readily depleted).[19,74] Rather, consistent with the "training hypothesis" of self-regulation (viewing self-regulation as potentially improving with practice),[75,76] it was recently indicated that when self-regulatory skills were taught in first exercise, then eating, contexts (rather than drawn from participants' innate abilities as had been the case in most of the previous research), a *strengthening* of the skills for controlled eating occurred.[60,64] As previously suggested, improvements in self-efficacy for exercise appeared to carry over to improvements in controlled eating because of a generalization of feelings of ability to manage an array of behaviors consistent with weight control.[52] Findings also suggested that increased satisfaction with the physical self (which was associated with persistence with exercise more than actual physiological changes[77-81]) and self-regulatory skill usage[82] are associated with maintained weight loss. These findings are consistent with studies suggesting the positive effects of self-regulation on improved eating (ie, fruit and vegetable consumption) and on weight loss sustained at two-year follow-ups,[83,84] and hypothesized that feelings of accomplishment (ie, self-efficacy) fostered persistence.

Additionally, findings indicated that a significant improvement in mood requires a minimum of only about 2 sessions of moderate exercise per week,[85,86] with no dose-response effect (ie, more exercise was not associated with greater change in mood),[87,88] rather than the "public health dose" of at least 5 sessions per week (ie, 17.5 kcal/kg/week, or approximately 150 minutes per week) previously suggested.[89] Moreover, it was determined that exercise durations and intensities could be purposefully adjusted to induce acute improvements in post-exercise feeling states (eg, increased revitalization; decreased physical exhaustion) that are consistent with both long-term mood improvements[46,90,91] and, of key importance, adherence to exercise through their reinforcement effects.[47,92-94] Although the indirect relationship between exercise program participation and weight loss was strong,[50,58,62] less than 15% of the weight loss, across studies, was attributable to caloric expenditures associated with exercise. This further supported the contention that the association of exercise program participation with weight loss in obese and deconditioned individuals is associated more with changes in psychosocial variables than direct caloric expenditure. Through this research program, important proposed relationships were suggested and are presented graphically in Figure 2.

Assessing Propositions Within a New Model

Intervention researchers have long been underinformed about the specific function that exercise plays in weight loss and, more specifically, how exercise-related changes in mood, self-efficacy, and self-regulation may affect controlled eating. After review and consolidation of our stream of findings, specific relationships emerged as important for treatment-based

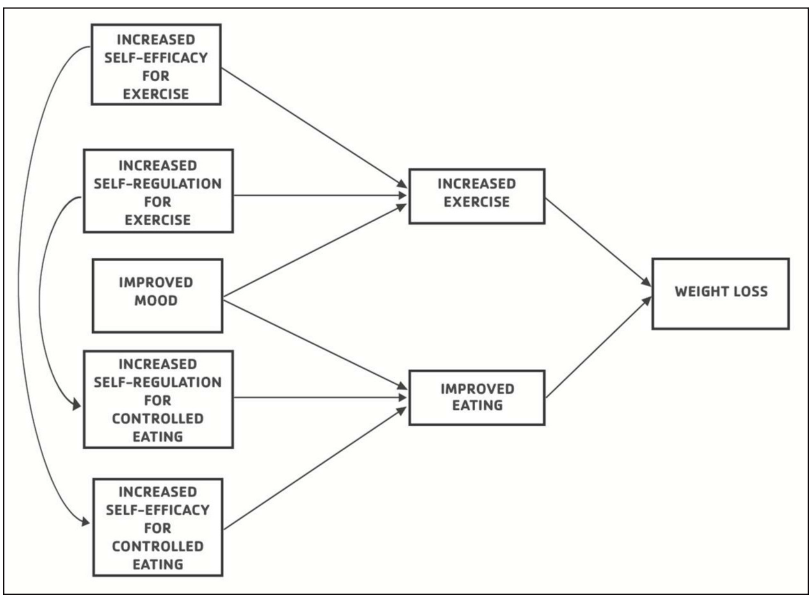

Figure 2. Proposed pathways of treatment-induced psychological changes, behavioral changes, and weight loss derived from a synthesis of research.

testing. Thus, for the present study, we incorporated conditions of: 1) The Coach Approach exercise adherence protocol coupled with nutrition education, and 2) The Coach Approach protocol coupled with a cognitive-behavioral approach to reducing caloric intake that complemented the behavioral methods already being employed within the exercise context.[a] This facilitated a contrast of treatment effects and allowed testing of proposed relationships among variables. Severely obese adults were selected for testing to allow investigation with a difficult population, but one in great need.

Hypothesized Findings

Consistent with both theory and the synthesis of previous findings, pairing The Coach Approach with the proposed cognitive-behavioral approach to reducing calories was expected to demonstrate significantly greater improvements in self-regulation and self-efficacy for controlled eating, food consumption, and weight, than The Coach Approach paired with traditional nutrition education.

In terms of relationships of variables identified for testing, improvements in domain-specific feelings of ability to overcome perceived barriers (ie, self-efficacy) and use of behavioral skills to overcome barriers (ie, self-regulatory skill usage) were expected to significantly predict improvements in both exercise and eating behaviors. Changes in mood were expected to strengthen these relationships (eg, mood changes would increase the explanatory power of self-efficacy and self-regulation). Improvements in both self-efficacy and self-regulatory skill use for exercise were expected to predict improved self-efficacy and self-regulation for controlled eating. It also was expected that improvements in mood would be associated with a minimum of 2 exercise sessions per week, and a greater frequency would not be associated with greater improvement. Additionally, it was anticipated that change in mood would be more strongly associated with change in self-efficacy to control emotional eating than with other dimensions of self-efficacy for controlled eating, and that a very small portion of the observed weight loss (<15%) would be directly attributable to caloric expenditure associated with exercise.

Study Methods

Participants

Men and women responded to advertisements in local newspapers soliciting volunteers for research incorporating physical activity and nutrition instruction for weight loss. Inclusion criteria were: 1) minimum age of 21 years, 2) BMI ≥ 35 kg/m^2, 3) no regular exercise within the previous year (less than 20 minutes per week on average), and 4) a goal of weight loss. Exclusion criteria were current or soon-planned pregnancy and/or taking medications prescribed for weight loss or a psychological or psychiatric condition. A wellness specialist assessed BMI in a private office before participants were accepted into the study. A written statement of adequate physical health to participate was required from a physician. Appropriate institutional review board approval and written consent from all participants was obtained.

There was no significant difference in proportion of women (overall 82.6%), age (overall mean = 42.5 years, standard deviation [SD] = 10.0), BMI (overall mean = 41.7 kg/m^2, SD = 6.5), and racial make-up (overall 45% White, 51% African American, and 4% of other racial/ethnic groups) between participants randomly assigned to a treatment of The Coach Approach plus standard nutrition education (Nutrition Education group; n = 183) and The Coach Approach plus a version of cognitive-behavioral methods applied to caloric reduction (Cognitive-Behavioral Nutrition group; n = 247). The socioeconomic strata of most participants (90%) were classified as middle class. Within the Nutrition Education condition, some individuals might have been exposed to unplanned nutritional lectures and support within 1 of the 6 study facilities. Thus, their data were omitted, which explains the difference in group sample sizes. Exploratory analyses indicated that the omitted individuals did not significantly differ from the overall pool of participants on any personal characteristic or baseline measure.

Measures

Self-efficacy

Self-efficacy for exercise (perceived ability to overcome barriers to completing exercise) was measured by the Exercise Self-Efficacy Scale.[95] It requires responses to 5 items that begin with the stem, "I am confident I can participate in regular exercise when:" (eg, "I am tired," "I have more enjoyable things to do"), ranging from 1 (not at all confident) to 7 (very confident). Internal consistencies were reported to range from 0.76 to 0.82, and test-retest reliability over 2 weeks was 0.90.[96]

Self-efficacy for controlled eating (perceived ability to overcome barriers to managing one's eating) was measured by the Weight Efficacy Lifestyle Questionnaire.[97] It is made up of 5 subscales of 4 items each, derived from factor analysis, that are Negative Emotions (eg, "I can resist eating when I am depressed [or down"), Social Pressure (eg, "I can resist eating even when others are pressuring me to eat"), Availability (eg, "I can resist eating even when high-calorie foods are available"), Physical Discomfort (eg, "I can resist eating when I feel uncomfortable"), and Positive Activities (eg, "I can resist eating when I am watching TV"). Responses range from 0 (not at all confident) to 9 (very confident). Individual subscale responses are summed for a total score. Internal consistencies were reported to range from 0.70 to 0.90.[97] The predictive validity of the Weight Efficacy Lifestyle Questionnaire for weight loss has been supported in multiple studies.[98]

Self-regulation

Self-regulation for exercise and self-regulation for eating were separately measured by modified versions of a scale where items are based on intervention content.[99] An example of a self-regulation for exercise item for the present study was, "I set physical activity goals." An example of a self-regulation for eating item was, "I say positive things to myself about eating well." Following the taxonomy by Abraham and Michie,[35] items measured self-regulatory skills related to intention formation, barrier identification, specific goal setting, review of behavioral goals, self-monitoring of behavior, feedback on performance, self-talk, relapse prevention, and time management. Each scale required responses to 10 items ranging from 1 (never) to 5 (often). In a previous version, internal consistency (0.75), test-retest reliability over 2 weeks (0.77), and predictive validity were supported.[100] Construct validity was indicated because the measure partially mediated the relationship between self-efficacy and physical activity.[100] In separate testing of the present versions, the internal consistency of the self-regulation for physical activity scale was 0.79, and the test-retest reliability over 2 weeks was 0.78.[64] For self-regulation for eating, the internal consistency was 0.81, and test-retest reliability was 0.74.[64]

Mood

Mood was measured by Total Mood Disturbance—an aggregate measure of the Profile of Mood States Short Form scales of Tension (eg, anxious), Depression (eg, sad), Fatigue (eg, weary), Confusion (eg, bewildered), Anger (eg, annoyed), and Vigor (eg, energetic) (5 items for each of the 6 subscales).[101] Respondents rate feelings over the past week ranging from 0 (not at all) to 4 (extremely). Internal consistency for the subscales was reported to range from 0.84 to 0.95, and test-retest reliability at 3 weeks averaged 0.69.[101] Concurrent validity was suggested through contrasts with accepted measures such as the Beck Depression Inventory, Manifest Anxiety Scale, and Minnesota Multiphasic Personality Inventory.[101]

Exercise

Volume of exercise was measured by the Godin Leisure-Time Exercise Questionnaire.[102] It required entry of weekly frequencies of strenuous ("heart beats rapidly") (eg, running, basketball, vigorous swimming), moderate ("not exhausting") (eg, fast walking, easy bicycling), and light ("minimal effort") (eg, easy walking, yoga) exercise for "more than 15 minutes" per session. These responses are multiplied by 9, 5, and 3 standard metabolic equivalents (METs), respectively, and then summed. For adults, test-retest reliability over 2 weeks was reported to be 0.74.[102] Construct validity was supported by significant correlations of scores with accelerometer and VO_{2max} measurements of exercise volume.[103,104] Using this measure for an individual of 115 kg, a score of 10 and 20 would indicate an approximate weekly expenditure from exercise of 450 and 900 calories, respectively.

Food Consumption

A survey recalling the number of servings of fruits and the number of servings of vegetables consumed "in a typical day" ("looking back over the last month"), based on the US Food Guide Pyramid and its descriptions of foods and portion sizes, was used. The quantity of fruit and vegetable servings reported consumed was summed. Research suggests the adequacy of this measure for both its responsiveness in the context of the present nutrition treatments and to minimize participant burden.[105] Test-retest reliability over 2 weeks averaged 0.82, and concurrent validity was suggested through significant correlations with longer, more invasive, food frequency questionnaires.[106]

Pilot research suggested that the participant burden with administration of a full food frequency questionnaire (sometimes requiring approximately 60 minutes to complete), along with the aforementioned surveys within this investigation, would compromise respondents' attention and degrade the validity of responses. Thus, because research suggests that fruit and vegetable consumption, alone, is a good predictor of overall caloric consumption,[107,108] the present measure was selected.

Weight and Waist Circumference

A recently calibrated digital scale was used to measure weight (kg), and a tape measure was used to measure waist circumference (cm) at the umbilicus. Although used less frequently than weight, recent research suggests waist circumference to be a superior measure for the prediction of health risks.[109,110]

Procedure

Each participant reported to a YMCA, received an orientation to study processes associated with his or her group, and was provided full access to the facility for the duration of the investigation.

Exercise Support Component

The exercise adherence support component was identical in both the Nutrition Education and Cognitive-Behavioral Nutrition groups. It consisted of a standard protocol (ie, The Coach Approach) of 6 one-hour meetings with a trained wellness specialist, spaced across 26 weeks and supported by a computer program.[17,47] These one-on-one sessions included an orientation to exercise apparatus and facilities, but most time was spent within an office setting on an array of cognitive-behavioral methods intended to foster adherence. Following recent suggestions,[111,112] long-term goals were identified, documented, and broken down into process-oriented short-term goals where ongoing progress was tracked graphically. Instruction in additional self-regulatory skills such as restructuring unproductive thoughts, addressing cues to exercise, and preparedness for occurrences of barriers to exercise and "slips" in one's exercise routine (ie, relapse prevention[113]) was given during the sessions. A summary of each self-regulatory skill also was provided for participants' ongoing reference. In order that behavioral treatments may be accurately contrasted with others, Abraham and Michie[35] recommended a standardized description of their components. According to their taxonomy of behavior change techniques,[35] the following methods were included within The Coach Approach sessions according to a clearly defined protocol: 1) provision of information on consequences, 2) prompting intention formation, 3) prompting barrier identification, 4) provision of encouragement, 5) setting graded tasks, 6) provision of instruction in desired behaviors, 7) prompting specific goal setting, 8) prompting review of behavioral goals, 9) prompting self-monitoring of behavior, 10) provision of feedback on performance, 11) teaching the use of prompts or cues, 12) establishment of a behavioral contract, 13) facilitating social supports, 14) prompting self-talk, 15) teaching relapse prevention, 16) addressing stress management, and 17) facilitating time management methods.

Specific modalities used in exercise plans (eg, walking or stationary cycling) were based on each participant's preference. Cardiovascular exercise progressed from a minimum of 20 minutes at a moderately light to moderately hard intensity according to the Rate of Perceived Exertion scale,[114] which was explained to participants. Exercise sessions could be completed inside or outside of the YMCA facilities. Widely used recommendations for volume of weekly exercise (ie, 150 minutes of moderate aerobic physical activity[115]) were described, but it was also suggested that *any* volume of exercise may be beneficial.

Nutrition Components

The nutrition component of the treatments varied by group. In the Nutrition Education group, a standardized nutrition education protocol[116] of 6 one-hour sessions was administered over 3 months. These sessions, however, began between 4 and 6 weeks after initiating The Coach Approach exercise support protocol. They were led by a certified wellness specialist in a group format. Examples of program components were: understanding carbohydrates, protein, fats, and calories; using the US Food Guide Pyramid; menu planning; and developing a plan for snacking. An emphasis was placed on participants understanding healthy eating. Treatment techniques, based on Abraham and Michie's taxonomy,[35] included: 1) provision of information on consequences, and 2) general encouragement.

Changes in volume of exercise and fruit and vegetable consumption explained a significant portion of the variance in changes in weight …

The Cognitive-Behavioral Nutrition group had the identical format for meeting times and length as the Nutrition Education group, but components substantially differed. They also followed a standardized protocol. It included: establishing caloric goals and logging daily food and calorie intake, regular self-weighing, cognitive restructuring, relapse prevention training, understanding cues to overeating, and relaxation strategies. An emphasis was placed on increasing participants' self-regulatory skills that could be used to manage their eating. Following Abraham and Michie's taxonomy,[35] with the exception of establishment of a behavioral contract (which was not used), the same array of behavior change techniques used in The Coach Approach exercise support component was incorporated here. In both treatment conditions, increasing intake of fruits and vegetables was emphasized.

No participant was in both treatment groups. Wellness specialists were trained in the protocols (with no overlap between those instructing the educational or cognitive-behavioral nutrition components), and were blind to the purposes of the investigation. Fidelity of treatment protocols was assessed by trained staff and, if deviations occurred, corrective measures were immediately taken by YMCA supervisors in cooperation with study administrators. Assessments were administered in a private area at baseline, week 13, and week 26 by Master's level health educators.

Data Analyses

An intention-to-treat design was incorporated. Thus, data from all participants initiating treatment were retained, regardless of their compliance. To account for missing data, multiple imputation[117] was used. This method is favorable because it effectively represents uncertainty in missing values.[118] Results were, however, nearly identical to the more straightforward method of last-observation-carried forward, often used in research on weight loss.[72,119] Data from week 13 were used to improve imputation, where applicable. Consistent with related research[24] and recent suggestions,[120] change scores were the unadjusted difference between scores from baseline and scores from week 26. Statistical significance was set at $\alpha = 0.05$ (2-tailed).

Initially, a series of mixed-model repeated measures analysis of variances (ANOVAs) were conducted. This statistical method simultaneously assesses both within- and between-group differences. Thus, the statistical significance of within-group changes in Exercise Self-Efficacy, self-regulation for exercise, Weight Efficacy Lifestyle (self-efficacy for controlled eating), self-regulation for controlled eating, Total Mood Disturbance, exercise, fruit and vegetable consumption, weight, and waist circumference scores occurring over the 26 weeks was assessed; while also determining whether there were significant differences in those changes between the Nutrition Education and Cognitive-Behavioral Nutrition groups.

Next, to assess the viability of proposed relationships among study variables, data from both treatment conditions were aggregated (because the relationships proposed were not specific to a particular treatment condition). Two hierarchical multiple regression analyses were conducted that assessed the ability of changes in self-regulation, self-efficacy, and mood to predict exercise and eating changes. In the first regression equation, the first block of analyses assessed the variance in change in volume of exercise accounted for through simultaneous entry of Exercise Self-Efficacy and self-regulation for exercise changes. In the second regression equation, the first block assessed the variance in change in fruit and vegetable consumption accounted for through simultaneous entry of Weight Efficacy Lifestyle and self-regulation for controlled eating changes. Change in Total Mood Disturbance was subsequently entered as an additional predictor in both of the regression equations. Bivariate regression analyses then assessed the ability of change in Exercise Self-Efficacy to predict Weight Efficacy Lifestyle change, and the ability of change in self-regulation for exercise to predict self-regulation for controlled eating change. Finally, the amount of the variance in weight and waist circumference change explained by exercise and fruit and vegetable consumption change was assessed through multiple regression.

Consistent with previous research,[17,86] a one-way ANOVA was used to test whether there was a significant difference in Total Mood Disturbance change whether a mean of 0 to 1.9, 2.0 to 3.9, or 4.0 to 7.0 days of moderate exercise per week was completed. These time frames were derived from aforementioned research assessing minimal exercise volumes required for significant mood changes to occur.[17,86,89] Also, correlational analysis was used to test whether Total Mood Disturbance change was related to change in the Negative Emotions subscale of the Weight Efficacy Lifestyle Questionnaire (ie, self-efficacy to control emotional eating) scores more strongly than scores on the other 4 subscales of that survey. Consistent with previous research,[63] METs, derived from the Godin measure of exercise,[102] were converted to energy expenditures to estimate the percentage of weight loss associated with exercise over the course of the investigation using a recently validated formula.[121] All analyses were conducted using SPSS software, version 15.0 (SPSS, Chicago, IL).

Results

Attendance in exercise support (overall mean = 4.2, SD = 0.9 [70%]) and nutrition treatment (overall mean = 4.1, SD = 1.0 [68%]) sessions did not significantly differ by group. There also was no significant difference in any baseline score between participants in the Nutrition Education and Cognitive-Behavioral Nutrition groups. There was no group difference in participants completing the 26-week investigation (overall 76%). Significant overall changes were found during 26 weeks in all measures ($p < 0.001$). Descriptive statistics and within-group changes derived from follow-up dependent *t*-tests are reported in Table 1. Improvements were significantly greater for the Cognitive-Behavioral Nutrition group in self-regulation for controlled eating, $F(1, 428) = 5.83$, $p = 0.02$, $\eta^2_p = 0.013$; fruit and vegetable consumption, $F(1, 428) = 8.80$, $p = 0.003$, $\eta^2_p = 0.020$; weight, $F(1, 428) = 5.15$, $p = 0.02$, $\eta^2_p = 0.012$; and waist circumference, $F(1, 428) = 7.47$, $p = 0.007$, $\eta^2_p = 0.017$ (Table 1, with significant differences annotated by different superscripts between groups on the same measure). In the Nutrition Education group, 40 (21.9%) participants lost at least 5% of their original body weight, and 9 (4.9%) lost at least 10%. In the Cognitive-Behavioral Nutrition group, 83 (33.6%) participants lost at least 5% of their original weight and 21 (8.5%) lost at least 10%.

Changes in Exercise Self-Efficacy and self-regulation for exercise significantly predicted change in exercise volume (Table 2). Changes in Weight Efficacy Lifestyle and self-regulation for eating significantly predicted change in fruit and vegetable consumption (Table 2). Entry of Total Mood Disturbance change significantly improved the explained variances in both equations (Table 2). Change in Exercise Self-Efficacy significantly predicted Weight Efficacy Lifestyle change, $\beta = 0.53$, SE = 0.13, $p < 0.001$, and change in self-regulation for exercise significantly predicted self-regulation for controlled eating change, $\beta = 0.68$, SE = 0.03, $p < 0.001$. Changes in volume of exercise and fruit and vegetable consumption explained a significant portion of the variance in changes in weight, $R^2 = 0.28$, $F(2, 427) = 81.56$, $p < 0.001$, and waist circumference, $R^2 = 0.28$, $F(2, 427) = 83.66$, $p < 0.001$, with changes in both predictors significantly contributing, uniquely, to the variances explained, βs = -0.43 (SE = 0.01) and -0.19 (SE = 0.14), and -0.45 (SE = 0.02) and -0.17 (SE = 0.17), respectively, all p values <0.001.

Change in Total Mood Disturbance significantly differed at exercise frequencies of 0 to 1.9 days (n = 194; mean = -2.62, SD = 9.97), 2.0 to 3.9 days (n = 129; mean = -14.47, SD = 17.16), and 4.0 to 7.0 days (n = 107; mean = -16.48, SD = 14.45) per week, $F(2, 427) = 47.50$, $p < 0.001$, $\eta^2 = 0.182$. A Bonferroni follow-up test indicated that the participants completing 2.0 to 3.9 and 4.0 to 7.0 days per week of exercise demonstrated significantly greater reduction in Total Mood Disturbance than those completing 0 to 1.9 days, but they did not significantly differ from one another. The correlation between Total Mood Disturbance change and change in the Negative Emotion subscale was significant, $r = -0.31$, $p < 0.001$, and stronger than those of the other 4 subscales of the Weight Efficacy Lifestyle Questionnaire. Only 12.9% of the observed weight loss was accounted for through exercise completed over the course of the investigation.

Discussion

Consolidation of Findings

Initially, a description of the problem of treating obesity with standard methods, and a review of a research program suggesting an alternate treatment route was given. An experimental research design was then established on the basis of a review of theory and our previous findings

Table 1. Changes in study measures during the 26-week investigation

	Baseline		Week 26		Change during 26 weeks		
	Mean	SD	Mean	SD	$\text{Mean}_{\text{change}}$	SD	95% CI
Nutrition Education group (n = 183)							
Exercise Self-Efficacy	29.67	11.59	33.19	11.21	3.51[a]	10.07	2.04, 4.98
Self-regulation for exercise	20.13	5.60	26.31	7.72	6.17[a]	7.87	5.03, 7.32
Weight Efficacy Lifestyle	98.93	33.73	115.91	33.73	16.98[a]	30.20	12.57, 21.38
Self-regulation for controlled eating	21.31	6.04	25.45	6.93	4.15[a]	5.97	3.28, 5.02
Total Mood Disturbance	22.17	16.52	13.30	18.42	-8.87[a]	14.44	-10.98, -6.77
Exercise	9.61	9.87	22.95	19.25	13.34[a]	17.13	10.84, 15.84
Fruits and vegetables	4.46	2.08	4.97	2.17	0.51[a]	1.40	0.31, 0.71
Weight (kg)	118.88	18.83	116.35	17.96	-2.53[a]	4.44	-3.17, -1.88
Waist circumference (cm)	122.46	13.61	118.95	13.56	-3.51[a]	6.61	-4.47, -2.54
Cognitive-Behavioral Nutrition group (n = 247)							
Exercise Self-Efficacy	29.87	11.49	32.52	11.37	2.64[a]	10.67	1.31, 3.98
Self-regulation for exercise	20.87	4.99	27.28	7.36	6.41[a]	7.53	5.47, 7.35
Weight Efficacy Lifestyle	96.68	35.10	117.07	37.46	20.39[a]	32.56	16.31, 24.47
Self-regulation for controlled eating	21.34	5.94	26.89	7.40	5.55[b]	6.04	4.80, 6.31
Total Mood Disturbance	20.44	16.63	10.27	16.84	-10.17[a]	15.42	-12.11, -8.24
Exercise	9.47	9.81	25.31	18.45	15.84[a]	18.36	13.53, 18.14
Fruits and vegetables	4.37	1.80	5.33	2.01	0.96[b]	1.64	0.75, 1.16
Weight (kg)	116.26	20.45	112.63	20.13	-3.63[b]	5.38	-4.31, -2.96
Waist circumference (cm)	122.30	14.90	117.15	15.39	-5.15[b]	5.79	-5.88, -4.42

A different letter superscript adjacent to the mean score ($\text{mean}_{\text{change}}$) ([a] or [b]) within the same measure denotes a statistically significant difference between the Nutrition Education and Cognitive-Behavioral Nutrition groups; 95% CI = within-group changes with a 95% Confidence Interval.
CI = confidence interval; SD = standard deviation

of interrelations of exercise, psychosocial changes, improved eating, and weight loss. After addressing exercise adherence concerns through the use of The Coach Approach protocol in both treatment conditions, findings indicated that an exercise and nutrition treatment focused on self-regulatory skills was associated with significantly more weight loss and reduction in waist circumference during 26 weeks than a treatment where the nutrition component was educationally based (as is the typical practice). Also consistent with expectations, changes in self-regulatory skill usage and self-efficacy were significantly related to both increased exercise and improved eating, with exercise-induced mood change significantly adding to the explained variances in improvements. It was confirmed that only 2 sessions per week of moderate exercise was sufficient to improve overall mood, with a higher volume unrelated to greater improvement. Also as expected, increased use of self-regulatory skills for exercise predicted greater use of self-regulation for controlled eating, and improvements in self-efficacy for exercise predicted greater changes in self-efficacy to control one's eating.

... it now appears prudent to construct and test an original weight-loss protocol emphasizing maintained exercise and development of self-regulation and self-efficacy for both exercise and controlled eating.

Although the average loss in weight in the Cognitive-Behavioral Nutrition group was a modest 3.6 kg (just over 3% of initial weight), it should be noted that the conservative intention-to-treat design used in this study included data from *all* individuals initiating treatment—including early drop-outs and those with very poor treatment attendance. Thus, its improvement over the Nutrition Education group (a group still receiving considerable treatment) of 30% is noteworthy. That being said, because of the improved understanding of salient psychosocial predictors of weight change, important treatment components should be carefully scrutinized for improved effect in the future. For example, findings indicated that improvement in self-efficacy for controlled eating was not significantly different between treatment conditions. Because of the present findings on the association of self-efficacy and exercise and eating improvement, more attention to this is warranted in the future. It is also not known if the considerable mood changes associated with even minimal volumes of exercise may be specifically channeled to address emotion-triggered overeating; and, if so, how this may further improve effects. Thus, it is likely that a considerably longer time frame for the nutrition component will be required to attend to these issues.

Results overwhelmingly supported relationships depicted in the proposed model (Figure 2), and extended previous research on the positive effects of self-regulation on exercise and eating,[122-124] and carry-over effects from self-regulating for exercise to self-regulating for controlled eating.[23,71,76] Although the positive effects of increased self-efficacy on exercise and appropriate eating behaviors were previously indicated,[125,126] their interrelationship was only recently suggested,[72,73] as was the effect of improved mood on, "… 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."[52p320] Our own research program[50,53-56,58,60,62-66,69,70,81,82] was also extended in a manner that may now guide the development of an original intervention that is substantially different from those previously tested; one in which physical exercise supported by methods emphasizing self-regulation, self-efficacy, and mood change is central to reliably improving eating behavior through a psychosocial pathway.

A Look Forward

A key to meaningfully improving lagging weight-loss treatment outcomes is by reviewing past research failures and successes, better understanding relation-

Table 2. Results of hierarchical multiple regression analyses for the prediction of changes in exercise and fruit and vegetable consumption (N = 430)

	β	SE	R^2	*F*	*df*	p	ΔR^2	*F*	p
Δ Exercise									
Model 1			0.40	139.88	2, 427	<0.001			
Δ Exercise Self-Efficacy	0.11	0.07				0.01			
Δ Self-regulation for exercise	0.58	0.10				<0.001			
Model 2			0.43	106.35	3, 426	<0.001	0.03	24.14	<0.001
Δ Exercise Self-Efficacy	0.10	0.07				0.01			
Δ Self-regulation for exercise	0.46	0.11				<0.001			
Δ Total Mood Disturbance	-0.22	0.05				0.001			
Δ Fruit and vegetable consumption									
Model 1			0.17	44.48	2, 427	<0.001			
Δ Weight Efficacy Lifestyle	0.27	0.003				0.001			
Δ Self-regulation-controlled eating	0.20	0.01				<0.001			
Model 2			0.20	34.30	3, 426	<0.001	0.03	11.71	<0.001
Δ Weight Efficacy Lifestyle	0.22	0.003				<0.001			
Δ Self-regulation-controlled eating	0.13	0.02				0.02			
Δ Total Mood Disturbance	-0.18	0.01				0.001			

Δ = change in score from baseline to week 26.

ships among psychosocial predictors of weight loss, and implementing a plan for extension of research toward applied ends. Only then might the consideration of previous theories, models, and results have true practical value. The experimental literature is abundantly clear that failures in the behavioral treatment of obesity predominate,[8] and suggest that nutrition education, severe reductions in calories ("diets"), and cognitive-behavioral techniques primarily targeting reduced intake of food, are insufficient, and will, overwhelmingly, result in rapid regain of any short-term weight loss. Even the arguably most "state-of-the-art" behavioral treatment failed to sustain weight loss when its concentration was fundamentally on extreme caloric intake change.[13,19] What remains is knowledge of what, apparently, will *not* work, enhanced data concerning relationships among psychosocial variables within a context of exercise supported by cognitive-behavioral means, and a need for innovation related to the development of a successful intervention based on this knowledge.[9] Thus, rather than acquiesce to recent pessimistic suggestions (precipitated by the routine failures in treatments) that, "… psychosocial research should perhaps shift away from work on treatment [of obesity] …,"[9p710] it is proposed that sufficiently different methods with new and different emphases grounded in the emerging findings require development and sufficient testing.

Because there is considerable research suggesting that participation in regular exercise is a robust predictor of maintained weight loss (but not directly reconciled through associated caloric expenditure) and, on the basis of the present results indicating that exercise affects weight loss through associations with psychosocial predictors of controlled eating, cognitive-behaviorally supported exercise as possibly the central component of the architecture of an effective weight-loss treatment is indicated. Specifically, a treatment emphasizing: 1) attention to adherence to an exercise program, 2) participants' assimilation of new and enhanced self-regulatory skills through exercise both before and throughout their application to managed eating, 3) feelings of competence around progressive health behavior changes, and 4) an enhanced psychological profile exemplified by exercise-induced improvements in overall mood is suggested. Thus, self-regulatory abilities, self-efficacy, and improved mood, nurtured through a focused exercise-support component paired with a similar component for support of controlled eating, may help attain improvements well beyond that of the array of treatment approaches presently available. For example: 1) self-efficacy may be advanced through simultaneous emphases on short-term goal attainment in both the exercise (eg, increase walking for exercise from 60 to 90 minutes per week within 1 month) and eating (eg, increase fruit and vegetable consumption from 3 to 6 servings daily within 6 weeks) domains, 2) self-regulatory skills may be nurtured by presenting them in a similar manner in both the context of supporting regular exercise and controlling one's eating (eg, practice in cognitive restructuring to overcome a desire to lapse in exercise when increased stress is present may serve to support modifying unproductive thoughts when preparing to use food to manage anxiety), and 3) in efforts to keep exercise manageable to maximize adherence, the minimum volume identified as consistent with mood improvements (ie, 2 sessions per week of moderate intensity) may be suggested rather than much higher dosages (that are most commonly prescribed to expedite weight loss, but few individuals are able to maintain). Although considerable testing will be required—especially with follow-ups of at least several years—methods applied to such a newly focused intervention would exemplify innovation, use of the most current evidence, and address suggestions that, "… future research focus on exercise as a treatment for obesity."[8p230]

Limitations

Although substantial progress was made within this research on consolidating theory-based psychosocial relationships concerning exercise, managed eating, and weight loss, there were limitations that should be addressed. Additional variables within social cognitive theory (eg, observational learning and social support) may be useful for furthering the prediction of weight loss. Although partially justified through preliminary propositions (Figure 1),[52] earlier research,[62,64] and the present experimental design in which self-regulation skills were first developed within an exercise context (ie, 4 to 6 weeks before the onset of the respective nutritional component), the directionality of the relationships (eg, between exercise- and eating-related self-regulation and self-efficacy) requires additional investigation. Additionally, field studies, as described here, have limited experimental controls such as through perceived instructor expectations and external social supports. Although field settings benefit the ability to readily apply findings to practice,[39] replication is required before it is appropriate to generalize results to specific groups such as nonvolunteers (eg, individuals whose physicians have insisted on their immediate participation in a weight-management treatment), individuals affected by certain physical (eg, diabetes, cancer) or psychiatric/psychological (eg, depression) pathologies, and those with a lower degree of overweight. Confirmatory analyses should carefully assess the validity of the proposed model across such disparate groups.

Conclusion

The present review of theory and previous findings, including summarization of a systematic research program on the relationship of supported exercise with psychosocial correlates of controlled eating and weight loss, was extended here to include direct testing of differing nutrition treatment components and a refined set of behavioral predictors. As a result, it now appears prudent to construct and test an original weight-loss protocol emphasizing maintained exercise and development of self-regulation and self-efficacy for both exercise and controlled eating. Additionally, findings suggest that effects of mood change associated with even minimal volumes of exercise can further improve behaviors—especially emotional eating. It is hoped that this review, field experiment, consolidation of findings, and suggestions for future research and practice provides an enhanced understanding of the role that cognitive-behaviorally supported exercise plays in controlled eating and, ultimately, facilitates greatly improved treatment results that may be widely disseminated. It is incumbent on the fields of behavioral and medical science to collaborate in a quest for more effective methods to successfully intervene with the growing epidemic of obesity through continued extension of the existing knowledge base. ❖

[a] A cognitive-behavioral treatment approach relates to a family of methods in which the purposeful changing of thoughts and perceptions are used to shape behaviors useful to the individual being cared for.

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The Commonest Disease

Obesity is the commonest disease in the United States.
The aged are particularly prone to it, when one by one other physical pleasures have been outlived or denied, and there remains only the joys of the table.

— Kern, Richard A. Chapter 29: The care of the aged. In Musser JH, Wohl MG, eds. Internal Medicine: Its Theory and Practice, 5th ed, Philadelphia: Lea & Febiger; 1951