Int. J. Behav. Med. (2010) 17:168–175
DOI 10.1007/s12529-009-9056-2

Psychological Factors Discriminating Between Successful and Unsuccessful Weight Loss in a Behavioral Exercise and Nutrition Education Treatment

James J. Annesi · Ann C. Whitaker

Published online: 4 August 2009

Abstract
Background Psychological and behavioral characteristics that predict success or failure with weight-loss treatments are poorly understood.
Purpose The purpose of this study was to assess whether social cognitive theory-based factors discriminate between women who are successful and unsuccessful at weight loss.
Method Obese women (BMI=30 to 45 kg/m^2) who participated in a treatment of behavioral exercise support counseling and nutrition education were divided into quartiles based on percentage of body weight lost over 6 months. Factors based on social cognitive theory, both at baseline and change over 6 months, and exercise attendance were used to discriminate between the *successful* (highest quartile, $M_{\text{change in body weight}}$=−9.3%; n=40) and *unsuccessful* (lowest quartile, $M_{\text{change in body weight}}$=1.9%; n=37) groups.
Results Stepwise discriminant analyses indicated that body satisfaction and tension (anxiety) scores at baseline, and changes over 6 months in self-regulatory efficacy and body satisfaction, made significant contributions to predicting group membership (64% and 69% of cases were correctly classified, respectively). Attendance percentage of exercise sessions was significantly greater for the successful weight-loss group, and when added as a predictor, changes in self-regulatory efficacy and attendance made a significant contribution to predicting group membership (81% of cases were correctly classified).
Conclusion Further research may enable psychological determinants to better guide weight loss theory and treatments.

Keywords Exercise · Weight loss · Social cognitive · Behavioral · Self-efficacy · Physical activity

Introduction

In the USA, approximately two thirds of the adult population is now either overweight (body mass index (BMI)=25.0 to 29.9 kg/m^2) or obese (BMI≥30.0 kg/m^2) [1]. The World Health Organization [2] has deemed the increasing prevalence of overweight and obesity an international problem. In the USA, more women (33.4%) than men (27.5%) are obese. At any given time, approximately 44% are attempting to lose weight—mostly by trying to eat less [3]. Restricting caloric intake (dieting) for weight loss, however, has overwhelmingly been ineffective [4, 5].

Although there has been preliminary research on the psychological and behavioral factors that predict success or failure with weight loss, findings have not been incorporated into a comprehensive model. For example, in retrospective research, it appeared that weight-loss failure was associated with dichotomous thinking, perception of weight-loss barriers, evaluation of self-worth through body shape, and use of eating to regulate mood [4, 6]; success was associated with intrinsic motivation, a positive appraisal of physical outcomes, self-efficacy, and the use of self-management strategies to overcome barriers [7, 8]. The moderating effects of psychological variables on treat-

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

A. C. Whitaker
Kaiser Permanente,
Atlanta, GA, USA

ments' association with weight loss have, however, remained understudied. This is probably because research goals have been limited to generating hypotheses for further investigation [9]. In practice, many treatments still emphasize information in desirable nutrition practices without accounting for cognitive–behavioral factors that may well predict success or failure with requisite behavioral changes.

In addition to psychological factors, physical activity is a robust correlate of weight loss [10, 11]. Although physical activity may have benefits for weight loss well beyond just the energy expended [12], many behavioral weight-loss treatments have deferred initiating an exercise program because of fears that it may overwhelm limited self-management abilities, already being tested by a restrictive diet. Regimens of regular physical activity have been hard to adhere to. This is exemplified by research suggesting that half to two thirds of those initiating exercise programs will drop out within 3 to 6 months [13, 14], and only about 3% of American women get the suggested minimum amount of physical activity [15]. Although mechanisms of the physical activity–weight loss relationship remain unclear, an adaptation of social cognitive and self-efficacy theory [16, 17] posited that participation in an exercise program would improve mood, body image, self-efficacy, self-esteem, and coping and, thus, increases behaviors associated with weight loss [18].

A recent behavioral treatment incorporated previous findings on the psychological characteristics of success/failure with weight loss, tenets of social cognitive and self-efficacy theory, propositions made by Baker and Brownell [18], and exercise adherence intervention research to support physical activity and weight loss through improvements in self-efficacy, satisfaction with one's body, and mood [19, 20]. For example, the self-efficacy components of task self-efficacy (i.e., perceived physical capabilities) and self-regulatory efficacy (i.e., perceived self-management capabilities) [21] were addressed by inducing participants to feel an increased sense of competence about their physical abilities and teaching them self-management and self-regulatory skills (e.g., goal setting, cognitive restructuring, stimulus control) so that they feel competent at countering common barriers (e.g., time, discomfort). Improvements in body satisfaction were attempted through a focus on incremental process goals (e.g., progressively increasing time and intensity of exercise) over simple physiological measurements (e.g., body weight, circumference measurements) that may be disappointingly slow and discouraging. Research showed that when manageable short-term goals were established, attained, and acknowledged, feelings of competence and mastery were associated with an increased satisfaction with one's body—even when physiological improvements were minimal [22]. Mood improvements such as a reduction in anxiety and depression and increased energy were thought to be a function of simply completing some regular exercise. Most reviews suggested that improved mood, which is quite reliable for new exercisers, has little association with physical activity amounts [23, 24]. Improvements in mood were, thus, highlighted to maximize its reinforcement value for participants. As recommended, after treatment effects on weight loss were determined, findings were decomposed to determine the impact of theory-based factors [25, 26].

The present research was intended to extend previous findings and use theoretically based psychological factors to discriminate between successful and unsuccessful participants in a behavioral weight-loss treatment incorporating physical activity at its outset. The psychological factors of self-efficacy, body satisfaction, and mood were suggested to be both *directly* associated with weight loss and *indirectly* associated through proposed paths that related the psychological changes and exercise, and exercise with weight loss [12, 20]. The comparative strengths of these two conceptual approaches for predicting weight-loss success or failure were unclear; thus, both were tested. Moreover, psychological variables at treatment initiation, along with changes in the variables over the course of treatment, appeared important to account for when predicting weight-loss success or failure. Thus, psychological factors at treatment initiation, along with their responses to the dynamic process of weight loss during treatment, were assessed. It was expected that higher amounts of self-efficacy, body satisfaction, and mood at baseline, and greater improvement on those factors over the duration of the treatment, would be associated with membership in the successful weight-loss group and vice versa. Additionally, it was thought that exercise session attendance would strengthen the percentage of participants correctly classified into successful and unsuccessful weight-loss groups. Although theory and previous research have given *some* useful direction to behavioral weight loss intervention, findings still suggest that individual responses to treatment are *highly* variable, and there remains a minimal understanding of factors and processes predictive of success or failure with weight loss. It is hoped that findings will facilitate a better understanding of how social cognitive theory factors and physical activity predict success or failure within a behavioral weight-loss treatment.

Method

Participants

Participants were derived from a pool of 148 obese women (BMI=30 to 45 kg/m^2) who responded to advertisements in the local print media and voluntarily participated in a 6-

month supported exercise and nutrition education treatment for weight loss. Along with the above BMI range, inclusion criteria were (a) age of 21 to 65 years, (b) no regular exercise within the previous year, and (c) reporting a goal of weight loss. Exclusion criteria were (a) inadequate physical condition for exercise, (b) being, or planning to soon become, pregnant, (c) taking medications for weight loss, and (d) previous surgery for weight loss. Informed consent was required in writing, along with written permission to participate from a physician. Appropriate institutional review board approval was received.

Individuals were designated as being in either the *successful weight-loss group* or the *unsuccessful weight-loss group* by assessing their percentage of change in body weight over 6 months and by partitioning into quartiles. The successful weight-loss group (quartile with the greatest weight loss; n=40) had a mean of 9.3% weight loss (SD=4.6) or a mean loss of 9.3 kg (SD=4.8). The unsuccessful weight-loss group (quartile with the least weight loss, or with weight gain; n=37) had a mean of 1.9% weight gain (SD=2.1) or a gain of 1.8 kg (SD=1.9). Uneven group sizes are due to ties on weight change percentages. Overall, participants' mean age was 44.2 years (SD=9.2), and ethnicities were 52% White, 41% African American, and 7% of other ethnic groups. Baseline physiological factor scores are given in Table 1. Participants were predominantly in the lower–middle and middle classes.

Measures

Self-efficacy Consistent with previous research [19], the two dimensions of self-efficacy (i.e., self-regulatory efficacy and task self-efficacy) [17, 21] were separately measured. The Exercise Self-Efficacy Scale (ESE; [27]) was used to measure self-regulatory efficacy or confidence in using internal psychological resources to overcome barriers to completing exercise. The ESE required responses to five items which began with the stem, "I am confident I can participate in regular exercise when:" (e.g., "I feel I don't have the time"), ranging from 1 (*Not at all confident*) to 7 (*Very confident*). Internal consistencies were .82 and .76, and test–retest reliability over 2 weeks was .90 [28].

The Physical Self-Concept Scale (PSC) of the Tennessee Self-Concept Scale [29] measured task self-efficacy or feelings of adequacy regarding the physical self. PSC required responses to 14 items (e.g., "I have a healthy body," "I am neither too fat nor too thin) ranging from 1 (*Always false*) to 5 (*Always true*). The internal consistency was .83, and test–retest reliability over 1 to 2 weeks was .79 [29]. Significant correlations with the Psychasthenia scale of the Minnesota Multiphasic Personality Inventory (MMPI), Body Shape Questionnaire, and Nash Body Image Scale suggested concurrent validity in women [29, 30].

Body satisfaction The Body Areas Satisfaction Scale (BAS) of the Multidimensional Body-Self Relations Questionnaire [31] evaluated satisfaction with areas of one's body (e.g., lower torso (buttocks, hips, thighs, legs), weight). The BAS required responses to five items ranging from 1 (*Very dissatisfied*) to 5 (*Very satisfied*). Internal consistency for women was .73, and test–retest reliability was .74 [31].

Mood Total Mood Disturbance (TMD) is an aggregate measure of mood derived from the six subscales of the Profile of Mood States-Short Form [32]. Respondents rate feelings over the past week on 30 items ranging from 0 (*Not at all*) to 4 (*Extremely*). Internal consistency for the Tension (T), Depression (D), Fatigue, Confusion, Anger, and Vigor subscales ranged from .84 to .95, and test–retest reliability at 3 weeks averaged .69 [32]. The factor structure demonstrated consistency, and concurrent validity was suggested through contrasts with measures such as the Beck Depression Inventory, Manifest Anxiety Scale, and MMPI ([32], pp. 13–15).

Exercise Session Attendance Exercise session attendance was the ratio of sessions attended divided by the "ideal" number or 72 (three sessions assigned per week × 24 weeks), expressed as a percentage. Exercise sessions

Table 1 Descriptive statistics of age and physiological factors at baseline, by group

	Successful weight loss (n=40)		Unsuccessful weight loss (n=37)	
	M	SD	M	SD
Age (years)	45.9	8.7	42.4	9.4
Body fat percentage	37.6	4.4	37.2	3.5
Waist circumference (cm)	107.5	11.5	104.1	10.4
Resting heart rate (beats/min)	79.7	11.5	82.4	10.1
Blood pressure—systolic (mmHg)	135.9	17.9	131.5	16.9
Blood pressure—diastolic (mmHg)	81.6	10.3	84.6	11.6
Body mass index (BMI; kg/m^2)	37.8	4.8	35.7	4.3

completed were recorded electronically through a system that was suggested to be valid through strong significant correlations (r=.42 to .55) with changes in measures of cardiorespiratory function (e.g., $VO_{2\ max}$, blood pressure, resting heart rate) [22].

Physiological Factors A stadiometer and a recently calibrated digital scale were used to measure BMI (kg/m^2). A tape measure was used to measure waist circumference (cm). Body fat percentage was assessed using skinfold calipers at three sites (abdomen, ilium, and triceps) and applying the Jackson–Pollock equation [33]. Resting heart rate (beats/min) was assessed after a minimum of 5 min rest. An aneroid sphygmomanometer with attached stethoscope was used to measure systolic and diastolic blood pressure in mmHg. Measurements were each taken at a similar time of day by the same technician.

Change scores were calculated by subtracting the baseline score from the score at week 24.

Procedure

Participants were given access to YMCA wellness centers, along with enrollment in an exercise support protocol based on social cognitive theory [13] and a group nutrition education program [34]. The exercise support protocol consisted of a sequence of six 1-h meetings with a trained wellness leader, spaced across 6 months. These one-on-one meetings included an orientation to available exercise apparatus and administration of an array of methods intended to support the maintenance of exercise. Goal setting and progress feedback and other cognitive–behavioral methods such as contracting, stimulus control, cognitive restructuring, and dissociation from exercise-induced discomfort were presented. The exercise support protocol used has been associated with significant improvements in exercise adherence when contrasted with typical wellness center processes [13, 35].

Although specific modalities used in exercise plans (e.g., type of cardiovascular machines, incorporation of outdoor walking/running) were based on each participant's preference, three exercise sessions per week were uniformly assigned. The cardiovascular exercise progressed from a minimum of 20 min to a maximum of 30 min per session at a rate of perceived exertion of 13 to 14 (estimated 60% to 70% $VO_{2\ max}$) [36]. Exercise sessions could be completed both inside and outside of the available exercise facilities. Computerized kiosks provided within wellness centers and the Internet were used to record completed exercise. Graphic summaries of completed exercise were always available.

The nutrition education program consisted of six 1-h nutrition information sessions over the initial 3 months. They were led by a registered dietitian in a group format of approximately 15 participants based on a standardized format supported by a workbook [34]. Examples of program components were: (a) understanding calories, carbohydrates, protein, and fats; (b) using the food pyramid for number of servings and portion sizes; (c) developing a plan for snacking; and (d) menu planning.

Testing of the physiological and psychological factors was conducted in a private area at baseline and at week 24.

Data Analysis

Because this investigation was preliminary, several combinations of psychological factors were tested to accommodate variants of social cognitive theory. Within the adaptation of social cognitive theory of Baker and Brownell [18] that focused on the relationship of physical activity, psychological factors, and weight loss, a number of these variants were exemplified. For example, it was not known whether overall mood or tension and depression, specifically, should be included along with self-efficacy and body satisfaction factors as possible discriminators of success/failure with weight loss. In addition, it was not clear whether exercise session attendance should be treated as an additional discriminator or be considered as a possible outcome of the psychological factors tested, which would necessitate its analysis as a moderator of weight loss in a different experimental design. Moreover, because it was possible that self-efficacy, body satisfaction, and mood factors at both baseline, and change from baseline to treatment end, would discriminate between success or failure with weight loss, *both* temporal scenarios were tested. Largely for these reasons, the present analytic strategy was considered justified to provide direction for future, more thorough, investigation of factors associated with success or failure within a behavioral weight-loss treatment incorporating exercise from its outset.

An intention-to-treat design was used where missing data associated with treatment dropout were imputed using the baseline carried forward method [37]. Because research suggests that short-term weight loss will typically revert to baseline soon after terminating treatment [38], this method, previously used under conditions similar to this study [9, 39–41], was employed. It had the advantage of maximizing statistical power while not retaining data from only those with high treatment compliance or predicting changes (and imputing) based on results from participants who successfully complied [37]. Survey responses that were missing on a random basis were imputed using the expectation maximization approach [42, 43].

Statistical significance was set at α=.05 (two-tailed). The sequential Bonferroni procedure suggested by Jaccard [44] and Holm [45] was used to adjust alpha levels for

multiple *t* tests. Thus, for the smallest alpha value (within a grouping of *t* tests), .05 would be divided by the number of tests conducted to establish the critical value for statistical significance (e.g., .05/4 tests=critical value of .01). If significance is met, the second smallest alpha value would have the .05 value divided by the number of tests minus 1 to establish the critical value (e.g., .05/3=critical value of .02). This process continues one by one with the progressively greater alpha values until statistical significance is no longer met. Research suggests that this method performs better than the traditional Bonferroni correction procedure in maintaining statistical power, while also controlling for inflation of the Type I error rate [46]. Because of the exploratory nature of this investigation, adjusted alpha values based on a marginal significance of α=.10 were also reported.

Initially, group differences in age, baseline scores on physiological factors, and ethnicities were assessed. Independent *t* tests were then conducted to contrast mean scores at baseline on the self-efficacy factors of PSC and ESE, the body satisfaction factor of BAS, and the mood factors of TMD, T, and D between participants in the successful and unsuccessful weight-loss groups. Following this, stepwise discriminant analyses (p<.05 to enter; p<.10 to remove) were conducted to determine the most relevant of these factors at baseline for predicting membership in the successful and unsuccessful weight-loss groups. Models were tested that separately included the three mood factors assessed (TMD, T, and D). For each model, classification accuracy was then calculated and contrasted with the a priori criterion set which was ≥125% of the proportional by-chance accuracy rate.

Independent *t* tests were then conducted to contrast score changes over the 6 months of treatment (mean difference scores) on the aforementioned psychological factors and exercise session attendance over 6 months. On further analyses, stepwise discriminant analyses were conducted to determine the most relevant of these factors for predicting membership in the successful and unsuccessful weight-loss groups. In the first of the models, changes in scores of PSC, ESE, BAS, and TMD were included. Changes in T and D scores were then individually substituted for changes in TMD scores in additional models. Finally, exercise session attendance was added to each of the models. Classification accuracy was calculated and contrasted with the criterion set.

Results

Independent *t* and χ^2 tests indicated no significant group differences in age, baseline physiological factors, or ethnic group makeup. The unsuccessful weight-loss group had significantly higher baseline scores than the successful weight-loss group on BAS and T. Their higher scores on PSC and TMD were marginally significant (Table 2). Results of the stepwise discriminant analyses where PSC, ESE, BAS, and TMD scores at baseline were predictor variables indicated that only BAS made a significant contribution to predicting membership in the successful and unsuccessful weight-loss groups, Wilks' λ=.92, $\chi^2(1)$=6.22, p=.013. The factor correctly classified 55.8% of cases, which was below the accuracy criterion set. There was no difference in the results when D was substituted for TMD. When T scores at baseline were substituted for TMD scores in a discriminant analysis, results indicated that T and BAS made a significant contribution to predicting group membership, Wilks' λ=.85, $\chi^2(2)$=11.64, p=.003. Standardized canonical correlations were .70 and −.67, respectively. The factors correctly classified 63.6% of cases, which was above the accuracy criterion set.

Exercise session attendance percentage in the successful weight-loss group (M=79.60%, SD=18.69) was significantly greater than in the unsuccessful weight-loss group (M=59.29%, SD=16.90). The difference reached statistical significance, $t(75)$=4.99, p<.001, d=1.14. Mean change scores from baseline to month 6 were significantly greater on ESE in the successful weight-loss group (Table 3).

Results of the stepwise discriminant analyses where changes in PSC, ESE, BAS, and TMD scores over 6 months were predictor variables indicated that ESE and BAS made a significant contribution to predicting membership in the successful and unsuccessful weight-loss groups, Wilks' λ=.86, $\chi^2(2)$=11.13, p=.004. Standardized canonical correlations were .79 and .67, respectively. The factors correctly classified 68.8% of cases, which was above the accuracy criterion set. There was no difference in the results when changes in T and D scores were separately substituted for TMD scores. When exercise session attendance was added to each of the above models, exercise session attendance and ESE made a significant contribution to predicting group membership, Wilks' λ=.71, $\chi^2(2)$=25.00, p<.001. Standardized canonical correlations were .88 and .53, respectively. The factors correctly classified 80.5% of cases, which was above the accuracy criterion set.

Discussion

This investigation assessed the ability of self-efficacy, body satisfaction, mood factor scores, and exercise session attendance to discriminate between obese women in a supported exercise and nutrition education treatment that were in the most and least successful weight-loss quartile groups. At baseline, no significant group differences in age, ethnicity, and measures of body composition and cardio-

Table 2 Group differences in means on psychological factor scores at baseline

	Successful weight loss (n=40)		Unsuccessful weight loss (n=37)		t(75)	p value	d
	M	SD	M	SD			
Physical Self-Concept Scale (PSC)	36.30	8.53	39.95	5.84	2.17	.03**	.59
Exercise Self-Efficacy Scale (ESE)	15.68	4.98	17.05	2.30	1.42	.16	.35
Body Areas Satisfaction Scale (BAS)	9.23	1.95	10.43	2.19	2.56	.01*	.58
Total Mood Disturbance (TMD)	18.83	14.92	12.25	10.85	2.20	.03**	.50
Tension (T)	4.63	3.56	2.84	2.05	2.67	.01*	.62
Depression (D)	3.96	2.77	2.74	2.76	1.94	.06	.44

d Cohen's measure of effect size

*p<.05, **p=.05 to .10, with the sequential Bonferroni adjustment applied

vascular functioning were found. Findings suggested that at the start of treatment, perceptions of adequacy of the physical self, satisfaction with one's body, and mood were worse for the successful weight-loss group. Body satisfaction and tension were the critical factors in discriminating between membership in the successful and unsuccessful weight-loss groups. While these findings may appear unsupportive of social cognitive theory, alternate explanations are possible within the context of the present research. For example, it is possible that less satisfaction with one's body served to energize and make more productive the short-term goal setting and incremental feedback aspects of the present behavioral treatment. It is also possible that women with a poorer image of their bodies were especially motivated by feedback that reinforced perceptions of competence and mastery associated with undertaking an exercise program. Body image improvements have been associated with even low-to-moderate amounts of physical activity, and these changes have been disproportionally positive compared to measured physiological changes in obese women [22]. This may have been even more pronounced for the present study's participants that had initially low body satisfaction. Moreover, as suggested by Baker and Brownell [18], perceptions of competence with physical activity may have generalized to feelings of control over eating, thus, more success overall with weight reduction.

Participants with initially more negative mood may have benefited most in their weight loss quests if emotion-induced eating was tempered through the mood-enhancing properties of exercise [47]. Significant improvements in tension and depression have previously been associated with a program of two 20- to 25-min bouts of moderate cardiovascular exercise per week [13], which was typical of the successful weight-loss group within this investigation. Both the reinforcing properties of a more positive psychological outlook and reduced occurrences of low mood that may trigger overeating may, thus, have affected weight loss. Continued research on relations of trait and state moods with eating and on low mood "thresholds" associated with overeating may direct treatment research to better consider implications of individuals' psychological makeup. It should be noted that the above propositions are tentative and require direct testing.

The important role that *changes* in self-regulatory efficacy and in body satisfaction played in discriminating

Table 3 Group differences in means on changes in psychological factor scores over 6 months

	Successful weight loss (n=40)		Unsuccessful weight loss (n=37)		t(75)	p value	d
	M	SD	M	SD			
Δ Physical Self-Concept Scale (PSC)	2.45	7.21	2.46	4.49	0.01	.99	.00
Δ Exercise Self-Efficacy Scale (ESE)	1.58	5.02	−1.03	3.59	2.60	.01*	.60
Δ Body Areas Satisfaction Scale (BAS)	2.70	3.12	1.43	1.82	2.15	.03	.50
Δ Total Mood Disturbance (TMD)	−12.87	18.31	−10.20	12.54	0.74	.46	.17
Δ Tension (T)	−1.63	3.42	−0.38	2.66	1.78	.08	.41
Δ Depression (D)	−1.07	3.16	−0.80	2.16	0.44	.66	.10

The delta symbol (Δ) denotes score change from baseline to month 6

d Cohen's measure of effect size

*p<.05, with the sequential Bonferroni adjustment applied

between the successful and unsuccessful weight-loss group participants is consistent with social cognitive and self-efficacy theory, Baker and Brownell's [18] adaptation of these theories, and previous research [19, 20]. An increased ability to effectively deal with barriers to exercise was likely to have affected adherence to exercise and generalized to appropriate eating behaviors, "…through a more general sense of weight-loss self-efficacy." ([18], p. 323). It is likely that the present intervention's focus on self-management and self-regulation skills affected this. It is also likely that improvements in satisfaction with one's body had a highly reinforcing effect that supported persistence with weight-loss behaviors. A more attractive, lighter body is a highly sought after outcome for obese women involved in weight-loss treatments [48].

On a methodological note, the present findings suggest a need to continue addressing psychological changes made during treatment as a predictor of weight-loss outcomes. The dynamics of individuals' psychological changes during the course of treatment have been understudied and may hold great value in both the development of theoretical models and treatments. If, for example, a treatment fails to increase participants' ability to overcome barriers, additional training in self-management/self-regulatory methods may benefit. If body satisfaction does not improve, increased attention to markers such as improved cardiorespiratory functioning and greater muscular strength may induce perceptions of an improved physical self. Ultimately, efforts to account systematically for salient psychological factors at both treatment initiation and changes in those factors over time may enable treatments to be both widely disseminated and sensitive to individual differences.

It should also be noted, however, that the predictors of successful and unsuccessful weight loss assessed here might have been affected by self-selection associated with the treatment recruitment process. Treatment goals (e.g., appearance, health, mood) may also have affected how important change in a particular psychological variable was by participant, thus, affecting results. Additionally, weight loss goals may have varied between participants and that may have affected amounts of weight lost. Although every attempt was made to standardize treatment, variations in treatment administrators' personal styles may also have affected results, along with confounds based on participants' expectations. Although the above threats to internal validity should be considered in replications of this research extended to difference sample types over longer periods, a strength of this investigation was its external validity fostered by use of a naturalistic setting. The systematic investigation of behavioral predictors of weight loss within "the context in which programs are conducted" has been specifically suggested to best advance weight loss interventions and behavioral medicine in general ([49], p. 19).

Extensions of this research examining multiple causal paths are required to define the specific role of exercise in the weight loss process and ascertain how the predictive value of social cognitive theory factors may be best used to advance both the theory and treatment of weight loss. The association of exercise with weight loss found here extended what was known on psychological predictors of weight loss success and failure [20, 50]. To improve effects on weight loss, it is strongly advised that future weight-loss treatments be first derived from the evidence base in behavioral research and then be decomposed to determine the integrity of their theoretical bases on the actual weight-loss process observed. Based on the poor results of weight-loss treatments for reducing health risks, to date, behavioral science may need to play a larger role in the development of interventions.

References

1. Hedley AA, Ogden CL, Johnson CL, Carroll MD, Curtin LR, Flegal KM. Obesity among U.S. children, adolescents, and adults, 1999–2002. J Am Med Assoc. 2004;291:2847–50.
2. World Health Organization (2008) Obesity and overweight. Retrieved September 26, 2008, from http://www.who.int/dietphysicalactivity/publications/facts/obesity/en/.
3. Serdula MK, Mokdad AH, Williamson DF, Galuska DA, Mendlein JM, Heath GW. Prevalence of attempting weight loss and strategies for controlling weight. J Am Med Assoc. 1999;282:1353–8.
4. Byrne SM, Cooper Z, Fairburn CG. Psychological predictors of weight regain in obesity. Behavior Research and Therapy. 2004;42:1341–56.
5. Mann T, Tomiyama J, Westling E, Lew AM, Samuels B, Chatman J. Medicare's search for effective obesity treatments: diets are not the answer. Am Psychol. 2007;62:220–33.
6. Kruger J, Blanck HM, Gillespie C. Dietary and physical activity behaviors among adults successful at weight loss maintenance. International Journal of Behavioral Nutrition and Physical Activity. 2006;3:17. http://www.ijbnpa.org/contents/3/1/17.
7. Elfhag K, Rossner S. Who succeeds in maintaining weight loss? A conceptual review of factors associated with weight loss maintenance and regain. Obes Rev. 2005;6:67–85.
8. Tiexiera PJ, Going SB, Houtkooper LB, Cussler EC, Martin CJ, Metcalfe LL, et al. Weight loss readiness in middle-aged women: psychosocial predictors of success for behavioral weight reduction. J Behav Med. 2002;25:499–523.
9. Tiexiera PJ, Palmeira AL, Branco TL, Martins SS, Minderico CS, Brata JT, et al. Who will lose weight? A reexamination of predictors of weight loss in women. International Journal of Behavioral Nutrition and Physical Activity. 2004;1:12. doi:10.1186/1479-5868-1-12. http://www.ijbnpa.org/content/1/1/12.
10. Miller WC, Koceja DM, Hamilton EJ. A meta-analysis of the past 25 years of weight loss research using diet, exercise, or diet plus exercise intervention. Int J Obes. 1997;21:941–7.
11. Pronk NP, Wing RR. Physical activity and long-term maintenance of weight loss. Obes Res. 1994;2:587–99.
12. Brownell KD. Exercise and obesity treatment: psychological aspects. Int J Obes Relat Metab Disord. 1995;10(Suppl):122–5.
13. Annesi JJ. Effects of a cognitive behavioral treatment package on exercise attendance and drop out in fitness centers. European Journal of Sport Science. 2003;3(2):1–16.

14. Buckworth J, Dishman RK. Exercise psychology. Champaign, IL: Human Kinetics; 2002.
15. Troiano RP, Berrigan D, Dodd KW, Masse LC, Tilert T, McDowell M. Physical activity in the United States measured by accelerometer. Medicine & Science in Sports & Exercise. 2008;40:181–8.
16. Bandura A. Social foundations of thought and action: a social cognitive theory. Englewood Cliffs, NJ: Prentice Hall; 1986.
17. Bandura A. Self-efficacy: the exercise of control. New York, NY: Freeman; 1997.
18. Baker CW, Brownell KD. Physical activity and maintenance of weight loss: physiological and psychological mechanisms. In: Bouchard C, editor. Physical activity and obesity. Champaign, IL: Human Kinetics; 2000. p. 311–28.
19. Annesi JJ. Relations of changes in exercise self-efficacy, physical self-concept, and body satisfaction with weight changes in obese White and African American women initiating a physical activity program. Ethn Dis. 2007;17:19–22.
20. Annesi JJ, Whitaker AC. Weight loss and psychologic gain in obese women - participants in a supported exercise intervention. Permanente Journal. 2008;12(3):36–45.
21. McAuley E, Peña MM, Jerome GJ. Self-efficacy as a determinant and an outcome of exercise. In: Roberts G, editor. Advances in motivation in sport and exercise. Champaign, IL: Human Kinetics; 2001. p. 235–61.
22. Annesi JJ. Effects of minimal exercise and cognitive behavior modification on adherence, emotion change, self-image, and physical change in obese women. Percept Mot Skills. 2000;91:322–36.
23. Landers DM, Arent SM. Physical activity and mental health. In: Singer RN, Hausenblas HA, Janelle CM, editors. Handbook of sport psychology. 2nd ed. New York: Wiley; 2001. p. 740–65.
24. Wipfli BM, Rethorst CD, Landers DM. The anxiolytic effects of exercise: a meta-analysis of randomized trials and dose-response analysis. J Sport Exerc Psychol. 2008;30:392–410.
25. Baranowski T, Anderson C, Carmack C. Mediating variable framework in physical activity interventions. How are we doing? How might we do better? Am J Prev Med. 1998;15:266–97.
26. Baron RM, Kenny DA. The moderator-mediator variable distinction in social psychological research: conceptual, strategic, and statistical considerations. J Pers Soc Psychol. 1986;51:1173–82.
27. Marcus BH, Selby VC, Niaura RS, Rossi JS. Self-efficacy and the stages of exercise behavior change. Res Q Exerc Sport. 1992;63:60–6.
28. McAuley E, Mihalko SL. Measuring exercise-related self-efficacy. In: Duda JL, editor. Advances in sport and exercise psychology measurement. Morgantown, WV: Fitness Information Technology; 1998. p. 371–90.
29. Fitts WH, Warren WL. Tennessee Self-Concept Scale manual. 2nd ed. Los Angeles, CA: Western Psychological Services; 1996.
30. Popkess-Vawter S, Banks N. Body image measurement in overweight females. Clin Nurs Res. 1992;1:402–17.
31. Cash TF. The Multidimensional Body-Self Relations Questionnaire users' manual. Norfolk, VA: Old Dominion University; 1994.
32. McNair DM, Lorr M, Droppleman LF. Manual for the Profile of Mood States. San Diego, CA: Education and Industrial Testing Service; 1992.
33. Jackson AS, Pollock ML. Practical assessment of body composition. Phys Sportsmed. 1985;13:76–90.
34. Kaiser Permanente Health Education Services. Cultivating Health weight management resource guide. Portland, OR: Author; 2002.
35. Annesi JJ, Unruh JL. Effects of THE COACH APPROACH® intervention on drop out rates among adults initiating exercise programs at nine YMCAs over three years. Percept Mot Skills. 2007;104:459–66.
36. Borg G. Borg's perceived exertion and pain scales. Champaign, IL: Human Kinetics; 1998.
37. Gadbury GL, Coffey CS, Allison DB. Modern statistical methods for handling missing repeated measurements in obesity trial data: beyond LOCF. Obes Rev. 2003;4:175–84.
38. Jeffery RW, Drewnowski A, Epstein LH, Stunkard AJ, Wilson GT, Wing RR, et al. Long-term maintenance of weight loss: current status. Health Psychol. 2000;19(Suppl):5–16.
39. Toobert DJ, Stryker LA, Glaskow RE, Barrera M, Angell K. Effects of the Mediterranean lifestyle program on multiple risk behaviors and psychosocial outcomes among women at risk for heart disease. Annals Behav Med. 2005;29:128–37.
40. Warziski MT, Sereika SM, Styn MA, Music E, Burke LE. Changes in self-efficacy and dietary adherence: the impact on weight loss in the PREFER study. J Behav Med. 2008; 31:81–92.
41. Womble LG, Wadden TA, McGuckin BG, Sargent SL, Rothman RA, Krauthamer-Ewing ES. A randomized controlled trial of a commercial weight loss program. Obes Res. 2004;12:1011–8.
42. Rubin DB. Multiple imputation for nonresponse in surveys. New York: Wiley; 1987.
43. Schafer JL. Multiple imputation: a primer. Stat Methods Med Res. 1999;8:3–15.
44. Jaccard J. Interaction effects in factorial analysis of variance: Sage University paper series on quantitative applications in the social sciences, series no. 07-118. Thousand Oaks, CA: Sage; 1998.
45. Holm D. A simple sequentially rejective multiple test procedure. Scand J Stat. 1979;6:65–70.
46. Kromery JD, Dickson WB. The use of an overall *F* test to control Type I error rates in factoral analysis of variance: limitations and better strategies. JAppl Behav Anal. 1995;31:51–64.
47. Jakicic JM, Wing RR, Winters-Hart C. Relationship of physical activity to eating behaviors and weight-loss treatment. Medicine & Science in Sports & Exercise. 2002;34:1653–9.
48. O'Brien K, Venn BJ, Perry T, Green TJ, Aitken W, Bradshaw A, et al. Reasons for wanting to lose weight: different strokes for different folks. Eat Behav. 2007;8:132–5.
49. Glasgow RE. What types of evidence are most needed to advance behavioral medicine? Annals Behav Med. 2008;35:19–25.
50. Wilfley DE, Brownell KD. Physical activity and diet in weight loss. In: Dishman RK, editor. Advances in exercise adherence. Champaign, IL: Human Kinetics; 1994. p. 361–93.