Eat Weight Disord (2015) 20:223–232
DOI 10.1007/s40519-014-0159-7

ORIGINAL ARTICLE

Theory-based psychosocial factors that discriminate between weight-loss success and failure over 6 months in women with morbid obesity receiving behavioral treatments

James J. Annesi · Ping H. Johnson

Received: 29 August 2014 / Accepted: 5 October 2014 / Published online: 21 October 2014

Abstract

Purpose To improve success rates of behavioral weight-loss treatments, a better understanding of psychosocial factors that discriminate between weight-loss success and failure is required. The inclusion of cognitive–behavioral methods and manageable amounts of exercise might induce greater improvements than traditional methods of education in healthy eating practices.

Methods Women with morbid obesity [body mass index (BMI) $\geq$40 kg/m^2] were recruited for a treatment of supported exercise paired with either a cognitive–behavioral or an educational approach to eating change over 6 months. They were classified as either successful with (i.e., at least 5 % loss; $n = 40$) or failed at (no loss, or weight gain; $n = 43$) weight loss. Discriminate function analysis incorporated theory-based models of 1 (self-efficacy), 5 (self-efficacy, self-regulation, mood, physical self-concept, body satisfaction), and 3 (self-efficacy, self-regulation, mood) psychosocial predictors at both month 6, and change from baseline–month 6.

Results All three models significantly discriminated weight-loss success/failure (66, 88, and 87 % for success; and 81, 87, and 88 % for failure, respectively). Self-regulation had the strongest correlations within the multi-predictor models (0.90–0.96), and all variables entered were above the standard of 0.30 set for relevance. Participants in the cognitive–behavioral nutrition group demonstrated significantly greater improvements in all psychosocial variables and success with weight loss. Completing at least two sessions of exercise per week predicted success/failure with weight loss better than overall volume of exercise.

Conclusions New and relevant findings regarding treatment-induced psychosocial changes might be useful in the architecture of more successful behavioral weight-loss interventions.

Keywords Obesity · Weight loss · Psychological factors · Behavioral theory

Introduction

Behavioral weight-loss treatments have mostly been unsuccessful beyond their first several months [1, 2]. This is especially true for individuals with morbid obesity [body mass index (BMI) $\geq$40 kg/m^2] who have the greatest health risks and healthcare costs [3, 4]. Thus, invasive and expensive methods such as bariatric surgery (e.g., gastric bypass, gastric banding) have become common for this group [5]. Although it is clear that weight loss is predominantly a function of reduced energy intake [6], incorporation of exercise might have benefits that are not yet well-understood [1, 2]. For example, although physical activity is the strongest predictor of sustained weight loss [7, 8], its benefits might be more related to associated improvements in psychosocial predictors of eating changes than the minimal caloric expenditures possible in unfit individuals [9, 10]. Previous research indicates that adherence to exercise can be problematic [11], particularly in women with morbid obesity who might be uncomfortable with both physical exertion and displaying their bodies during exercise in a culture that values female thinness

J. J. Annesi (✉)
YMCA of Metro Atlanta, 100 Edgewood Avenue NE, Suite 1100, Atlanta, GA 30303, USA
e-mail: jamesa@ymcaatlanta.org

J. J. Annesi · P. H. Johnson
Kennesaw State University, Kennesaw, USA

[12]. A protocol of self-regulatory methods has improved exercise adherence in women with obesity [13]. Thus, the value of cognitive-behaviorally supported exercise might present increased opportunities for success within behavioral weight-management interventions.

Although trends are changing for the better in federally funded trials, many behavioral weight-loss treatments and practices have been atheoretical [14]. They frequently focused on educating individuals on healthy eating practices and the need to engage in regular exercise, in spite of the findings that such methods have not reliably induced expected behavioral changes [1]. At the same time, research on theory-based psychosocial predictors of weight loss is present, and suggests that self-regulation [15–19] and self-efficacy (i.e., feelings of ability and mastery) [20–23] are associated with weight loss. It was, however, proposed that such social-cognitive factors explain only a part of treatment effects, and "affective process of behavior change" may also play an important role in weight-loss success [19, p 21]. Supporting this, it was suggested that exercise-induced mood change leads to weight loss partially through its effect on emotional eating [24]. Other psychosocial factors found to be significantly associated with weight loss include self-determination, intrinsic motivation, body image, and self-esteem [21, 25, 26]. Several studies suggested that self-regulation is an especially strong predictor, and might also influence other psychosocial predictors of weight loss [16–19].

Based partially on these findings, interventions have sometimes incorporated a cognitive–behavioral focus and concentrated on behavioral methods that might yield perceptions of incremental success, acceptance with one's body, and techniques to negotiate day-to-day barriers such as the constant availability of high-fat foods and social pressures to overeat successfully [27]. For example, The Diabetes Prevention Program [28] educated participants in a variety of self-management and cognitive–behavioral methods, and attained promising long-term effects on weight loss [29]. Although such positive findings have selectively occurred, most behavioral treatments remain ineffective beyond the short term [30], and psychosocial factors predictive of success (or failure) remain unclear. Thus, refinements and innovation in behavioral treatments have been called for [2], including through increased use of accepted behavioral theory and more thorough analyses of effects of exercise [1].

Cognitive–behavioral treatment foci are often based on the behavioral theories of Albert Bandura [31, 32] who suggested how cognitive or mental processes can serve as both antecedents and reinforcers in shaping resilient behaviors (e.g., health behaviors). Bandura's [31] social cognitive theory describes an interplay of behavioral, cognitive, and environmental factors (i.e., triadic reciprocal causation). For example, the need for a healthy and attractive body (cognitive factors) might initiate an effort toward weight loss in a setting of constant food availability and temptations (environmental factors). Learned psychological skills and feelings of ability (behavioral factors) would be called upon to manage the challenges. The three processes interact and influence each other in a dynamic manner. Although interwoven with social cognitive theory, Bandura's [32] self-efficacy theory emphasizes the role of mastery and ability (i.e., self-efficacy) in behavior change. For example, an individual might initiate weight-loss behaviors because she saw an overweight female neighbor (whom she viewed as being similar to herself) succeed. She might sustain the changed behaviors because she felt increasing mastery over healthier cooking and her physical health through consistent reductions in weight and need for medications.

While self-efficacy theory has a single construct to guide behavior-change interventions, social cognitive theory is more subject to interpretation. For example, Baker and Brownell proposed that treatment-induced improvements in coping (i.e., self-regulation, or the ability to address barriers and control one's behaviors), self-concept, mood, body image, and self-efficacy would be associated with increased exercise and improved eating behaviors [9]. Annesi extended this paradigm through field research and proposed that changes in treatments only need to focus on self-regulation, mood, and self-efficacy to maximize weight-loss success [33]. In agreement with Baker and Brownell [9], several of his studies suggested similar effects emanating from changes in the psychosocial constructs applied to exercise and improved eating [34].

Previous research has suggested that success with weight loss might be defined by a commonly used cut point for clinically relevant health improvements such as at least a 5 % reduction from baseline weight [35, 36]. Failure might be considered to be no loss, or weight gain. Identifying factors that best predict weight-loss success/failure could inform both weight-loss theory, and the establishment of what psychosocial constructs warrant the most attention within behavioral treatments. Therefore, this study was designed to contrast the three aforementioned theoretical approaches (i.e., the 1-factor self-efficacy theory [32], the 5-factor Baker and Brownell model adapted from social cognitive theory [9], and the 3-factor Annesi model also adapted from social cognitive theory [33]) for predicting weight-loss success/failure.

Additionally, this study examined effects of a cognitive–behavioral vs. educational approach to nutrition change in predicting both relevant psychosocial changes and weight-loss success/failure. As important factors for weight-loss success are identified, knowledge of the type of treatment most associated with their improvement will hold great practical value.

Furthermore, increased knowledge of the role of exercise in success with weight loss is also needed. Although others have suggested that greater amounts of exercise are required [37], Annesi et al. [33, 38] suggested that no more than two sessions per week of moderate exercise is needed to induce significant improvements in psychosocial predictors of weight loss. It was also suggested that greater volumes of physical activity might not be associated with additional benefits [33]. Seeking only two sessions/week would serve to minimize the amount of physical exertion requested of unfit individuals, which could benefit their adherence to a program of exercise [39], a strong predictor of success with weight loss [7, 8]. It is presently unclear whether success with weight loss in individuals with obesity would better be predicted from increased exercise ("more is better"), or simply attaining a minimum volume of physical activity (e.g., 2 moderate bouts/week). Although it seems logical that greater energy expenditure through more exercise would better-predict weight loss, it has been proposed that the association of exercise with weight-loss success is more complex, and exercise-induced changes in eating (rather than energy expenditure) best explain weight-loss success [33].

Identifying treatment approaches, relevant psychosocial factors, and exercise amounts for predicting success and failure with weight loss will inform the architecture of future behavioral treatments, especially for individuals with morbid obesity who might readily adopt surgical options because of repeated failures with ineffective behavioral approaches. Thus, to advance behavioral weight-loss intervention research, this exploratory study was based on the following hypotheses and research questions:

1. It was expected that scores of self-efficacy theory- and social cognitive theory-based psychosocial measures at the end of the 6-month treatment, and changes over 6 months, would significantly discriminate between classifications of success and failure with weight loss. It was, however, left as a research question whether the proposed 1-, 5-, or 3-factor model would most accurately discriminate between success and failure.
2. When participants are classified by treatment type, it was hypothesized that the cognitive–behavioral nutrition treatment would be associated with significantly greater improvements in the psychosocial variables and success with weight loss than the treatment of nutrition education.
3. The dichotomous measure of completion of (or failure to complete) a minimum of two moderate bouts of exercise/week was expected to predict success/failure with weight loss more accurately than the continuous measure of overall volume of exercise per week.

Materials and methods

Participants

Data were extracted from a larger study ($n = 430$) of mostly women with varied degrees of obesity from the southeastern United States [33]. The following descriptors are of those participants incorporated into the current research. Inclusion criteria were: (1) female; (2) age of at least 21 years; (3) BMI of 40–55 kg/m^2 (morbid obesity); (4) no regular exercise (less than 20 min/week average, through self-report); and (5) a reported goal of weight loss. Exclusion criteria were: (1) current or planned pregnancy; (2) current participation in a medical, commercial, or self-help weight-loss program; and (3) use of 1 or more medications for a psychological/psychiatric disorder. After a brief description of the program was provided, each participant provided written informed consent and written approval to participate from her physician. Appropriate institutional review board approval was granted, and requirements of the Declaration of Helsinki were followed.

There was minimal attrition from the present sample due to an inability to make phone or email contact ($n = 8$) and reported problems with transportation ($n = 4$). The mean age of participants was 44.0 ± 9.6 years, with a mean BMI of 45.4 ± 3.9 kg/m^2. The racial/ethnic make-up was 51 % white, 45 % African American, and 4 % others. Based on self-reported annual family income, nearly all participants were in the middle class (US$ 25,500–76,500). For this study, inclusion in one of the following classifications was required: (1) those who were successful with weight loss (i.e., at least 5 % reduction from baseline weight; $n = 40$); and (2) those who failed at weight loss (i.e., no reduction, or weight gain; $n = 43$). In the original data set [33], participants were randomly assigned to groups where cognitive–behavioral support of a newly initiated exercise program was paired with either a cognitive–behavioral or an educational nutrition treatment component.

Measures

Self-regulation

A validated scale [40] was adapted based on the content of the present treatments. Specifically, separate scales were developed to measure the use of self-regulation skills for exercise, and the use of self-regulation skills for eating. Examples of the ten items for each scale were, "I set physical activity goals", and "I purposefully address my barriers to eating appropriately", respectively. Responses ranged from 1 (never) to 5 (often). Internal consistencies were $\alpha = 0.79$–0.91, and test–retest reliabilities were 0.74–0.78 [34]. For the present sample, internal consistency was

$\alpha = 0.82$ for exercise-related self-regulation and $\alpha = 0.82$ for eating-related self-regulation. Considering both theory [41] and the strong intercorrelation between the two measures (0.45), the exercise- and eating-related self-efficacy scales were aggregated into a single measure entitled "self-regulation" (Self-Reg). After equally weighting scores from both scales, the possible score range was 10–50, with a higher score indicating greater use of self-regulation.

Self-efficacy

The Exercise Self-Efficacy Scale [42] has five items starting with, "I am confident I can participate in regular exercise when…" (e.g., "I feel I don't have the time"). Responses ranged from 0 (not at all confident) to 9 (very confident). Internal consistencies were $\alpha = 0.76$–0.82, and test–retest reliabilities were 0.74–0.78 [42]. For the present sample, internal consistency was $\alpha = 0.77$. The Weight Efficacy Lifestyle Scale [43] measured eating-related self-efficacy. The scale has four items each for its five factors of negative emotions, food availability, physical discomfort, positive activities, and social pressure (e.g., "I can resist eating even when others are pressuring me to eat") that were summed. Item responses ranged from 0 (not confident) to 9 (very confident). Internal consistencies were $\alpha = 0.70$–0.90 [43]. For the present sample, internal consistency was $\alpha = 0.79$. Only the total scale score was used for this research.

Considering both theory [32] and the strong intercorrelation between the two measures (0.52), the exercise- and eating-related self-efficacy scales were aggregated into a single measure entitled "self-efficacy" (Self-Eff). After equally weighting scores from both scales, the possible score range was 0–18, with a higher score indicating greater self-efficacy. Aggregation of the self-regulation and self-efficacy measures also enabled a reduction in the number of predictor variables in the planned discriminant function analyses. This maximized the study's experimental power.

Mood

The total mood disturbance scale of the Profile of Mood States Short Form [44] measured mood. Participants responded to feelings over the past week via 1- to 3-word items (e.g., anxious, sad) ranging from 0 (not at all) to 4 (extremely). There were five items each within subscales of tension, depression, fatigue, confusion, anger, and vigor, which were aggregated. Because the score from the vigor subscale was subtracted from the sum of the others, scores of the 30 total items could be either negative or positive. The possible score range was -20 to 100, with a lower score indicating less negative mood. Internal consistency ranged from $\alpha = 0.84$ to 0.95. Test–retest reliability averaged 0.69 [44]. For the present sample, internal consistency averaged $\alpha = 0.81$.

Physical self-concept

Physical self-concept, or an individual's perception of his/her physical appearance, skills, and health, was measured by the physical self-concept scale of the Tennessee Self-Concept Scale [45]. The scale required responses to 14 items (e.g., "I have a healthy body") ranging from 1 (always false) to 5 (always true). The possible score range was 14–70, with a higher score indicating greater physical self-concept (PhysSC). Internal consistency was $\alpha = 0.83$, and test–retest reliability was 0.79 [45]. Concurrent validity was established through contrasts with the Minnesota Multiphasic Personality Inventory, Body Shape Questionnaire, and Nash Body Image Scale [45, 46]. For the present sample, internal consistency was $\alpha = 0.81$.

Body satisfaction

The body areas satisfaction scale of the Multidimensional Body-Self Relations Questionnaire [47] measured body satisfaction. The present version evaluated areas of the body through five items [e.g., lower torso (buttocks, hips, thighs, legs), weight] ranging from 0 (very dissatisfied) to 4 (very satisfied). The possible score range was 0–20, with a higher score indicating greater body satisfaction (BodySat). Internal consistency for women was $\alpha = 0.73$, and test–retest reliability was 0.74 [47]. For the present sample, internal consistency was $\alpha = 0.78$.

Physical activity

The Godin–Shephard Leisure-Time Physical Activity Questionnaire [48] measured volume (frequency, duration, intensity) of exercise. Scores are expressed in metabolic equivalent of tasks (METs; a measure of energy costs) per week. One MET approximates the use of 3.5 ml of O_2/kg/min [49]. The Godin–Shephard Questionnaire required entry of the number of sessions of strenuous (approximately 9 METs; e.g., running), moderate (approximately 5 METs; e.g., fast walking), and light (approximately 3 METs; e.g., easy walking) physical activities/exercises undertaken for greater than 15 min in the previous week. Test–retest reliability over 2 weeks was 0.74 [50]. The Questionnaire's concurrent validity was indicated through strong correlations with both accelerometer and peak volume of oxygen uptake measurements [51, 52]. For the present study, two measures of exercise based on the Godin–Shephard Leisure-Time Physical Activity Questionnaire scores were used. The first measure of physical activity (continuous) assessed overall volume of exercise/week based on total METs/week, with a higher score indicating a greater amount of exercise. The second measure of physical activity (dichotomous) was based on whether 10 METs/week (approximately 2 moderate sessions of exercise/week) was achieved. If at least 10 METs/week was scored, a code of "1" was assigned; if not, a code of "0" was assigned.

Body weight

After weight was measured in kg using a recently calibrated digital scale (Health o meter Model 597KL, Boca Raton, FL), percent weight change (gain or loss) was calculated by dividing each participant's change in weight over 6 months by her weight at baseline. Based on that, success with weight loss was defined as at least 5 % reduction from baseline weight, and was coded "1". Weight-loss failure was defined as either no reduction, or weight gain, and was coded "0".

Procedure

Participants were provided access to YMCA facilities. The entire treatment lasted approximately 6 months and included components of a previously validated protocol (The Coach Approach) [13] of cognitive-behaviorally supported physical activity that was administered to each participant individually by a certified YMCA wellness specialist, plus group-based (i.e., 10–20 participants, 1 certified YMCA wellness specialist) nutrition classes emphasizing either education in healthy nutrition practices [36] or cognitive–behaviorally based support of reduced caloric intake and increased intake of fruits and vegetables.

The exercise support sessions each lasted 45–60 min, and were administered at study start, and weeks 2, 6, 10, 17, and 24. In addition to exercise plans based on individual preference and tolerance, the wellness specialist delivered cognitive–behavioral methods such as goal setting and incremental progress tracking, cognitive restructuring, stimulus control, and relapse prevention to each participant through a computer application (FitLinxx, Shelton, CT). Exercise plans generally started at 15–20 min of cardiovascular activity/session on 3–4 days/week that could be completed either within or outside of the YMCA facility.

The nutrition component consisted of six 1-h sessions administered at weeks 8, 10, 12, 14, 16, and 18. Instruction in the educational nutrition approach was supported by a manual consisting of: (1) understanding macronutrients; (2) stocking healthy foods; (3) healthy recipes and food-preparation methods; (4) eating outside of the home, and (5) snacking [53]. Instruction in the cognitive–behavioral nutrition approach emphasized goal setting and the practice of self-regulation. Specific methods included: (1) establishing caloric goals; (2) logging foods consumed and associated calories; (3) unproductive thought identification and restructuring; (4) cues and triggers to inappropriate eating; and (5) relapse prevention. Both approaches emphasized fruit and vegetable consumption. All participants received the same exercise support component (The Coach Approach) along with one of the two nutrition treatment components.

Instructors were blind to the goals of the research. There were fidelity assessments conducted by study staff on approximately 15 % of treatment sessions. Few minor violations occurred and were quickly corrected. Assessments were administered at baseline and month 6 by wellness professionals who were not otherwise involved in the study.

Statistical analyses

The expectation–maximization algorithm [54] was used to impute the combined 11 % of missing values of the predictor (e.g., psychosocial factors) and outcome (weight) variables within the current sample. Statistical significance was set at $p \leq 0.05$. Because of the exploratory goals of this research, statistical significance of $p > 0.05$ to $p \leq 0.10$ was also noted. Time × group mixed-model repeated measure ANOVAs assessed whether changes in each psychosocial variable were significant over 6 months, and whether those changes significantly differed by participants who either succeeded or failed with weight loss. Bonferroni-adjusted follow-up dependent *t* tests ($p \leq 0.05/5$ tests were adjusted to $p \leq 0.01$) assessed significance of within-group changes. As suggested for research within the present context [55], gain (or change) scores from baseline–month 6 were unadjusted for baseline values. Effect sizes were expressed as partial eta-square (η_p^2) for ANOVAs, and Cohen's *d* for *t* tests, where 0.01, 0.06; and 0.14, and 0.20, 0.50, and 0.80 denote small, moderate, and large effects, respectively.

Classification of success/failure with weight loss

Because data adequately fit assumptions of an approximately normal distribution (both skew and kurtosis values ≤2 standard errors) and the sample size was small for logistic regression [56, 57], the "…more powerful and efficient analytic strategy" [58, p 579], discriminant function analysis, was instead used. For the planned discriminant function analysis predicting either success or failure with weight loss using up to five psychosocial predictor variables, a minimum of 50 participants was required [59]. Because it was unclear whether data at month 6, or change from baseline–month 6, would be the most useful, and that this research was exploratory, both measures were incorporated as the psychosocial predictors in separate equations. It was thought that data from month 6 would indicate the salience of an ending score on a psychosocial variable (within this 6-month time frame); while a change score would indicate the importance of change on the variables of interest, regardless of ending score.

Specifically, based on the theories under consideration, three models were fit assessing the ability of a 1-factor (Self-Eff only: self-efficacy theory) [32], 5-factor (Self-Reg, Self-Eff, Mood, PhysSC, BodySat: social cognitive theory—Baker and Brownell version) [9], and 3-factor (Self-Reg, Self-Eff, Mood: social cognitive theory—Annesi version) [33] set of predictors for classification of success or failure with weight loss. Wilks' lambda (λ) and its corresponding Chi-square test (χ^2) assessed the overall significance of each model. That was followed by correlational analyses within the discriminant function that ordered the relative contribution of each predictor variable for that classification of success/failure. A coefficient $\geq|0.30|$ was considered relevant. Finally, the percentage of correctly predicted outcomes was calculated. The effect size for χ^2 was expressed as phi ($\Phi = \sqrt{\chi^2/n}$) or Cramer's phi ($\Phi_c = \sqrt{\chi^2/n \times df}$), where 0.10, 0.30, and 0.50 denote small, moderate, and large effects, respectively.

Association of treatment type with psychosocial changes

Participants were next grouped based on their originally assigned nutrition treatment type (i.e., educational or cognitive–behavioral). Mixed-model repeated measure ANOVAs and follow-up dependent *t* tests were then computed to assess overall, between, and within-group changes in the psychosocial factors being tested. Chi-square testing again assessed the group difference in success/failure with weight loss.

Association of physical activity volume with success/failure with weight loss

The ability of the two measures of exercise (i.e., ≥ 2 sessions/week or overall volume of exercise/week) to predict success/failure with weight loss was assessed using Kendall's tau-b correlation (τ_b). Descriptive statistics are presented as mean ± standard deviation.

Results

Changes in psychosocial variables by success/failure with weight loss

No significant difference was found on psychosocial measures at baseline in the successful vs. failure weight-loss group ($ps = 0.127$–0.981). Mixed-model repeated measures ANOVAs ($dfs = 1, 81$) indicated significant ($ps < 0.001$) overall improvements in Self-Reg, $F = 148.86$, $\eta_p^2 = 0.65$; Self-Eff, $F = 45.98$, $\eta_p^2 = 0.36$; Mood, $F = 68.06$, $\eta_p^2 = 0.46$; PhysSC, $F = 83.68$, $\eta_p^2 = 0.51$; and BodySat, $F = 35.34$, $\eta_p^2 = 0.30$. There were also significant ($ps < 0.001$) time × group interactions for Self-Reg, $F = 109.65$, $\eta_p^2 = 0.58$; Self-Eff, $F = 29.61$, $\eta_p^2 = 0.27$; Mood, $F = 50.39$, $\eta_p^2 = 0.38$; PhysSC, $F = 58.58$, $\eta_p^2 = 0.42$; and BodySat, $F = 19.32$, $\eta_p^2 = 0.19$, with greater improvements in the successful weight-loss group. Significant within-group improvements were found for each psychosocial factor in the successful weight-loss group, but none were found in individuals who failed at weight loss (Table 1).

Classification of weight-loss success/failure

Self-efficacy theory

A discriminant function analysis with Self-Eff at month 6 as the predictor of success/failure with weight loss was significant, Wilks' $\lambda = 0.89$, $\chi^2(1) = 9.74$, $p = 0.002$, $\Phi = 0.34$. Change in Self-Eff from baseline–month 6 as the predictor was also significant, Wilks' $\lambda = 0.73$, $\chi^2(1) = 25.08$, $p < 0.001$, $\Phi = 0.55$. Percentages of successful classifications are given in Table 2.

Social cognitive theory: Baker and Brownell version

A discriminant function analysis with Self-Reg, Self-Eff, Mood, PhysSC, BodySat at month 6 as predictors of success/failure with weight loss was significant, Wilks' $\lambda = 0.48$, $\chi^2(5) = 57.66$, $p < 0.001$, $\Phi_c = 0.83$. Change in the five psychosocial variables from baseline–month 6 as the predictors was also significant: Wilks' $\lambda = 0.37$, $\chi^2(5) = 77.47$, $p < 0.001$, $\Phi_c = 0.97$. Percentages of successful classifications are given in Table 2. Rank ordering of correlational analyses indicating relative contributions of predictors in the above models is given in Table 3.

Social cognitive theory: Annesi version

A discriminant function analysis with Self-Reg, Self-Eff, and Mood at month 6 as predictors of success/failure with weight loss was significant, Wilks' $\lambda = 0.49$, $\chi^2(3) = 57.06$, $p < 0.001$, $\Phi_c = 0.83$. Change in the three psychosocial variables from baseline–month 6 as the predictors was also significant, Wilks' $\lambda = 0.40$, $\chi^2(3) = 72.27$, $p < 0.001$, $\Phi_c = 0.93$. Percentages of successful classifications are given in Table 2. Rank ordering of correlational analyses indicating relative contributions of predictors in the above models is given in Table 3.

Table 1 Within-group changes over 6 months in psychosocial predictors of success/failure with weight loss

Measure group	Baseline	Month 6	t	p	(99 % CI)	Change from baseline–month 6	d
Self-regulation (Self-Reg)							
Successful weight loss	21.44 ± 4.68	32.41 ± 4.69	11.82	<0.001	(8.47, 13.48)	10.97 ± 5.86	2.34
Failed at weight loss	21.77 ± 5.24	22.60 ± 5.73	2.33	0.025	(−0.13, 1.81)	0.84 ± 2.36	0.16
Self-efficacy (Self-Eff)							
Successful weight loss	9.51 ± 3.24	13.72 ± 3.77	6.51	<0.001	(2.46, 5.96)	4.21 ± 4.09	1.30
Failed at weight loss	10.66 ± 3.51	11.12 ± 3.57	1.64	0.109	(−0.30, 1.22)	0.46 ± 1.85	0.13
Total mood disturbance (Mood)							
Successful weight loss	24.23 ± 18.42	0.98 ± 15.61	-7.95	<0.001	(−31.17, −15.33)	−23.25 ± 18.49	1.26
Failed at weight loss	23.51 ± 18.44	21.77 ± 19.12	-1.63	0.111	(−4.63, 1.15)	−1.74 ± 7.02	0.09
Physical self-concept (PhysSC)							
Successful weight loss	39.00 ± 7.61	49.73 ± 8.06	8.92	<0.001	(7.47, 13.98)	10.73 ± 7.60	1.41
Failed at weight loss	38.97 ± 5.97	39.92 ± 6.81	1.85	0.072	(−0.44, 2.35)	0.95 ± 3.39	0.16
Body areas satisfaction (BodySat)							
Successful weight loss	5.35 ± 3.35	8.30 ± 3.50	5.26	<0.001	(1.43, 4.47)	2.95 ± 3.54	0.88
Failed at weight loss	4.79 ± 2.39	5.23 ± 2.71	2.50	0.017	(−0.04, 0.92)	0.44 ± 1.16	0.18

Scores are given as mean ± standard deviation

Successful weight loss group $n = 40$, $df = 39$. Failure with weight loss group $n = 43$, $df = 42$

t and p values refer to within-group changes from baseline–month 6

Bonferroni-corrected $p \leq 0.01$ was used

The corresponding 99 % confidence interval (99 % CI) is given

d, Cohen's d [$(\text{mean}_{\text{month 6}} - \text{mean}_{\text{baseline}})/\text{standard deviation}_{\text{baseline}}$]

Table 2 Percentages of accurate classifications of success and failure with weight loss ($N = 83$)

Accurately classified	Self-efficacy theory		Social cognitive theory—Baker and Brownell version		Social cognitive theory—Annesi version	
	Month 6	ΔBaseline–Month 6	Month 6	ΔBaseline–Month 6	Month 6	ΔBaseline–Month 6
Overall sample	66.3	80.7	88.0	86.7	86.7	88.0
Successful with weight loss	67.5	67.5	92.5	80.0	90.0	82.5
Failed at weight loss	65.1	93.0	83.7	93.0	83.7	93.0

Values are expressed as percentage correctly classified

Δ, change from baseline–month 6

Table 3 Correlations within discriminate function analyses ordered by their relative contributions to 3 models' classification of success/failure with weight loss ($N = 83$)

Self-efficacy theory				Social cognitive theory—Baker and Brownell version				Social cognitive theory—Annesi version			
Month 6		ΔBaseline–Month 6		Month 6		ΔBaseline–Month 6		Month 6		ΔBaseline–Month 6	
Self-Eff	1.00	Self-Eff	1.00	Self-Reg	0.91	Self-Reg	0.90	Self-Reg	0.92	Self-Reg	0.96
				PhysSC	0.64	PhysSC	0.66	Mood	−0.59	Mood	−0.65
				Mood	−0.58	Mood	−0.61	Self-Eff	0.35	Self-Eff	0.50
				BodySat	0.48	Self-Eff	0.47				
				Self-Eff	0.34	BodySat	0.38				

Δ, change from baseline–month 6; Self-Reg, self-regulation; Self-Eff, self-efficacy; Mood, total mood disturbance; PhysSC, physical self-concept; BodySat, body areas satisfaction

Changes in psychosocial variables by treatment type

No significant difference was found on baseline measures between participants in the cognitive–behavioral ($n = 36$) and educational ($n = 47$) nutrition treatments (ps = 0.104–0.504). Mixed-model repeated measures ANOVAs (dfs = 1, 81) indicated significant overall improvements (ps < 0.001) in Self-Reg, $F = 68.72$, $\eta_p^2 = 0.46$; Self-Eff, $F = 33.37$, $\eta_p^2 = 0.29$; Mood, $F = 42.75$, $\eta_p^2 = 0.35$; PhysSC, $F = 50.84$, $\eta_p^2 = 0.39$; and BodySat, $F = 31.79$, $\eta_p^2 = 0.28$. There were also significant time × treatment type interactions for Self-Reg, $F = 6.61$, $p = 0.012$, $\eta_p^2 = 0.08$; PhysSC, $F = 3.99$, $p = 0.049$, $\eta_p^2 = 0.05$; and BodySat, $F = 5.48$, $p = 0.022$, $\eta_p^2 = 0.06$, with greater improvements in the cognitive–behavioral treatment group than in the educational group. The cognitive–behavioral nutrition group had significantly more participants who were successful with weight loss ($n = 27$ or 75.0 % of the sample) than the educational nutrition group ($n = 13$ or 27.7 % of the sample), $\chi^2(1) = 18.24$, $p < 0.001$, $\Phi = 0.47$.

Physical activity and weight-loss success/failure

Both correlational models tested were significant (ps < 0.001). The prediction of success/failure with weight loss by the dichotomous measure of completion of a mean of ≥2 sessions of moderate exercise/week (completion $n = 56$; non-completion $n = 27$) ($\tau_b = 0.46$) was notably stronger ($p = 0.059$) than by the continuous measure of overall volume of exercise/week (range = 0–54 METs/week; mean = 18.20 ± 12.68 METs/week) ($\tau_b = 0.38$).

Discussion

This research served to inform future behavioral interventions for obesity through findings on theoretical, treatment, psychosocial, and exercise factors' ability to discriminate between success and failure at weight loss. The results extended previous research where success and failure were less clearly defined, and where theory was not well-considered [60–62]. As expected, 6-month changes in psychological constructs related to both self-efficacy theory and social cognitive theory significantly discriminated between weight-loss success and failure. However, the two social cognitive theory-based models demonstrated a somewhat stronger ability to discriminate successfully than self-efficacy theory. Annesi's 3-factor model [33] was as robust as Baker and Brownell's 5-factor model [9]. There might be advantages to basing treatments on fewer constructs because greater attention could be directed to especially important areas. In agreement with previous research, self-regulation was the strongest predictor in the corresponding discriminant function analyses. This suggests that architectures of future behavioral weight-loss treatments should emphasize instruction in specific self-regulatory skills such as cognitive restructuring, stimulus control, and relapse prevention. Extensions of this research should seek to prioritize self-regulatory methods for their relative contributions to increase the efficiency of treatment protocols and maximize their effects. Mood and self-efficacy changes were also strong predictors of success and failure with weight loss within both of the social cognitive theory-based models and are also deserving of attention within future treatments.

Also as expected, the cognitive–behavioral treatment was associated with greater improvements in the theory-based psychosocial variables, as well as with success with weight loss. The benefit of emphasizing training in specific self-regulatory skills and nurturing self-efficacy within treatments is consistent with previous research [15–19] and theory [63]. Given the current findings and related research [1], researchers and practitioners should favor cognitive–behavioral techniques that empower individuals with skills needed to persevere (e.g., goal setting and incremental progress feedback to enhance self-efficacy) over education alone on the need for healthy eating practices and regular exercise. Based on the present research and a concern with efficiency of treatment time, cost, and effort, intervention components that specifically target self-regulation, self-efficacy, and mood change are further indicated.

The finding that completion/non-completion of two sessions of moderate exercise per week had a stronger relationship with weight-loss success/failure than actual amounts of exercise was important. Thus, future treatments might seek for participants to attain this minimum volume of physical activity rather than press unfit individuals into exercise amounts that might be difficult for them to handle, and lead to drop out. Future research should carefully evaluate mediation effects of the relationship of minimal exercise with weight loss through psychosocial changes such as mood, self-efficacy, and self-regulation. Previous research suggests that only several days per week of walking is associated with improvements in each of those factors [38]. If, in fact, manageable amounts of exercise initiate a process of psychosocial changes that predict success with weight loss, interventions might benefit from establishment of regular exercise prior to introducing caloric reductions and food logging. Although previously suggested [33], this treatment format has not yet been adequately evaluated.

Limitations of this research should be noted. This study was of a rather brief duration. Longer-term studies are required to address the prediction of success/failure with maintained weight loss. Inclusion of a no-treatment control group will be essential to establish confidence in the present findings and to help reduce social support and/or expectation effects that are common in field research such as this [64]. Replications across sexes, ages, ethnic groups, degrees of obesity, and physical conditions (e.g., diabetes, cancer) are needed to assess generalizability of findings. Additionally, assessing changes in measures at two times (unavoidably) increased the measurement error [65]. However, when scores at month 6 were used in place of change scores, results were similar. Other markers of success with weight loss such as attainment of goal weight or obtaining a clinically defined healthy weight (i.e., BMI 18.5–24.9 kg/m^2) could also be incorporated into future research. Additionally, measures associated with other theories of behavioral change such as self-determination theory and theory of planned behavior should be similarly evaluated and contrasted with the present findings. Even with these limitations, important progress has been made in defining salient factors associated with success and failure with weight loss in a population of great need. It is hoped that this line of inquiry will continue, and the most current research findings are incorporated for the betterment of behavioral weight-loss treatments.

Acknowledgment We acknowledge Ms. Kristin McEwen for her role in data collection within this study.

Conflict of interest For this study the authors declare no conflict of interest.

References

1. Mann T, Tomiyama J, Westling E, Lew AM, Samuels B, Chatman J (2007) Medicare's search for effective obesity treatments: diets are not the answer. Am Psychol 62:220–233. doi:10.1037/0003-066X.62.3.220
2. Jeffery RW, Drewnowski A, Epstein LH, Stunkard AJ, Wilson GT, Wing RR et al (2000) Long-term maintenance of weight loss: current status. Health Psychol 19(suppl):5–16. doi:10.1037/0278-6133.19.Suppl1.5
3. Mokdad AH, Ford ES, Bowman BA, Dietz WH, Vinicor F, Bales VS, Marks JS (2003) Prevalence of obesity, diabetes, and obesity-related health risk factors, 2001. JAMA 289:76–79. doi:10.1001/jama.289.1.76
4. Andreyeva T, Sturm R, Ringle JS (2004) Moderate and severe obesity have large differences in health care costs. Obes Res 12:1936–1943. doi:10.1038/oby.2004.243
5. Santry HP, Gillen DL, Lauderdale DS (2005) Trends in bariatric surgical procedures. JAMA 15:1909–1917. doi:10.1001/jama.294.15.1909
6. Wing RR (1999) Physical activity in the treatment of the adulthood overweight and obesity: current evidence and research issues. Med Sci Sports Exerc 31(suppl 11):S547–S552. doi:10.1097/00005768-199911001-00010
7. Fogelholm M, Kukkonen-Harjula K (2000) Does physical activity prevent weight gain—a systematic review. Obes Rev 1:95–111. doi:10.1046/j.1467-789x.2000.00016.x
8. Svetkey LP, Stevens VJ, Brantley PJ, Appel LJ, Hollis JF, Loria CM et al (2008) Comparison of strategies for sustaining weight loss. JAMA 299:1139–1148. doi:10.1001/jama.299.10.1139
9. Baker CW, Brownell KD (2000) Physical activity and maintenance of weight loss: physiological and psychological mechanisms. In: Bouchard C (ed) Physical activity and obesity. Human Kinetics, Champaign, pp 311–328
10. American College of Sports Medicine (2009) Appropriate physical activity intervention strategies for weight loss and prevention of weight regain for adults. Med Sci Sports Exerc 41:459–471. doi:10.1249/MSS.0b013e3181949333
11. Buckworth J, Dishman RK (2002) Exercise psychology. Human Kinetics, Champaign
12. Strong SM, Williamson DA, Netemeyer RG, Geer JH (2000) Eating disorder symptoms and concerns about body differ as a function of gender and sexual orientation. J Soc Clin Psychol 19:240–255. doi:10.1521/jscp.2000.19.2.240
13. Annesi JJ, Unruh JL, Marti CN, Gorjala S, Tennant G (2011) Effects of The Coach Approach intervention on adherence to exercise in obese women: assessing mediation of social cognitive theory factors. Res Q Exerc Sport 82:99–108. doi:10.1080/02701367.2011.10599726
14. Rothman AJ (2004) Is there nothing more practical than a good theory: why innovations and advances in health behavior change will arise if interventions are used to test theory. Int J Behav Nutr Phys Act 1:11. doi:10.1186/1479-5868-1-11
15. Huisman S, Maes S, De Gucht VJ, Chatrou M, Haak HR (2010) Low goal ownership predicts drop-out from a weight intervention study in overweight patients with type 2 diabetes. Int J Behav Med 17:176–181. doi:10.1007/s12529-009-9071-3
16. Andrade AM, Coutinho SR, Silva MN, Mata J, Viera PN, Minderico CS et al (2010) The effect of physical activity on weight loss is mediated by eating self-regulation. Patient Educ Couns 79:320–326. doi:10.1016/j.pec.2010.01.006
17. de Bruin M, Sheeran P, Kok G, Hiemstra A, Prins JM, Hospers HJ et al (2012) Self-regulatory processes mediate the intention-behavior relation for adherence and exercise behaviors. Health Psychol 31:695–703. doi:10.1037/a0027425
18. Annesi JJ (2011) Self-regulatory skills usage strengthens the relations of self-efficacy for improved eating, exercise, and weight in the severely obese: toward an explanatory model. Behav Med 37:71–76. doi:10.1080/08964289.2011.579643
19. Anderson ES, Winett RA, Wojcik JR, Williams DM (2010) Social cognitive mediators of change in a group randomized nutrition and physical activity intervention: social support, self-efficacy, outcome expectations, and self-regulation in the guide-to-health trial. J Health Psychol 15:21–32. doi:10.1177/1359105309342297
20. Anderson ES, Winett RA, Wojcik JR, Williams DM (2007) Self-regulation, self-efficacy outcome expectations, and social support: social cognitive theory and nutrition behavior. Ann Behav Med 34:304–312
21. Teixeira PJ, Silva MN, Coutinho SR, Palmiera AL, Mata J, Viera PN et al (2009) Mediators of weight loss and weight loss maintenance in middle-aged women. Obesity 18:725–735. doi:10.1038/oby.2009.281
22. Warzinski MT, Sereika SM, Styn MA, Music E, Burke LE (2008) Changes in self-efficacy and dietary adherence: the impact on weight change in the PREFER study. J Behav Med 31:81–92. doi:10.1007/s10865-007-9135-2
23. Linde JA, Rothman AJ, Baldwin AS, Jeffrey RW (2006) The impact of self-efficacy on behavior change and weight change among overweight participants in a weight loss trial. Health Psychol 25:282–291. doi:10.1037/0278-6133.25.3.282
24. Annesi JJ, Tennant GA (2013) Exercise program-induced mood improvement and improved eating in severely obese adults. Int Q Community Health Edu 33:391–402. doi:10.2190/IQ.33.4.f
25. Palmiera AL, Markland DA, Silva MN, Branco TL, Martins SC, Minderico CS, et al. (2009) Reciprocal effects among changes in weight, body image, and other behavioral factors during

behavioral obesity treatment: a mediation analysis. Int J Behav Nutr Phys Act 6:9. doi:10.1186/1479-5868-6-9. http://www.ijbnpa.org/content/6/1/9
26. Mata J, Silva MN, Vieira PN, Carraça EV, Andrade AM, Coutinho SR (2009) Motivational "spill-over" during weight control: increased self-determination and exercise intrinsic motivation predict eating self-regulation. Health Psychol 28:709–716. doi:10.1037/a0016764
27. Wing RR, Tate DF, Gorin AA, Raynor HA, Fava JL (2006) A self-regulation program for maintenance of weight loss. N Engl J Med 355:1563–1571. doi:10.1056/NEJMoa061883
28. Diabetes Prevention Program Research Group (2002) The Diabetes Prevention Program (DPP): description of lifestyle intervention. Diabetes Care 25:2165–2171
29. Diabetes Prevention Program Research Group (2009) 10-year follow-up of diabetes and weight loss in the Diabetes Prevention Program Outcomes Study. Lancet 374:1677–1686. doi:10.1016/S0140-6736(09)61457-4
30. Cooper Z, Doll HA, Hawker DM, Byrne S, Bonner G, Eeley E et al (2010) Testing a new cognitive behavioural treatment for obesity: a randomized controlled trial with three-year follow-up. Behav Res Ther 48:706–713. doi:10.1016/j.brat.2010.03.008
31. Bandura A (1986) Social foundations of thought and action: a social cognitive theory. Prentice Hall, Englewood Cliffs
32. Bandura A (1997) Self-efficacy: the exercise of control. Freeman, Gordonsville
33. Annesi JJ (2012) Supported exercise improves controlled eating and weight through its effects on psychosocial factors: extending a systematic research program toward treatment development. Perm J 16(1):7–18
34. Annesi JJ, Marti CN (2011) Path analysis of cognitive–behavioral exercise treatment-induced changes in psychological factors leading to weight loss. Psychol Health 26:1081–1098. doi:10.1080/08870446.2010.534167
35. Willett WC, Dietz WH, Colditz GA (1999) Guidelines for healthy weight. N Engl J Med 341:427–434. doi:10.1056/NEJM199908053410607
36. Flechtner-Mors M, Ditschuneit HH, Johnson TD, Suchard MA, Adler G (2000) Metabolic and weight loss effects of long-term dietary intervention in obese patients: four-year results. Obes Res 8:399–402. doi:10.1038/oby.2000.48
37. Dunn AL, Trivedi MH, Kampert JB, Clark CG, Chambliss HO (2005) Exercise treatment for depression: efficacy and dose response. Am J Prev Med 28:1–8
38. Annesi JJ, Tennant GA (2014) Generalization of theory-based predictions for improved nutrition and weight loss to adults with morbid obesity: implications of initiating exercise. Int J Clin Health Psychol 14:1–8
39. Trost SG, Owen N, Bauman AE, Sallis JF, Brown W (2002) Correlates of adults' participation in physical activity: review and update. Med Sci Sports Exerc 34:1996–2001. doi:10.1249/01.MSS.0000038974.76900.92
40. Saelens BE, Gehrman CA, Sallis JF, Calfas KJ, Sarkin JA, Caparosa S (2000) Use of self-management strategies in a 2-year cognitive–behavioral intervention to promote physical activity. Behav Ther 31:365–379. doi:10.1016/S0005-7894(00)80020-9
41. Baumeister RF, Vohs KD, Tice DM (2007) The strength model of self-control. Curr Dir Psychol Sci 16:351–355. doi:10.1111/j.1467-8721.2007.00534.x
42. Marcus BH, Selby VC, Niaura RS, Rossi JS (1992) Self-efficacy and the stages of exercise behavior change. Res Q Exerc Sport 63:60–66. doi:10.1080/02701367.1992.10607557
43. Clark MM, Abrams DB, Niaura RS, Eaton CA, Rossi JS (1991) Self-efficacy in weight management. J Consult Clin Psychol 59:739–744. doi:10.1037/0022-006X.59.5.739
44. McNair DM, Heuchert JWP (2005) Profile of Mood States technical update. Multi-Health Systems, North Tonawanda
45. Fitts WH, Warren WL (1996) Tennessee Self-Concept Scale manual, 2nd edn. Western Psychological Services, Los Angeles
46. Popkess-Vawter S, Banks N (1992) Body image measurement in overweight females. Clin Nurs Res 1:402–417. doi:10.1177/105477389200100408
47. Cash TF (1994) The Multidimensional Body-Self Relations Questionnaire users' manual. Old Dominion University, Norfolk
48. Godin G (2011) The Godin–Shephard Leisure-Time Physical Activity Questionnaire. Health Fit J Can 4(1):18–22
49. Jetté M, Sidney K, Blümchen G (1990) Metabolic equivalents (METS) in exercise testing, exercise prescription, and evaluation of functional capacity. Clin Cardiol 18:555–565. doi:10.1002/clc.4960130809
50. Godin G, Shephard RJ (1985) A simple method to assess exercise behavior in the community. Can J Appl Sport Sci 10:141–146
51. Jacobs DR, Ainsworth BE, Hartman TJ, Leon AS (1993) A simultaneous evaluation of 10 commonly used physical activity questionnaires. Med Sci Sport Exerc 25:81–91
52. Miller DJ, Freedson PS, Kline GM (1994) Comparison of activity levels using Caltrac accelerometer and five questionnaires. Med Sci Sport Exerc 26:376–382
53. Kaiser Permanente Health Education Services (2008) Cultivating health weight management kit, 8th edn. Kaiser Permanente Northwest, Portland
54. Schafer JL, Graham JW (2002) Missing data: our view of the state of the art. Psychol Methods 7:147–177. doi:10.1037/1082-989X.7.2.147
55. Glymour MM, Weuve J, Berkman LF, Kawachi I, Robins JM (2005) When is baseline adjustment useful in analyses of change? An example with education and cognitive change. Am J Epidemiol 162:267–278. doi:10.1093/aje/kwi187
56. Grimm LG, Yarnold PR (eds) (1995) Reading and understanding multivariate statistics. American Psychological Association, Washington DC
57. Hsieh FY, Bloch DA, Larsen MD (1998) A simple methods of sample size calculation for linear and logistic regression. Stat Med 17:1623–1634
58. Tabachnick BG, Fidell LS (1996) Using multivariate statistics. Harper Collins, New York
59. Diekhoff GM (1992) Statistics for the social and behavioral sciences: univariate, bivariate, multivariate. Brown, Dubuque
60. Kruger J, Blanck HM, Gillespie C (2006) Dietary and physical activity behaviors among adults successful at weight loss maintenance. Int J Behav Nutr Phys Act 3:17. doi:10.1186/1479-5868-3-17
61. Tiexiera PJ, Going SB, Houtkooper LB, Cussler EC, Martin CJ, Metcalfe LL et al (2002) Weight loss readiness in middle-aged women: psychosocial predictors of success for behavioral weight reduction. J Behav Med 25:499–523. doi:10.1023/A:1020687832448
62. Annesi JJ, Whitaker AC (2010) Psychological factors discriminating between successful and unsuccessful weight loss in a behavioral exercise and nutrition education treatment. Int J Behav Med 17:168–175. doi:10.1007/s12529-009-9056-2
63. Bandura A (2005) The primacy of self-regulation in health promotion. Appl Psychol Int Rev 54:245–254
64. Morgan WP (1997) Methodological considerations. In: Morgan WP (ed) Physical activity and mental health. Taylor & Francis, Washington DC
65. Nunally JC, Bernstein IH (1994) Psychometric theory, 2nd edn. McGraw-Hill, New York