International Journal of Obesity (2001) 25, 340–345
 0307–0565/01 $15.00
www.nature.com/ijo

PAPER

Psychological and behavioral predictors of weight loss during drug treatment for obesity

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OBJECTIVE: This study investigated whether baseline eating behavior, emotions, and body image were significant predictors of change in body mass index (BMI) over 6 month and 12 month time intervals for individuals enrolled in a weight loss program that combined appetite suppressant medications and behavior therapy for obesity.
METHOD: Participants were asked to complete self-report questionnaires at baseline, 6 months, and 12 months. In addition, their height and weight were measured and they were administered a body image assessment procedure at each time interval.
RESULTS: At baseline, perceived hunger, dietary restraint, current body size, and trait anxiety were important components in a model for prediction of weight loss at 6 months. Perceived hunger, dietary restraint, and current body size as measured at baseline were important components in the prediction of weight loss at 12 months. These predictive variables, together with gender and initial BMI, accounted for 48.6% of the variance in weight loss at 6 months and 51.7% of the variance in weight loss at 12 months.
DISCUSSION: These findings suggest that scores on certain paper and pencil tests may be useful as predictors of success or failure for individuals entering a weight loss program using pharmacological and behavioral interventions.
International Journal of Obesity (2001) **25,** 340 – 345

Keywords: dietary restraint; perceived hunger; weight loss; body mass index

Introduction

Individual responses to weight loss interventions are quite variable. Furthermore, reliable predictors of successful weight loss are limited. Initial response to pharmacotherapy (losing at least 4 pounds in the first 4 weeks of treatment) has been examined as one predictor of weight loss over a 6 month to 1 y period. Initial responders to medications were more likely to achieve a weight loss of $>5\%$ of their body weight over a 6 month time interval.[1] In the INDEX study, using dexfenfluramine, 60% of initial responders lost $>10\%$ of their baseline body weight after 1 y of treatment.[2]

Foster *et al*[3] examined baseline *psychological* variables as predictors of the effectiveness of weight loss interventions, combining cognitive–behavioral treatment with varying levels of low-energy diets. The Eating Inventory (EI[4]) scales dietary restraint, disinhibition and perceived hunger, were examined as potential predictors of weight loss. Dietary restraint describes an individual's attempt to restrict energy intake to control body weight.[5] Disinhibition refers to a person's tendency to overeat, which may result from emotions (eg sadness or boredom) or exposure to appetizing foods.[6] Perceived hunger specifies a person's propensity to feel hungry most of the time. Foster *et al*[3] found baseline dietary restraint to be negatively associated with weight loss after 5–6 months. The magnitude of this association was modest, however ($r=-0.15$, $P=0.03$). Those participants with lower initial restraint scores lost more weight during treatment in comparison to those with higher restraint scores. This finding suggests that other psychological tests might have some potential for predicting response to weight loss treatments.

The present study investigates whether eating behavior (dietary restraint, disinhibited eating and perceived hunger), emotions (state anxiety, trait anxiety and depression), body image (perceived current body size and perceived ideal body size) are significant predictors of BMI change over 6 and 12 month time intervals for individuals enrolled in a multifaceted weight loss program. The goal of this study was to identify baseline psychological predictors of weight loss that clinicians could discover using readily accessible questionnaire methods.

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Received 5 March 2000; revised 4 September 2000;
accepted 9 October 2000

Method

Participants

Participants in this study were among the $n=349$ participants in a clinical weight loss program conducted at the Pennington Biomedical Research Center from 1993 to 1997. Selection into the study sample was dependent upon the participant having undergone psychological measurement at baseline and having had BMI evaluation within 2 weeks of the 6 or 12 month anniversary in the program. A total of 59 individuals ($n=31$ females and $n=28$ males) were entered into the 6 month sample and 32 individuals ($n=15$ females and $n=17$ males) were entered into the 12 month sample. Thirty-one of those in the 12 month sample were included in the 6 month sample. The average baseline age of the 28 males was 50.21 y (s.d. = 7.39) and 45.72 y (s.d. = 9.42) for the 31 females. The average baseline BMI for the males was 39.94 (s.d. = 5.99) and 40.34 (s.d. = 8.20) for the females. Participants lost 17.2% (s.d. = 7.2) and 18.8% (s.d. = 9.1) of their initial weight after 6 and 12 months, respectively. Sample sizes of participants taking various drug combinations can be seen in Table 1. Most participants were administered fenfluramine in combination with either mazindol or phentermine. The results of this weight loss study are described by Ryan *et al*.[7] Maximal mean weight loss for the entire sample ($17.9\pm6.3\%$ for men and $19.9\pm7.4\%$ for women) was achieved after approximately 6 months, which was followed by weight regain starting at 12 months.

Consent forms explaining the purpose and procedures of the study were read and signed by the participants prior to data collection. Confidentiality was assured. Each data collection took place prior to a clinic visit and weight loss group meeting at the Pennington Biomedical Research Center.

Assessment measures

Beck Depression Inventory (BDI). The BDI is a 21-item questionnaire that assesses the cognitive, behavioral, affective and somatic symptoms of depression. The BDI has good internal consistency and has been found to be a valid measure of depression.[8]

Speilberger State Trait Anxiety Inventory (STAI). The STAI is a measure of anxiety at the time of test-taking (state) and day-to-day anxiety (trait). Test–retest reliability over 20 days for the trait subscale ranges from 0.76 to 0.86 and for the state subscale ranges from 0.27 to 0.54. Coefficient alphas range from 0.83 to 0.92 for both the state and trait subscales.[9]

Table 1 Sample sizes of participant drug combinations at 6 and 12 months.

Drug combination	*Months*	n
Fenfluramine + Mazindol	6	29
Fenfluramine + Phentermine	6	25
Caffeine + ephedrine	6	2
Mazindol	6	3
Fenfluamine + Mazindol	12	18
Fenfluramine + Phentermine	12	11
Caffeine + ephedrine	12	1
Mazindol	12	2

Eating Inventory (EI). This 51-item scale assesses three factors: dietary restraint (21 items), disinhibition (16 items), and perceived hunger (14 items). The scale comprises 15 forced-choice items and 36 true/false items.[4] Sample items on the dietary restraint scale include 'When I have eaten my quota of calories, I am usually good about not eating any more' and 'I count calories as a conscious means of controlling my weight'. Sample items on the disinhibition scale include 'I usually eat too much at social occasions, like parties and picnics' and 'When I feel blue, I often overeat'. Sample items on the perceived hunger scale include 'I sometimes get very hungry late in the evening or at night' and 'Dieting is so hard for me because I just get too hungry'.

In addition to the self-report measures described above, the participant's height and weight were measured and the Body Image Assessment procedure for obese individuals (BIA-O) was administered.[10] The original BIA[11] presented nine silhouettes of female body sizes ranging from thin to obese in random order. Individuals were asked to select the silhouette that best represented their current body size. The silhouettes were presented in a second random order and the individuals were asked to select the silhouette that best represents their ideal body size. The BIA-O uses 18 silhouettes of males and females ranging from very thin to obese. The assessment procedure is identical to that of the original BIA and recent research supports the reliability and validity of the BIA-O.[10]

Procedure

Each participant completed this assessment packet upon initiation of the weight loss program, after 6 months, and after 12 months. Body weight and height as well as the body image assessment were measured simultaneously. Participants were debriefed about the purpose of the study and any questions or concerns were addressed. Each data collection period lasted approximately 20 min.

Results

Baseline correlations

In the 6 month sample at baseline, the correlations between perceived current body size and perceived ideal body size with BMI were significant and positive ($r=0.54$, $P<0.01$ for the former and $r=0.33$, $P<0.01$ for the latter). Those with a larger BMI perceived their current body size as larger and their ideal body size as larger. In the 12 month sample at baseline, the correlations between perceived current body size and perceived ideal body size with BMI were also positive ($r=0.57$, $P<0.01$ for the former and $r=0.33$, $P>0.05$ for the

latter). The 12 month sample is comprised of a subset of the 6 month sample, which explains why the correlation coefficients are similar. Further, the 12 month sample is smaller than the 6 month sample, which explains why the correlation between perceived ideal body size and BMI only approached significance.

Multiple regression

To control for the bias due to varying initial BMIs of the participants, baseline BMI was used as a covariate in the analysis. The dependent variable was change in BMI over the 6 month period ($BMI_{6\ months}-BMI_{baseline}$). Baseline measures of depression, state anxiety, trait anxiety, dietary restraint, disinhibition, perceived hunger, perceived current and ideal body sizes, initial BMI, and gender were entered as predictors of change in BMI. Dietary restraint, hunger and perceived current body size emerged as significant predictors; trait anxiety was marginally nonsignificant. The variables entered in the model explained 51% of the variance in the change in BMI. Summary of the 6 month regression analysis can be seen in Table 2.

Interpretation of the meaning of positive and negative regression coefficients must take into consideration that the dependent variable is a difference score ($BMI_{6\ months}-BMI_{baseline}$). A positive change in BMI means weight gain and a negative change in BMI means weight loss. A positive association with any explanatory variable (eg dietary restraint, hunger) implies that those with higher scores gain more weight. All of the changes in BMI in this sample were negative, meaning all participants lost weight. Therefore, it is more correct to say that there is a tendency to lose less weight for those participants with high scores on a variable that is positively associated with change in BMI, relative to those with low scores. With that said, those participants who scored higher on dietary restraint and hunger at baseline were less likely to lose weight over the 6 month period. Those participants with a smaller perceived body size at baseline were less likely to lose weight over the 6 month period.

In the second analysis, the dependent variable was change in BMI over the 12 month period ($BMI_{12\ months}-BMI_{baseline}$). Summary of the regression analysis can be seen in Table 3. Hunger emerged as the sole significant predictor of change in BMI while restraint approached significance. The model variables explained 63% of the variance in the change in BMI. Overall, those participants who scored higher on hunger at baseline were less likely to lose weight over the 12 month period.

Model selection

The goal of model selection in this context is to identify an optimal model for weight loss (change in BMI) prediction at both 6 and 12 months from among the psychological measures taken at baseline. To focus on psychological predictors of weight loss over and above the contribution attributable to gender and initial BMI, these two variables were forced into all models under consideration. Model selection was implemented by means of the r^2 method;[14] this algorithm is preferred over various stepwise approaches in that regressions based on all possible subsets of explanatory variables are considered.

In the model selection process, the coefficient of multiple determination (r^2) for each model is employed as a measure of the proportion of the total variation in the response variable accounted for by the regression model. Additionally, the mean squared error (m.s.e.) serves as a valuable estimate of the variance, and Mallow's C_p statistic provides a measure of total mean squared error, the sum of the mean squared error and the squared bias of the model. Tables 4 and 5 summarize the r^2, m.s.e., and C_p statistics for the five 'best' models (in rank order on the basis of largest r^2) as a function of number of parameters in the model for change in BMI at 6 months and 12 months, respectively.

Table 2 Regression of 6-Month change in BMI with independent variables

Predictor variable	*Parameter estimate*	t-*Value*	P
Intercept	−8.89	−2.54	0.014
$BMI_{baseline}$	−0.02	−0.32	0.754
Gender (='F')[a]	1.07	1.58	0.12
Beck Depression Inventory	0.02	0.20	0.84
Current body size	−0.49	−3.12	<0.01
Dietary restraint	0.31	3.06	<0.01
Disinhibition	0.13	0.92	0.37
Ideal body size	−0.05	−0.21	−0.84
Perceived hunger	0.40	3.39	<0.01
State anxiety	−0.07	−1.22	0.23
Trait anxiety	0.09	2.00	0.051

Note: *denotes significance at $P < 0.05$.
[a]Intercept estimate is that for males; the estimate for gender is the adjustment to the intercept to provide an intercept estimate for females.

Table 3 Regression of 12-month change in BMI with independent variables

Predictor variable	*Parameter estimate*	t-*Value*	P
Intercept	−2.37	−0.42	0.68
$BMI_{baseline}$	−0.04	−0.42	0.68
Beck Depression Inventory	0.18	1.00	0.33
Gender (='F')[a]	1.33	1.07	0.30
Current body size	−0.28	−1.03	0.31
Dietary restraint	0.30	1.92	0.07
Disinhibition	−0.47	−1.53	0.14
Ideal body size	−0.55	−1.06	0.30
Perceived hunger	0.69	2.67	0.01*
State anxiety	0.09	0.64	0.53
Trait anxiety	−0.11	−1.16	0.26

Note: *denotes significance at $P < 0.05$.
[a]Intercept estimate is that for males; the estimate for gender is the adjustment to the intercept to provide an intercept estimate for females.

Table 4 Model Selection Criteria for BMI change at 6 months

Variables in model in addition to intercept, gender and initial BMI	P	r^2 (%)	C_p	*m.s.e.*
Hunger	4	26.8	20.3	7.8
Current body size	4	22.7	24.4	8.3
Restraint	4	21.5	25.6	8.4
Ideal body size	4	20.7	26.3	8.5
Trait	4	20.0	27.0	8.5
Restraint, hunger	5	37.9	11.6	6.8
Hunger, current body size	5	35.8	13.6	7.0
Current body size, trait	5	28.3	21.0	7.8
Hunger, ideal body size	5	27.4	21.8	7.9
Hunger, trait	5	27.4	21.8	7.9
Restraint, hunger, current body size	6	44.1	7.5	6.2
Restraint, hunger, trait	6	39.4	12.1	6.7
Hunger, current body size, trait	6	39.1	12.4	6.7
Restraint, disinhibition, hunger	6	38.3	13.2	6.8
Restraint, hunger, depression	6	38.1	13.4	6.9
Restraint, hunger, current body size, trait	7	48.6	5.1	5.8
Restraint, hunger, depression, current body size	7	45.6	8.1	6.1
Restraint, disinhibition, hunger, current body size	7	45.2	8.5	6.2
Restraint, hunger, current body size, state	7	44.4	9.2	6.3
Restraint, hunger, current body size, ideal body size	7	44.3	9.4	6.3
Restraint, hunger, current body size, state, trait	8	49.8	5.9	5.8
Restraint, disinhibition, hunger, current body size, trait	8	49.2	6.5	5.8
Restraint, hunger, depression, current body size, trait	8	48.6	7.1	5.9
Restraint, hunger, current body size, ideal body size, trait	8	48.6	7.1	5.9
Restraint, disinhibition, hunger, depression, current body size	8	46.5	9.2	6.2
Full model	11	50.8	11.0	6.0

Note: P = total number of model parameters, including intercept, gender, and initial BMI; C_p = Mallow's statistic; m.s.e. = mean squared error; hunger = perceived hunger; restraint = dietary restraint; state = state anxiety; trait = trait anxiety.

Table 5 Model selection criteria for BMI change at 12 months

Variables in model in addition to intercept, gender and initial BMI	P	r^2 (%)	C_p	*m.s.e.*
Ideal body size	4	32.9	13.8	12.8
Current body size	4	30.2	15.1	13.4
Hunger	4	27.4	16.7	14.0
Restraint	4	25.8	17.9	14.3
Disinhibition	4	22.3	19.5	15.0
Restraint, hunger	5	43.0	10.0	11.4
Current body size, ideal body size	5	42.5	10.2	11.8
Hunger, current body size	5	42.0	10.5	11.6
Restraint, ideal body size	5	41.3	10.9	11.7
Disinhibition, hunger	5	38.8	12.3	12.2
Restraint, hunger, current body size	6	51.7	7.1	10.0
Restraint, disinhibition, hunger	6	50.6	7.7	10.3
Restraint, hunger, ideal body size	6	48.5	8.9	10.7
Restraint, current body size, ideal body size	6	47.2	9.6	10.9
Hunger, current body size, ideal body size	6	46.8	9.8	11.0
Restraint, hunger, current body size, ideal body size	7	55.6	6.9	9.7
Restraint, disinhibition, hunger, current body size	7	55.2	7.1	9.7
Restraint, disinhibition, hunger, ideal body size	7	54.2	7.7	9.9
Restraint, hunger, current body size, trait	7	52.4	8.7	10.3
Restraint, hunger, depression, current body size	7	52.2	8.8	10.3
Restraint, disinhibition, hunger, current body size, ideal body size	8	58.2	7.4	9.4
Restraint, disinhibition, hunger, state, trait	8	57.8	7.9	9.5
Restraint, hunger, depression, current body size, ideal body size	8	56.7	8.3	9.7
Restraint, disinhibition, hunger, depression, current body size	8	56.4	8.5	9.8
Restraint, disinhibition, hunger, depression, trait	8	55.6	8.7	9.9
Full model	11	62.5	11.0	9.6

Note: P = total number of model parameters, including intercept, gender, and initial BMI; C_p = Mallow's statistic; m.s.e. = mean squared error; hunger = perceived hunger; restraint = dietary restraint; state = state anxiety; trait = trait anxiety.

In the 6 month sample (Table 4), the best of the seven-parameter models includes dietary restraint, hunger, current body size, and trait anxiety. This model accounts for most of the r^2 attributed to the full model presented in the previous section, and it very nearly achieves a minimum in the m.s.e. Further, the C_p statistic provides an indication of small bias for both this model and the best of the six-parameter models. The observation that the best six-parameter model is a reduced version of the best seven-parameter model allows a test of the two ($t=2.145$, d.f.$=52$, $P=0.0037$). This test shows that these two models are significantly different from one another, which means that the variable associated with the seven-parameter model yields explanatory information beyond the six-parameter model. Therefore, the seven-parameter model shall serve as the optimal model for weight loss prediction at 6 months.

In a similar fashion, the best of either the six- or seven-parameter models in Table 5 could be taken as potential candidates for optimal weight loss prediction at 12 months. Each can be seen to have an r^2 that is a large proportion of that of the full model. The m.s.e. of each is relatively small (near minimal), and the C_p statistic confirms that the bias should be small in either case. As in the 6 month sample, the relationship between the two models allows testing ($t=-1.484$, d.f.$=25$, $P=0.150$). In this case, this test shows that these two models are not significantly different from another, which means that the variable associated with the seven-parameter model does not yield explanatory information beyond the six-parameter model. Therefore, the six-parameter model shall serve as the optimal model for weight loss prediction at 6 months.

Fitted models derived through model selection are presented in Table 6. Model selection tends to confirm the impressions drawn from multiple regression in that dietary restraint, hunger and current body size are components of the optimal models. At six months, trait anxiety seems to be an additional factor of import.

Discussion

The purpose of this study was to identify psychosocial variables that could predict success in a weight management program. In a similar study, Foster *et al*[3] found dietary restraint to be modestly associated with change in BMI over a 5–6 month period in that those with lower initial restraint scores lost more weight. The present study examined the relationship of psychosocial variables with weight loss over both 6- and 12-month periods.

Those participants with greater levels of dietary restraint, perceived hunger and trait anxiety were less likely to lose weight over the 6 month period. Those participants who perceived themselves as being smaller were less likely to lose weight over the 6 month time-period. The optimal model, which controlled for initial BMI and gender and included dietary restraint, hunger, trait anxiety and current perceived body size as model variables, accounted for 48.6% of the variance in weight loss at 6 months.

Over the 12 month period, those participants with greater levels of perceived hunger and dietary restraint were less likely to lose weight. Those participants who perceived themselves as being smaller were less likely to lose weight over the 12 month period. The optimal model, which controlled for initial BMI and gender and included restraint, hunger and current perceived body size as model variables, accounted for 51.7% of the variance in weight loss. Thus, of the psychosocial variables that were tested, perceived hunger was a consistent predictor of weight loss over a 12 month trial of appetite suppressant medication.

The medications used in this study work to suppress feelings of hunger and heighten satiety. Those participants who begin weight loss studies with the greatest levels of hunger are less likely to lose weight. Perhaps medications do not sufficiently suppress extreme levels of perceived hunger. Those participants with higher levels of baseline dietary restraint were probably dieting and suppressing weight gain prior to entering the weight loss trial. Since these participants may have suppressed weight gain prior to treatment, it is not surprising that they lost less weight than unrestrained eaters. Foster *et al*[3] came to similar conclusions. Those participants who perceive themselves as smaller in size may feel less need to lose weight than those persons who perceive themselves as larger. This conclusion is consistent with previous findings that perceived body size is highly correlated with body size dissatisfaction.[11] Finally, it seems likely that those participants with greater trait (day-to-day) anxiety would be less likely to lose weight. One weight loss study found that emotional eating was associated with non-compliance.[12] A second weight loss study found that participants who endorsed high levels of emotional eating at baseline and who subsequently reduced emotional eating during treatment were more successful at reaching their target weight than participants who continued to endorse high levels of emotional eating.[13]

One limitation of the present pilot study is the small sample size. A second limitation is that the medications used in this study (fenfluramine and Phentermine) are no longer on the market. Future studies may want to replicate these findings in weight loss groups with larger sample sizes

Table 6 Model selection: optimal models

	Parameter estimate	
Variable	*6 month*	*12 month*
Intercept	−9.42	−8.49
Gender (=F)[a]	1.10	1.27
$BMI_{baseline}$	−0.04	−0.02
Dietary restraint	0.30	0.35
Perceived hunger	0.44	0.65
Current body mass index	−0.46	0.51
Trait	0.07	—

Note: [a]intercept estimate is that for males; the estimate for gender is the adjustment to the intercept to provide an intercept estimate for females.

using appetite suppressant medications that are currently approved by the Food and Drug Administration.

Initial response to pharmacotherapy (losing at least 4 pounds in the first 4 weeks of treatment) has been validated as a predictor of weight loss in response to sibutramine, phenylpropanolamine, and dexfenfluramine.[1,2,14] A 4-week drug trial is more costly and time consuming than the administration of simple paper and pencil measures at baseline. These findings suggest that the EI[4] and the BIA-O[10] may be valid predictors of who will respond well to treatment at baseline.

These findings also have implications for pharmacological studies of weight loss. A common strategy in drug trials is to match participants on initial BMI.[15] This matching is used to control group differences in body weight, a variable that is well established as a predictor of weight loss during a treatment trial (ie heavier participants usually lose more weight). The findings of this study suggest that drug trials may want to control for individual differences in perceived hunger (especially in trials of appetite suppressant medications) and dietary restraint (in drug trials and behavioral trials).

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