British Journal of Health Psychology (2005), 10, 601–614

The British Psychological Society
www.bpsjournals.co.uk

Early treatment response as a predictor of ongoing weight loss in obesity treatment

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Objectives. This study examined early treatment response in obesity treatment, defined as early change in body mass index (BMI) and early change in eating behaviour, as a predictor of ongoing weight loss in obese patients.

Methods. We conducted a repeated measures analysis of eating behaviour, emotional factors (depression, stress, perfectionism) and BMI, over a 9 month period. Subjects were 344 females, aged 18–65 (mean = 41.8), with a BMI of at least 25 (mean BMI = 33.7), engaged in very-low calorie (VLCD) or low-calorie (LCD) diets.

Results. Multi-level modelling identified four significant predictors of ongoing weight loss (weight loss occurring between 5 weeks and 9 months after the start of treatment). These included: type of diet, early BMI change (start to 5 weeks), number of weigh-ins and the early change in uncontrolled eating (start to 5 weeks). Estimates based on multi-level modelling indicate that patients with strong versus weak early treatment responses would be expected to show large differences in ongoing weight loss.

Conclusions. Early improvements in eating behaviour and weight appear to have additive effects in the prediction of ongoing weight change. Future research is required to identify the optimal rate of weight loss, whether there are critical periods for behaviour change, and factors which influence the likelihood of early behaviour change.

Obesity is among the most important risk factors for disease and mortality in developed countries and a huge economic burden on the health care system (Field, Barnoya, & Colditz, 2002; World Health Organization, 1998). Weight loss efforts are very common among overweight individuals (Meltzer & Everhart, 1996; Serdula *et al.*, 1999), but only a small percentage reach or maintain a healthy weight (Jeffery *et al.*, 2000; Wadden, Brownell, & Foster, 2002). Nevertheless, where successful, intentional weight loss appears to have positive effects in reducing disease and mortality (Gregg & Williamson, 2002). Research designed to elucidate factors responsible for successful or unsuccessful

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DOI:10.1348/135910705X43750

weight loss outcomes are therefore extremely important in view of the urgent need to develop more effective treatment methods. In the present study we looked at the relationship between self-reported behaviour change and weight loss among obese patients treated with low and very-low calorie diets and behaviour therapy by family doctors.

Behaviour and weight loss

Since weight changes are a function of energy intake and expenditure, factors that influence weight must do so by altering intake or expenditure (Bray, 2002). Eating and exercise behaviours and physiological factors affecting expenditure are 'direct' influences on weight, while other psychological and environmental factors must be considered 'indirect' influences, exerting their effects through behaviour or physiology. For example, depression might indirectly influence weight loss by increasing emotional eating behaviour or by reducing dietary adherence. Efforts to predict differential weight loss outcomes would benefit from a clear specification of behavioural and/or physiological mechanisms responsible for the effect.

Although it may seem obvious that weight loss is tied to behaviour change, given the requirement that the individual achieve a negative energy balance, a surprisingly small number of obesity treatment studies have looked at the relationship. A few studies of behaviour therapy have found a strong correlation between adherence to prescribed behaviour changes (e.g. keeping a diary, using self-reward, using stimulus control techniques) and weight loss (Coates & Thoresen, 1981; Sandifer & Buchanan, 1983; Stalonas & Kirschenbaum, 1985). On the other hand, Brownell, Heckerman, Westlake, Hayes, and Monti (1978) did not find a relation between adherence to programme behaviours, assessed daily over the 10-week treatment, and weight loss at post-treatment or follow-up. Results of adherence studies are complicated by the use of numerous methods of assessment, including self-monitoring records of unknown reliability, spouse ratings, and therapist assessment, and somewhat unique sets of target behaviours. The generalizability of the results to treatments other than behaviour therapy is also unknown.

A number of recent studies have utilized self-report measures of dietary restraint and disinhibition as predictors of weight loss. Results suggest that baseline measures of restraint and disinhibition were either not related to weight loss (Björvell, Aly, Langius, & Nordström, 1994; Cuntz, Leibbrand, Ehrig, Shaw, & Fichter, 2001; Fogelholm, Kukkonen-Harjula, & Oja, 1999; Westerterp-Plantenga, Kempen, & Saris, 1998), or had a weak but significantly negative relationship with weight loss (Foster *et al.*, 1998; Womble, Williamson, Greenway, & Redmann, 2001), reflecting a tendency for patients beginning with higher restraint and lower disinhibition to lose less weight in the initial months of treatment. Therefore, pre-treatment measures of eating control have in general proven to be weak predictors of weight loss, as have other characteristics of patients measured at pre-treatment (Wadden & Letizia, 1992).

However, conclusions about the ability of behavioural variables to predict weight loss cannot be based solely on pre-treatment measures of behaviour. Early treatment response may prove to be a better predictor of weight loss outcomes. This would be consistent with reports that the early response to treatment predicts its later course, for disorders such as depression (Fennell & Teasdale, 1987; Santor & Segal, 2001) and bulimia (Wilson, Fairburn, Agras, Walsh, & Kraemer, 2002). In obesity treatment, the early response can be defined in relation to (a) weight loss and (b) behaviour change.

Early response as a predictor of ongoing weight loss

Several studies have found that early weight loss predicts later weight loss (Astrup & Rossner, 2000; Fogelholm *et al.*, 1999; Jeffery, Wing, & Mayer, 1998; Wadden *et al.*, 1992). This may be for both physiological and psychological reasons; it may be that those who lose fastest have higher resting metabolic rates and/or stronger motivation to lose weight. The early change in eating (or exercise) behaviour may also be a predictor of later weight loss, but this has not been studied directly. The importance of early eating behaviour change as a predictor of weight loss is suggested by studies showing that dietary restraint and the tendency towards disinhibited eating measured 8–10 weeks after the start of treatment were significant predictors of ongoing weight loss and maintenance (Cuntz *et al.*, 2001; Westerterp-Plantenga *et al.*, 1998). Westerterp-Plantenga found that patients who were more successful at maintaining their weight loss during a 2 year follow-up period showed a significant increase in cognitive restraint of eating following the initial 8 weeks of dieting, while subjects who were less successful in maintaining weight loss did not show significant increases in restraint. Cuntz *et al.* (2001) found that scores on disinhibited eating measured after the 10 week treatment programme correlated with weight change during the 18 month follow-up. These results suggest that early improvements in eating behaviour may be related to weight loss maintenance, although it is not clear which aspects of eating behaviour (e.g. restraint, disinhibition) are most important in this regard. In fact, the exact relationship between restraint and disinhibition has not been determined, and some have suggested that they be regarded as two aspects of 'eating control' (Fogelholm *et al.*, 1999).

Our review of previous studies led us to hypothesize that improvements in eating behaviour would be a strong predictor of subsequent weight change. Unlike previous studies, we looked at predictors of ongoing weight loss, rather than weight loss maintenance. We first looked at early BMI change in relation to pre-treatment patient characteristics, although, based on previous studies, we did not expect very large effects. Thus, our primary analysis examined 'early change' scores as predictors of 'ongoing' BMI change.

In trying to predict ongoing BMI change, we compared the relative importance of early change in eating behaviour with that of early change in BMI. Would early BMI change predict ongoing BMI change, as in previous research, and would early reductions in eating behaviour add to the strength of the prediction? Additional moderating variables were type of diet (VLCD vs. LCD) and frequency of weigh-ins. We conducted supplementary analyses including changes in depression, stress reactions and perfectionism, to examine whether change in these psychological variables would add to prediction.

Method

Participants and treatment approach

The study included 344 female patients with a BMI of at least 25 (mean = 33.7, $SD = 6.4$, range = 25.1–53.8). Subjects ranged in age from 18 to 65 (mean = 41.8, $SD = 11.3$).

All subjects were beginning treatment for obesity with one of three general practitioners. The physicians followed a fairly consistent approach, using low or very low calorie diets and a brief form of behaviour therapy. Weekly counselling sessions were designed to be brief (15–20 minutes), and to include a medical evaluation, the selection of a diet plan, and behaviour therapy. The behavioural component included

the identification of behaviour change targets, the setting of specific proximal goals, and the implementation of self-monitoring and self-reinforcement strategies. Cognitive restructuring methods were used to modify negative thinking that could interfere with the completion of behavioural assignments, result in maladaptive emotional responses to dietary lapses, or lead to unrealistic expectations for weight loss.

Treatment was open-ended and patients were urged to continue well into the weight loss maintenance phase. Patients were given the assurance that they could return to treatment at any time if they happened to stop for some reason. Thus, the treatment combined the use of reduced-calorie diets and brief behaviour therapy in a continuous-care format.

Patients were presented with six diet options. Three types of VLCD (500, 600, 700 calories) and three types of LCD (1,000, 1,100, 1,200 calories) were offered. Sixty-two percent of subjects selected a VLCD in this sample.

Measures

We measured eating control with the 11-item uncontrolled eating subscale of the Larocque Obesity Questionnaire (LOQ- UE; Larocque & Stotland, 2000; Stotland & Larocque, 2003, 2004). This scale includes items describing a range of eating behaviour, tapping into restraint, disinhibition and hunger. Specific items assess consumption of fats and sweets, emotional eating, urges to overeat, situational overeating, and eating style (see Table 1).

The LOQ-UE scale had a Cronbach's α of .75 in the present sample, indicating acceptable internal consistency. Larocque and Stotland (2000) and Stotland and Larocque (2004) presented construct validity data on the LOQ. The LOQ-UE scale was found to be weakly correlated with the Dutch Eating Behaviour Scale (Van Strein, Frijters, Bergers, & Defares, 1986) eating restraint subscale, and strongly related to the emotional eating and hunger subscales.

Subjects were also administered several other scales from the LOQ, including Depression (LOQ-D), Stress response (LOQ-S) and Perfectionism (LOQ-P). Examples are provided in Table 1. LOQ-D, LOQ-S and LOQ-P demonstrated αs of .80, .67 and .74, respectively, in the present sample. LOQ-D is a 7-item scale measuring depressive symptoms that one is currently experiencing. LOQ-S is a 6-item scale measuring the occurrence of physical stress reactions, in the last month. LOQ-P includes seven items measuring general tendencies towards perfectionism. Preliminary construct validity data on these scales were presented by Larocque and Stotland (2000) and Stotland and Larocque (2004).

Subject inclusion criteria

The participants in this analysis came from a larger sample of 1,070 patients beginning obesity treatment. The analysis was based only on individuals who had at least two complete assessments, including both a weigh-in and psychological testing with the LOQ, within the designated time frame (21–60 days). These inclusion criteria were necessary because (a) in order to evaluate the impact of *change* in eating behaviour on subsequent weight loss we required subjects who participated in the second psychological assessment, and (b) because of differences in the length of intervals between the first two assessments we needed to control the time frame in order to minimize the effect of variable length of time on early change scores.

Table 1. Sample items from LOQ subscales

Scale	Sample items
LOQ-UE (Uncontrolled eating)	1. Using the meals that you had over the past few days as a reference, do you usually leave food on your plate?
	2. When I am disappointed or upset, I have to compensate by eating.
	3. During the last month, have you had the urge to eat as if you had not eaten for years?
	4. Aside from regular meals, do you eat while watching television?
	5. During the past week, did you eat fried foods, sauces or foods that were rich in fat?
LOQ-D (Depression)	1. I have the feeling that life is getting me nowhere and is worthless.
	2. I cry all the time.
	3. Life is hopeless.
LOQ-S (Physical stress reactions)	1. Over the past month, when not exerting yourself, have you experienced any of the following symptoms: pounding heart, a lump in your throat, or shortness of breath?
	2. During the past month, have you experienced any of the following symptoms: headache, backache, sore neck that cannot be attributed to any disease?
	3. During the past month, have you had any digestive problems?
LOQ-P (Perfectionism)	1. I demand a lot from myself and everything I do must be perfect.
	2. I feel guilty when things are not going well.
	3. I am quite anxious over the way people feel about me.

Thus, subjects were excluded from the analysis if they failed to complete a second weight assessment ('early drop-outs', $N = 246$; 23% of the original sample), or if they continued in treatment but failed to complete a second psychological assessment ($N = 266$), or completed their second assessment beyond the defined time limit ($N = 214$). We acknowledge that subjects included in our analysis are representative only of those patients who met the inclusion criteria. While it is conceivable that these individuals are significantly different in important ways from those who dropped out quickly or were not compliant with the treatment and/or assessment procedures, comparisons of the pre-treatment characteristics of these four groups (on age, pre-treatment BMI, type of diet chosen, and on the LOQ scales) did not show any significant differences (Table 2).

Assessment schedule

Subjects received treatment under normal, unstandardized clinical conditions. Thus, the precise form of the treatment and even the number and frequency of treatment sessions varied somewhat. A weekly schedule of visits was recommended to all patients, but the actual frequency was largely up to the individual. Similarly, we found considerable variability in the number of weight assessments. The average subject

Table 2. Means (standard deviations) for pre-treatment scores on Age, BMI, weight loss goal, and LOQ scales, and percentage of subjects selecting VLCD, for included and excluded subjects

	Group					
Variable	Included	Excluded 1[a]	Excluded 2[b]	Excluded 3[c]	F[d]	χ^2
N	344	246	266	219		
Age	41.8 (11.3)	41.4 (11.8)	43.2 (12.2)	44.1 (11.4)	2.87*	
BMI	33.7 (6.4)	33.4 (6.5)	33.0 (6.9)	32.8 (6.8)	0.95	
LOQ-UE[e]	33.5 (5.1)	33.7 (5.4)	32.8 (5.2)	33.6 (5.3)	1.82	
LOQ-D[f]	12.1 (3.4)	12.4 (3.9)	11.7 (3.2)	12.2 (3.4)	2.22	
LOQ-S[g]	12.3 (3.3)	12.7 (3.7)	12.2 (3.2)	12.6 (3.6)	1.41	
LOQ-P[h]	22.9 (3.6)	22.7 (3.9)	22.3 (3.6)	22.5 (3.6)	1.67	
Weight Loss Goal (kg)	25.4 (14.4)	24.5 (14.2)	23.9 (16.3)	22.5 (16.3)	1.62	
% Selecting VLCD	61.3	63.4	66.9	62.1		3.5

*$p < .05$.
[a] Subjects who dropped out of treatment by Time 2.
[b] Subjects who failed to complete a second psychological assessment.
[c] Subjects whose second assessment was not within the specified time frame (21–60 days after Time 1).
[d] $df = 3, 1066$.
[e] LOQ – Uncontrolled eating.
[f] LOQ – Depression.
[g] LOQ – Stress Responses.
[h] LOQ – Perfectionism.

completed 5.9 weight assessments (range = 3–10) during the 9 month observation period.[1] Psychological assessments were scheduled to occur at 4–6 week intervals, although once again there was substantial variability – the average length of time between the Time 1 and Time 2 psychological assessments was 37.8 (± 10.7) days.

Definition of early and ongoing change

The present study was concerned with the prediction of early and ongoing weight change. 'Early weight change' was that occurring between the first two assessments, which, as noted, averaged 37.8 days. 'Ongoing weight change' was examined during the period between Time 2 and 270 days. This length of observation period was chosen because previous studies have indicated that group weight loss typically stops at about the sixth month (Jeffery *et al.*, 2000; Wing, 2002), so we were confident that we would capture all of the weight loss, at least at a group level. Examination of weights at different time points confirmed that weight asymptoted at about 6 or 7 months.

To measure early change we used residual change scores (Cohen & Cohen, 1983), which express change in a variable relative to its starting level. The weight change score was created by regressing Time 2 BMI on Time 1 BMI. The residual weight change score was the difference between expected and observed weight at Time 2. Thus, positive residuals indicated that the Time 2 score was higher than expected, and negative residuals indicated that the Time 2 score was lower than expected. This approach allowed us to

[1] *In fact, some subjects were weighed much more frequently (e.g. weekly), but the weight was entered in the study database only if it was at least 3 weeks since the previous weight record.*

control for the strong correlation between starting weight and early weight loss. Residual change scores were computed in the same manner for the four LOQ subscales.

Statistical analysis

T tests were used to examine changes in BMI and psychological variables from Time 1 to Time 2. Regression analysis was used to test whether or not any of the psychological variables, type of diet (VLCD vs. LCD), or age predicted early change in BMI.

To examine predictors of ongoing weight change, we utilized multi-level modelling, also known as hierarchical linear modelling and random regression modelling. The advantages of this technique with repeated measures data from longitudinal treatment studies have been stressed by several authors (e.g. Gibbons *et al.,* 1993) and include the relaxation of the requirement for equal temporal spacing of observations, the relaxation of the requirement for non-missing data at each observation, and the capacity to model a variety of error covariance structures. Our analyses were modelled after Gibbons *et al.*'s and Elkin *et al.*'s (1995) analyses of a randomized clinical trial of four brief treatments for depression. We included type of diet group (VLCD, LCD) as a categorical variable, and number of weight assessments, early habit change and early weight change, and their interactions with Time, as predictors of weight change from Time 2 until the end of the 9 month observation period. Additional analyses considered whether early change in LOQ-D, LOQ-S or LOQ-P improved prediction.

Results

Average pre-treatment and Time 2 scores and intercorrelations for age, BMI, and LOQ subscales are presented in Table 3. It can be seen that BMI decreased by an average of 2.1 units by Time 2 (from 33.7 to 31.6), representing almost half of the total reduction occurring 6 months from start date (4.7 units). T tests indicated that there were significant improvements in BMI, and in the four LOQ scales, from Time 1 to Time 2 (all p's $< .0001$).

Inspection of Table 3 suggests that BMI at Time 1 and Time 2 was weakly related to eating and emotion variables. In contrast, the correlations between uncontrolled eating and the three emotion variables were small at Time 1 (r's ranging from .17 to .23), but considerably stronger at Time 2 (r's ranging from .31 to .45), suggesting a 'convergence' of these variables. The overall pattern of correlations suggests that changes in uncontrolled eating are more closely related to changes in depression, stress reactions and perfectionism, than to changes in BMI.

Predictors of early BMI change

Predictors of the early BMI residual change score were examined with regression analysis, comparing models including combinations of age, type of diet (VLCD, LCD), and pre-treatment LOQ scores.[2] A model including age and the four psychological variables accounted for only 2.84% of the variance in BMI change, $F_{(1,338)} = 1.98, p > .08$. Adding type of diet to this model added 10.44% to the amount of variance accounted for $F_{(1,337)} = 40.57, p < .001$, indicating that patients on VLCDs lost more weight than those on LCD's by Time 2. In contrast, the addition of the psychological variables to a model containing age and type of diet did not add significantly to the prediction of early BMI change, incremental $R^2 = .018$, $F_{(4,337)} = 1.71$, *ns*.

[2] *Age was included as a predictor in all models.*

Table 3. Means, standard deviations and intercorrelations for pre-treatment and Time 2 scores on Age, BMI and LOQ scales ($N = 344$)

Variable	1	2	3	4	5	6	7	8	9	10	11	Mean	Std. Dev.
1. Age	–	.01	.02	−.02	−.01	−.15*	−.12	.09	.03	−.13	−.17*	41.8	11.3
2. BMI 1		–	*.98***	.14*	−.01	.13	.04	.16*	.04	.08	.07	33.7	6.4
3. BMI 2			–	.11	.03	.14*	.07	.16*	.07	.07	.06	31.6	6.0
4. LOQ-UE[a] 1				–	*.43* **	.17*	.11	.19**	.15*	.23**	.21**	33.5	5.1
5. LOQ-UE 2					–	.06	.37**	.08	.45**	.05	.31**	28.1	4.6
6. LOQ-D[b] 1						–	*.64* **	.40**	.27**	.47**	.31**	12.1	3.4
7. LOQ-D 2							–	.31**	.50**	.30**	.47**	10.4	2.8
8. LOQ-S[c] 1								–	*.50* **	.30**	.20**	12.3	3.3
9. LOQ-S 2									–	.18*	.36**	9.9	3.2
10. LOQ-P[d] 1										–	*.66* **	22.9	3.6
11. LOQ-p 2											–	21.5	3.6

Note. italiced numbers are Time 1–Time 2 correlations for the same variable.
[b] $*p < .05$, $**p < .01$.
[a]LOQ – Uncontrolled eating.
[b]LOQ – Depression.
[c]LOQ – Stress Responses.
[d]LOQ – Perfectionism.

Thus, it appeared that only type of diet was associated with the rate of early weight loss, with subjects on VLCDs showing more rapid weight loss than those on LCDs.

Predictors of ongoing BMI change

We conducted a multi-level regression analysis, examining BMI's obtained at weigh-ins from 5 weeks to 270 days after the beginning of treatment. Predictors included length of time since the beginning of treatment, early change scores for BMI and LOQ-UE, type of diet (LCD vs. VLCD), the number of weight assessments occurring within 270 days, and the interactions of these variables with time. Analyses were performed using PROC MIXED, version 8.1 (SAS Institute Incorporated, 1999). Maximum likelihood estimation was used to estimate parameters in the models. Following Singer's (1998) recommendations, the degrees of freedom for *F*-tests were determined using the programme option which divides the residual degrees of freedom into between-subjects and within-subjects portions.

Inspection of the data suggested that BMI could not be modelled as a linear function of time since the beginning of the treatment. It is common in psychological and psychiatric treatments to find that initial change is rapid and that there is a subsequent flattening of the rate of change; logarithmic transformations of time can be employed to achieve a linear relation between the dependent variable and the temporal predictor (e.g. Gibbons *et al.*, 1993). We compared models using linear time, log-transformed time (time = log [1 + days]), and square root-transformed time (time = sqrt[days]). Both visual inspection and the AIC criterion indicated that the natural log transform yielded a good fit to the BMI data, and therefore subsequent analyses were carried out using log-transformed time. The regression coefficient for the time variable was negative, indicating that patients lost weight over the course of treatment. Larger absolute values of the regression coefficient indicate more steeply sloped (i.e. rapid) weight loss.

The three continuous predictors (early change in BMI, early change in LOQ-UE, and number of weight assessments) were standardized. The regression coefficients for these variables therefore indicated the impact of a 1 *SD* difference in the predictor. We were especially interested in the interactions of these predictors with time. Significant interactions would indicate that the rate of weight loss was greater (or lesser) depending on the value of the variable. Significant interactions were interpreted by calculating the slope (i.e. the regression coefficient) of weight as a function of time for patients who were 1 *SD* above or 1 *SD* below the mean on the predictor. Significant interactions with type of diet were interpreted by calculating the slopes for time separately for those on LCD and VLCD diets.

The model included the following fixed effects: time, type of diet, early weight loss, early change in uncontrolled eating, number of weight assessments, and the four interactions with time. Three random effects were included in the model: a random intercept, a random effect of time, and a first-order autoregressive parameter (AR[1]). The autoregressive parameter was included because errors from adjacent observations were considered likely to be more highly correlated than those from observations more separated in time.

All three random effects were significant (p's $< .001$) and were therefore retained in the model. The autoregressive parameter was .34, indicating a moderate degree of correlation between adjacent observations. The random intercept and the random slope parameters were negatively correlated (estimated $r = -.76$), indicating that patients

with high weights at their second observation tended to lose weight more rapidly than those with relatively lower weights.

Each of the interactions was significant: Diet × Time, $F(1, 1,347) = 6.96$, $p < .01$, $B = -.45$; Early Weight Loss × Time, $F(1, 1,347) = 12.38$, $p < .001$, $B = .29$; Early Change in Uncontrolled Eating × Time, $F(1, 1,347) = 40.63$, $p < .001$, $B = .51$; and Number of Weight Observations × Time, $F(1, 1,347) = 15.4$, $p < .001$, $B = -.34$. Slopes of BMI in relation to time were calculated for patients who received the LCD or VLCD diet and who were low or high on the continuous predictors. Weight loss was more rapid for those on a VLCD diet ($B = -1.15$, lower CI $= -.95$, upper CI $= -1.35$) compared with those on an LCD diet ($B = -.70$, lower CI $= -.44$, upper CI $= -.97$), for those with large early weight loss ($B = -1.22$, lower CI $= -.98$, upper CI $= -1.46$) compared with those with small early weight loss ($B = -.64$, lower CI $= -.42$, upper CI $= -.86$), for those with large early change in uncontrolled eating ($B = -1.44$, lower CI $= -1.21$, upper CI $= -1.67$) compared with those with small early change in uncontrolled eating ($B = -.42$, lower CI $= -.19$, upper CI $= -.64$), and for those with many weight observations ($B = -1.26$, lower CI $= -1.06$, upper CI $= -1.47$) compared with those with few weight observations ($B = -.59$, lower CI $= -.32$, upper CI $= -.86$). Interestingly, the largest effect was found for early change in uncontrolled eating.

The effects are illustrated in Figs 1 and 2. Figure 1 presents estimated BMIs at different time points for those low or high in early change in uncontrolled eating. Figure 2 shows

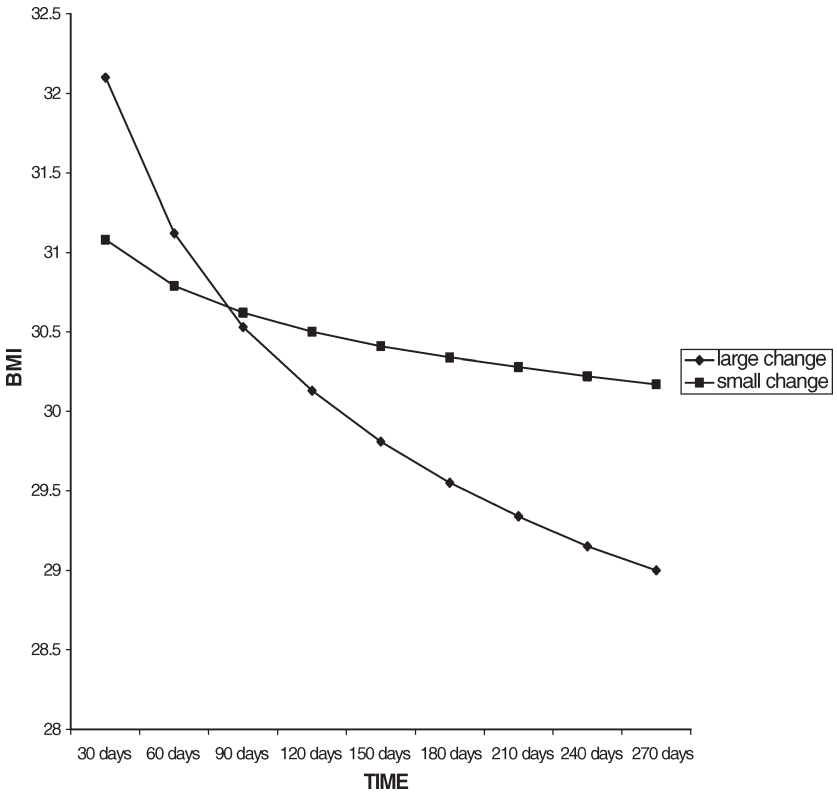

Figure 1. Estimated ongoing BMI change for subjects with large or small early reduction in uncontrolled eating.

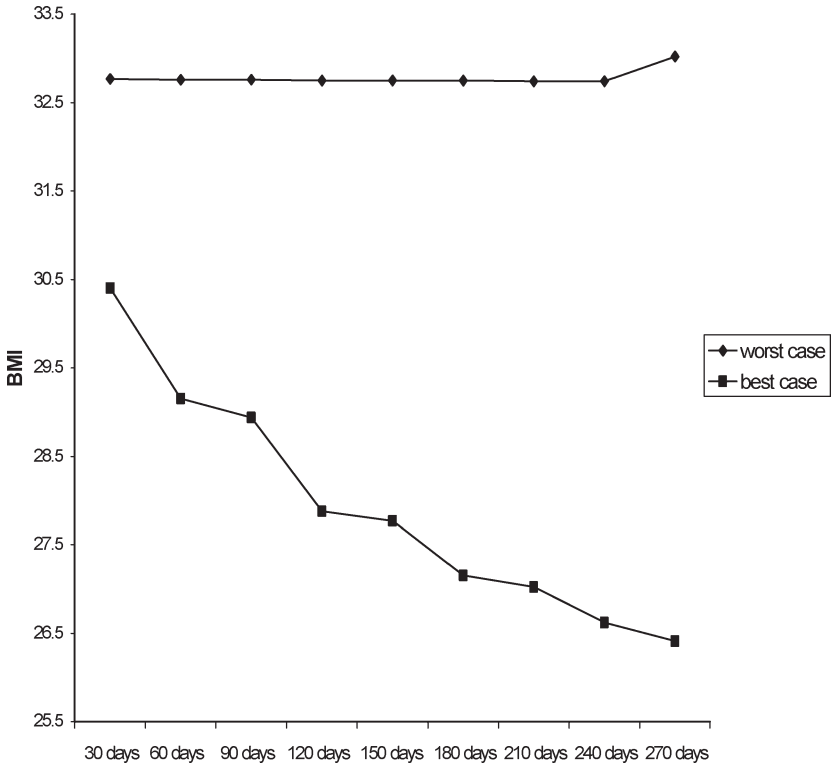

Figure 2. Estimated best case vs. worst case scenarios for ongoing BMI change based on all four predictors.

estimated BMIs for patients with favourable or unfavourable scores on all four predictors. Weight loss would be expected to be rapid and sustained when all factors were favourable; when all factors were unfavourable, treatment would be predicted to be completely ineffective.

We repeated the above analysis, including early change in emotional factors (depression, stress reactions, perfectionism) and excluding early change in uncontrolled eating. This analysis showed that early change in depression and stress reactions added to prediction of ongoing weight change. However, when change in uncontrolled eating was included in the model, the emotional factors were no longer significant predictors, while change in uncontrolled eating was highly significant. Therefore, the impact of change in emotional factors on subsequent weight change appeared to be because of a shared association with change in uncontrolled eating. Subjects showing greater reductions in LOQ-UE also tended to show better improvement in emotional factors. In fact, change in LOQ-UE correlated $r = .49$, .50, and .37, respectively, with change in LOQ-D, LOQ-S and LOQ-P. However, it is evident that change in uncontrolled eating was the variable with the strongest connection to subsequent weight change.

Discussion

The present study points out the importance of early response in obesity treatment. Subjects who showed a strong reduction in uncontrolled eating during the initial 5 weeks of treatment were subsequently much more successful in losing weight

compared with those who failed to show such behaviour changes. Other predictors of ongoing BMI change were early BMI change, type of diet (VLCD vs. LCD) and number of weight assessments, all of which would be expected based on previous research (Wadden & Phelan, 2002).

The present result adds to previous findings that greater early weight loss was a positive factor for ongoing weight loss (Astrup & Rossner, 2000; Jeffery *et al.*, 1998; Wadden *et al.*, 1992), by showing that early improvement in eating behaviour is equally or more important than early weight loss in predicting subsequent weight change. Thus, patients who show rapid weight loss without comparable improvements in eating control are less likely to have favourable long-term outcomes compared with patients whose early weight loss is accompanied by equal degrees of improvement in eating control.

A crucial question for future research concerns the nature of the behaviour changes that predict subsequent weight change. Earlier studies found that weight loss maintenance was predicted by either increased eating restraint (Cuntz *et al.*, 2001) or decreased tendency towards disinhibited eating (Westerterp-Plantenga *et al.*, 1998). The LOQ-UE appears to be closely related to measures of emotional eating and hunger, and secondarily to eating restraint (Larocque & Stotland, 2000; Stotland & Larocque, 2004). Therefore, the changes we observed in LOQ-UE in the present study certainly reflected reductions in emotional eating and hunger, and perhaps in increased restraint. Future studies could examine early changes in separate restraint, disinhibition and hunger scales, as predictors of ongoing weight loss. We tend to agree with Fogelholm *et al.* (1999) that it is difficult to disentangle these factors, and that it may be preferable to talk of a general dimension of eating control. However, it may be that different facets of eating behaviour change are crucial at different stages of weight control and in different treatment contexts.

Consistent with previous research, pre-treatment variables appeared to be poor predictors of early or ongoing weight loss. The type of diet (VLCD vs. LCD) was the only significant predictor of early BMI change, with patients on VLCD's showing greater weight loss than those on LCD's. Type of diet continued to be a significant (although weaker) predictor of ongoing BMI change. The number of weight assessments, which we regard as an index of the regularity of attendance in the clinic, was a significant positive predictor of ongoing BMI change. Early BMI change was also positively related to later BMI change.

In the present analysis, the best predictor of BMI change from 5 weeks to 9 months after the start of treatment was the early change in uncontrolled eating. Therefore, early improvement in the behavioural control over eating predicted better ongoing weight loss. The present findings suggest that a good early treatment response, measured in relation to weight loss and to reduction in uncontrolled eating, predicts a good later response. Conversely, patients who show a poor early response are likely to show a poor later response. The combination of the four significant predictors produced estimates of treatment outcome that diverged widely (Fig. 2); the difference between the best and worst case scenarios was predicted to be about 2 BMI units at 30 days and 6.5 units by 270 days.

Future research on obesity treatment should continue to explore the relationship between eating behaviour and weight change over longer periods of time (e.g. 1, 2 or 5 years), in order to determine whether the same or different factors predict longer term weight change. In this regard it would be important to examine the extent to which early reduction in uncontrolled eating is stable over time.

Acknowledgements

The authors would like to acknowledge the help of Dr David Zuroff for his assistance with the statistical analysis, and Drs Peter Forbes, Harry J. Lefebre, Charles Smart-Abbey, and Mr Paul Connolly for their ongoing support of the MLA research programme.

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Received 22 December 2003; revised version received 25 October 2004