A review of psychosocial pre-treatment predictors of weight control

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Summary

Prompted by the large heterogeneity of individual results in obesity treatment, many studies have attempted to predict weight outcomes from information collected from participants before they start the programme. Identifying significant predictors of weight loss outcomes is central to improving treatments for obesity, as it could help professionals focus efforts on those most likely to benefit, suggest supplementary or alternative treatments for those less likely to succeed, and help in matching individuals to different treatments. To date, however, research efforts have resulted in weak predictive models with limited practical usefulness. The two primary goals of this article are to review the best individual-level psychosocial pre-treatment predictors of short- and long-term (1 year or more) weight loss and to identify research needs and propose directions for further work in this area. Results from original studies published since 1995 show that few previous weight loss attempts and an autonomous, self-motivated cognitive style are the best prospective predictors of successful weight management. In the more obese samples, higher initial body mass index (BMI) may also be correlated with larger absolute weight losses. Several variables, including binge eating, eating disinhibition and restraint, and depression/mood clearly do not predict treatment outcomes, when assessed before treatment. Importantly, for a considerable number of psychosocial constructs (e.g. eating self-efficacy, body image, self-esteem, outcome expectancies, weight-specific quality of life and several variables related to exercise), evidence is suggestive but inconsistent or too scant for an informed conclusion to be drawn. Results are discussed in the context of past and present conceptual and methodological limitations, and several future research directions are described.

Keywords: Correlates, moderators, obesity, treatment.

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Introduction

During the last three decades, predictors of outcomes of obesity treatment have been periodically investigated in original research trials, and summarized in review articles (1,2) and book chapters (3,4). Collectively, these studies have concluded that predicting weight loss with acceptable accuracy is difficult to impossible. The large number of variables potentially involved, each explaining only a very small share of the variance in weight change, and the complex interactions among predictors, behaviours and types of treatment are possible reasons for the failure to build useful predictive profiles/models (5,6). However, a number of conceptual and methodological limitations may partially explain the disappointing results (7). Since the last major review on this topic was published (8) the number of research studies conducted on obesity treatment has increased substantially, treatment programmes have

evolved and new variables have been tested as potential predictors of weight loss. New analytical methods have also been introduced. For these reasons, and considering the likely usefulness of prospectively predicting outcomes in obesity treatment (1), an update on pre-treatment predictors of weight loss is warranted.

The heterogeneity of obesity and weight loss results

Obesity is a heterogeneous condition and individual responses to standardized protocols leading to weight change are highly variable (9). In real life settings such as obesity treatment programmes, physiological and psychological individual factors, some of which may carry a strong genetic influence (10), interact with environmental factors in a complex manner, producing a wide range or individual responses in both the magnitude and the rate of weight changes. At a psychological level, the principal focus of this review, individual variability is the norm. Some people perceive their excess weight as emotionally distressing, while others of similar weight appear unaffected (11,12). Individual perceptions of body weight and shape may determine a person's body image (13) and quality of life (14) more than weight itself. A subgroup of individuals presenting for obesity treatment displays dysfunctional eating behaviours while others display a normal relationship with food (15). Finally, a negative psychological impact of dieting appears to be present in some, but definitely not all dieting individuals (16).

A large degree of weight change variability is present in weight loss treatments such as hypocaloric balanced diets and behaviour modification (17), very-low calorie diets (VLCD) (18), dietary regimens without exercise (19), exercise without dieting (20) and various other therapeutic modalities (21–23). Regarding long-lasting weight control, while current prevalence data (24) and other reports (25) suggest widespread failure in available treatments, data from prospective trials (26,27), retrospective studies (28,29), as well as findings from self-selected groups of the population (30) suggest success is possible and indeed occurs for a sizeable number of people.

The source of the variability in response to obesity treatment remains unclear; researchers have not been able to adequately explain why some people adopt attitudes and behaviours needed for weight loss while others do not (31). In the last few decades, the majority of treatment studies have been focused on improving and contrasting treatment modalities in randomly grouped subjects, while investigating which treatments are more effective to which individuals, a long-standing need (32,33), has received less attention. Indeed, concerns have been raised that psychological, biological and environmental differences among the obese are too large for any single treatment to ever be effective in this population, if considered as a homogeneous group (34–37). Any treatment will be useful to some subjects, but no treatment will be effective for all, suggesting the need for a better matching between treatment features and patients' needs (32).

Several patient-matching treatment algorithms, primarily based on biological or morphological variables [e.g. degree of overweight, waist circumference, cardiovascular disease (CVD) risk factors] are now available (38–43), highlighting that not all overweight/obese persons are the same and that employing similar treatment protocols in diverse groups is not an effective approach. These guidelines also indicate that psychological factors such as personal preferences, expectations, attitudes towards physical activity, emotional distress, depression and body image should be considered when making treatment decisions (38–40,42). Unfortunately, empirical evidence supporting the ability of these or other variables to consistently predict outcomes is not widely available. Retrospective studies have identified behavioural (e.g. low levels of physical activity, lack of self-monitoring, emotional eating, a high-fat diet) as well as psychological (e.g. dichotomous thinking, body weight- and shape-based self-worth, unrealistic weight goals, low self-efficacy, higher anxiety and depression) correlates of unsuccessful long-term weight loss (29,30,44). However, thus far only 20–35% of the variance in subsequent weight loss has been predicted from baseline variables (17,45–51).

Why study predictors of weight loss?

The question of whether all individuals who *want* to lose weight *can* or *should* engage in weight reduction programmes at a particular time in their lives has been raised several times in the past (8,16,32,52). The assessment of participants' characteristics and level of readiness as they enter a programme has been justified in two primary ways. First, to optimize the intervention's efficacy for each individual or groups with similar profiles through a better matching of treatments to participants' measured characteristics (8,40). This is a long-standing goal in obesity treatment, but one that has rarely been practised (51,53–55). A second rationale is to screen some candidates out of treatment, if their likelihood of success is estimated as very low (36,52). This would spare them further distress upon a repeated failed attempt, save limited resources and permit a higher focus on individuals who stand a better chance of success. Under the title 'Ready or Not: Predicting Weight Loss', an expert panel on the evaluation and treatment of overweight and obesity observed that 'predicting a patient's readiness for weight loss and identifying potential variables associated with weight loss success is an important step in understanding the needs of patients' (p. 21) (56).

This article reviews what is known about predictors, emphasizes how conceptual and methodological factors have limited what has been studied and discovered and

suggests a new generation of studies to advance the field. We will focus on pre-treatment questionnaire-based psychosocial variables and other indices such as weight loss/dieting history and initial weight, all of which are easily accessible in most clinical, commercial and research settings.

Methods and study description

In the present review, articles published after 1995 reporting associations between baseline/pre-treatment individual factors and subsequent weight loss, within the context of adult obesity treatment programmes, were identified and analysed. The option of choosing only studies published since 1995 is based on the existence of several review papers and book chapters on this topic published up to, but not after 1995, as described later in this text. Independent measures were primarily psychosocial variables assessed by questionnaire. Because initial weight has been frequently considered a predictor of treatment outcomes and was available in many of the studies we selected, it was also included in this review. Other demographic variables such as age, gender, marital status, income and educational level were not analysed (as predictors) in the large majority of studies we selected, and were not included in this review.

Physical activity, diet, and behaviour therapy are currently recommended for all obese subjects (56). Thus, we included only intervention studies that involved a lifestyle behaviour modification programme generalized aimed at changing diet, or diet and physical activity. Studies using meal replacements, hypocaloric balanced diets (HBD, for the purpose of this review defined as an intake of approximately 1200–1500 kcal d^{-1}), low-calorie diets (LCD, approximately 800–1200 kcal d^{-1}), very-low-calorie diets (VLCD, approximately <800 kcal d^{-1}), and treatment for binge eating disorder (BED) were included as long as weight loss was a clear outcome of the study and a behavioural intervention was present. Whenever an LCD or VLCD was not mentioned in the text (or could not be assumed from caloric intake data reported), but some form dietary therapy appeared to be a part of the intervention, an HBD was assumed. In these cases, we cannot be sure that subjects were prescribed a diet lower than 1500 kcal d^{-1} but some degree of energy restriction can probably be assumed ('non-dieting' studies were not covered in this review). Only one study was identified that analysed psychosocial pre-treatment predictors of success using pharmacotherapy for weight loss (57); because no behavioural component was described as part of this study's intervention and considering its singularity compared to all other studies, it was not included. Surgery studies and interventions to prevent weight gain were also excluded.

Twenty-nine studies were identified and included in this review's primary analysis, reflecting 38 predictive models for weight loss and/or maintenance from variables assessed at baseline (Table 1). A model is defined by one or several predictors associated with a weight loss outcome for a given time period. Several studies included more than one model (i.e. if they covered different time periods). In Table 1, models are organized by the use of HBD/LCD (Table 1a) or VLCD (Table 1b). Programmes with VLCD are usually more intensive and induce larger average weekly weight losses, and are typically employed with groups displaying higher initial levels of obesity, which justifies the separate analysis. Within each category (HBD/LCD or VLCD), predictive models are sorted according to the duration of the study. Models with no follow-up/maintenance period or lasting less than 1 year are listed first and considered as *weight loss* studies (sorted by duration of initial treatment). They are followed by predictive models including weight loss and a follow-up/maintenance phase and reaching 1 year or more in duration (treatment + follow/up), which were considered *weight loss and maintenance* studies. One year is has been indicated by an expert panel on obesity as an appropriate threshold between weight loss and the maintenance of the weight lost (8). Finally, some models evaluated predictors of changes occurring only during the follow-up/maintenance period. They are listed last (*weight maintenance* studies).

Study description

All studies reviewed included female subjects while 15 (54%) had mixed-gender samples. Initial mean body mass index (BMI) for participants varied from ~29 to ~46 kg m^{-2} and sample size ranged from 42 to 444 subjects. The average duration of the weight loss phase was 21 weeks for studies with HBD/LCD and 22 weeks for VLCD trials, although the actual VLCD feeding period was shorter in some cases. In three VLCD studies, only a subgroup of the total sample underwent VLCD but outcomes were not shown separately regarding weight loss predictors. Approximate average weekly weight loss was 0.80 kg for VLCD studies and 0.58 kg for non-VLCD studies (weight loss was 0.52 kg $week^{-1}$ when only HBD studies were considered, i.e. when studies using LCD and treatment for BED were excluded). It should be noted that weight changes are reported for subjects completing the study. Intent-to-treat analyses, where data for all starting participants are included (which was not reported in the overwhelming majority of studies), may have yielded lower average weekly weight losses.

Average follow-up/maintenance phase in the 13 studies that included such a phase was approximately 63 weeks. During maintenance or follow-up, average yearly weight change was +4.9 kg and +1.1 kg for VLCD (six studies) and HBD/LCD (13 studies) respectively (overall average, +1.9 kg $year^{-1}$). Attrition rates were variable, ranging from

Table 1 Prediction models from studies using behaviour modification and (a) hypocaloric or low-calorie diets/(b) very-low-calorie diets as a means to weight loss

Model (reference)	Sample			Treatment, weight loss phase				Follow-up/maintenance phase			Outcome (dependent variable) predicted from baseline variables
	Size[1]	Gender	BMI	Type	Duration	Wt. loss	Attrition	Duration	Wt. change[2]	Attrition[3]	
(a)											
Poston_BL (205)	102	M + F	39	BM + LCD	8 weeks	~12 kg	NR				Weight change from baseline to 8 weeks
Bryan_BL (107)	42	F	34	BM + HBD	12 weeks	7.9 kg	~9%				Weight change from baseline to 12 weeks
Fontaine_BL (206)	177	M + F	~42	BM + LCD	14 weeks[4]	13.8 kg	11%[5]				Weight change from baseline to 14 weeks
Fontaine_BL2 (86)	109	M + F	42	BM + LCD	15 weeks[6]	13.9 kg	~11%[7]				Weight change from baseline to 15 weeks
Smith_BL (207)	54	F	32	BM + BED	15 weeks	4.5 kg	24%				Weight change from baseline to 15 weeks
Teixeira_BL (17)	112	F	31	BM + HBD	16 weeks	5.4 kg	21%				Weight change from baseline to 16 weeks
Wing_BL (61)	166	M + F	31	BM + HBD	17 weeks	~8 kg	10%				Weight change from baseline to 17 weeks
Traverso_BL (87)	50	M + F	33	BM + HBD	24 weeks	11.3 kg	NR				Weight change from baseline to 24 weeks
Sherwood_BL (71)	444	F	~31	BM + HBD	26 weeks	~8 kg[8]	14%				Weight change from baseline to 26 weeks
Eldredge_BL (124)	47	M + F	39	BM + BED	36 weeks	~3 kg	21%				Weight change from baseline to 36 weeks[9]
Dennis_BL (83)	109	F	31	BM + HBD	39 weeks	~9 kg	50%				Weight change from baseline to 39 weeks
Smith_BL2 (207)	54	F	32	BM + BED	15 weeks	4.5 kg	24%	41 weeks	+0.2 kg	30%	Weight change from baseline to 41 weeks
Wing_BL2 (61)	166	M + F	31	BM + HBD	17 weeks	~8 kg	10%	26 weeks	~+1 kg	18%	Weight change from baseline to 43 weeks
Linné_BL (208)	100	M + F	~41	BM[10] + HBD	11 weeks	~9 kg	NR	33 weeks[11]	~+1 kg	18%	Weight change from baseline to 44 weeks[12]
Gladis_BL (50)	118	F	36	BM + LCD	48 weeks	~15 kg	17%				Weight change from baseline to 48 weeks, for four groups based on BED status at baseline
Kiernan_BL (49)	177	M + F	~29	BM + HBD	52 weeks	NR	14%				Weight change from baseline to 52 weeks (two categories, –2 BMI units as criterion)
Smith_BLM (207)	54	F	32	BM + BED	15 weeks	4.5 kg	24%	52 weeks	+1.2 kg	37%	Weight change from baseline to 67 weeks
Teixeira_BLM (64)	158	F	31	BM + HBD	16 weeks	5.1 kg	14%	52 weeks	+0.5 kg	30%	Weight change from baseline to 68 weeks
Sherwood_BLM (71)	444	F	~31	BM + HBD	26 weeks	~8 kg[8]	14%	52 weeks[11]	~–4 kg[8]	21%	Weight change from baseline to 78 weeks
Leibbrand_BLM (120)	138	M + F	45	BM + HBD	10 weeks	~7 kg	NR	78 weeks[13]	–8.0 kg	21%	Weight change from baseline to 88 weeks
Gladis_BLM (50)	118	F	36	BM + LCD	48 weeks	~15 kg	17%	52 weeks	~+7 kg	36%	Weight change from baseline to 100 weeks, for four groups based on BED status at baseline
Jeffery_BLM (93)	130	M + F	31	BM + HBD	78 weeks	NR	NR	52 weeks	~–2 kg	20%	Weight change from baseline to 130 weeks
Nir_BLM (123)	66	F	30	BM + HBD	10 weeks	6.6 kg	NR	74–204 weeks	+3.1 kg	30%	Weight change from baseline to end of follow-up; duration of weight stability period
Poston_BM (205)	102	M + F	39	BM + LCD	8 weeks	~12 kg	NR	52 weeks	~+3 kg	NR	Weight change during follow-up (two categories, ≥1 kg as criterion)
Gladis_BM (50)	118	F	36	BM + LCD	48 weeks	~15 kg	17%	52 weeks	~+7 kg	36%	Weight change during follow-up, for four groups based on BED status at baseline
Cuntz_BM (131)	138	M + F	~46	BM + HBD	10 weeks	6.9 kg	NR	78 weeks	–1.5 kg	13%	Weight change during follow-up (three categories, ±2 BMI units as criterion)
(b)											
Fogelholm_VL (18)	85	F	34	BM + VLCD	12 weeks	13.5 kg	4%	40 weeks[14]	+0.4 kg	6%	Weight change from baseline to 12 weeks
Raymond_VL (209)	174	F	~36	BM + VLCD	24 weeks	~17 kg	12%				Weight change from baseline to 24 weeks
Smith_VL (210)	289	F	35	BM + VLCD[15]	~25 weeks	~11 kg	45%				Weight change from baseline to 20–30 weeks
Foster_VL (75)	223	F	37	BM + VLCD	26 weeks	16.7 kg	NR				Weight change from baseline to 26 weeks

Table 1 *Continued*

Model (reference)	Sample			Treatment, weight loss phase				Follow-up/maintenance phase			Outcome (dependent variable) predicted from baseline variables
	Size[1]	Gender	BMI	Type	Duration	Wt. loss	Attrition	Duration	Wt. change[2]	Attrition[3]	
Williams_VL (59)	128	M + F	41	BM + VLCD	26 weeks	~24 kg	8%				Weight change from baseline to 26 weeks
Cargill_VL (211)	159	M + F	~42	BM + VLCD[16]	26 weeks	NR	NR				Weight change from baseline to 26 weeks
Drapkin_VL (58)	93	M + F[17]	37	BM + VLCD[16]	52 weeks	~12 kg	15%				Weight change from baseline to 52 weeks
Williams_VLM (59)	128	M + F	41	BM + VLCD	26 weeks	~24 kg	8%	~73 weeks	~+6.4 kg	55%	Weight change from baseline to 100 weeks
Pekkarinen_VLM (62)	62	M + F	36	BM + VLCD	17 weeks	14.9 kg	5%	104 weeks	+9.1 kg	8%	Three categories of weight loss from baseline to 102 weeks (10% loss as criterion[18])
Westerterp-Platenga_VM (212)	57	F	31	BM + VLCD	8 weeks[19]	8.5 kg	NR	52 weeks[19]	+6.1 kg	53%	Weight regain during follow-up (three categories, 50% regain as criterion[20])
Raymond_VM (209)	174	F	~36	BM + VLCD	24 weeks	~17 kg	12%	52 weeks	~+12 kg	27%	Weight change during follow-up
Pasman_VM (63)	67	F	32	BM + VLCD	8 weeks	9.7 kg	NR	60 weeks	+7.0 kg	NR	Weight change during follow-up

In the first column: B, behaviour modification plus hypocaloric balanced diet (HBD, energy intake generally between 1200 and 1500 kcal d^{-1}) or low-calorie diet (LCD, energy intake generally between 800 and 1200 kcal d^{-1}); V, behaviour modification plus VLCD (energy intake generally <800 kcal d^{-1}); L, *weight loss* model; LM, *weight loss and maintenance* model; M, *weight maintenance* model (see text for details). In other columns: M, males; F, females; BMI, mean body mass index (kg m^{-2}) at baseline; BED, treatment for binge eating disorder; NR, not reported (when attrition rates were not reported, data were often reported for completers only). Whenever absent, initial BMI or weight changes were estimated from available data (e.g. initial weight, BMI changes) using a reference height of 1.70 m. Some studies were listed more than once, indicating multiple predicting models.

[1]In most cases, it represents initial sample size. In some cases, when attrition was not reported, it represents completers only.

[2]Indicates weight changes for subjects that completed the maintenance/follow-up periods. Because of attrition during this period, these subjects are not the same individuals as (i.e. they are a subset of) the group that underwent and completed the treatment phase.

[3]Indicates overall attrition rate (i.e. including treatment and follow-up periods).

[4]Represents mean treatment duration. Individualized treatments lasted between 0 and 33 weeks.

[5]Percentage of participants who failed to complete at least 6 weeks of treatment. Overall attrition was not reported.

[6]Represents mean treatment duration. Individualized treatments lasted between 0 and 34 weeks.

[7]Estimated attrition rate, based on study by Fontaine & Cheskin (206).

[8]Weight changes were calculated by averaging data from 11 different intervention groups (with sample sizes weighed) and thus represent a rough estimate of overall outcomes.

[9]Analyses at 12 and 24 weeks revealed a similar pattern as at 36 weeks.

[10]Dietary treatment not well described; the absence of VLCD is assumed.

[11]Included a weight maintenance programme with monthly group meetings.

[12]Represents mean treatment duration. Individualized treatments lasted between 6 and 121 weeks (total duration).

[13]Indicates overall attrition rate (i.e. including treatment and follow-up periods).

[14]Included a weight maintenance programme.

[15]Only a subgroup of all participants (51%) received VLCD treatment (30 weeks), the remaining receiving a low-calorie diet (LCD) lasting 20 weeks.

[16]Only a subgroup of all participants received VLCD treatment (number of subjects not reported, assumed to be approximately half), the remaining receiving a HBD.

[17]All participants had type II diabetes.

[18]Maintenance of at least 10% weight lost from baseline was the criterion for success and weight gain from baseline was the criterion for non-success.

[19]Study included two consecutive periods of VLCD (8 weeks) and follow-up (52 weeks); weight changes during treatment and follow-up were similar in both periods and were averaged in this table

[20]Twice a regain <50% of weight lost was the criterion for success and twice a regain >50% was the criterion for non-success.

6% to 55% but they were not reported or were incompletely reported in many cases. The most typical outcome variable was weight loss, expressed either in absolute (kg) or relative (% of initial weight) terms. In five cases, the dependent measure was a categorical variable, based on specific weight loss/maintenance criteria (e.g. reaching a change of 2 BMI units).

Table 2 shows all predictive models, organized by predictor (left column) and separated by the type and direction of the association observed. Independent variables are sorted by the overall number of predictive models available (i.e. variables with more evidence on top). Models are identified by the name of first author in the source article, and by one to two letters identifying the duration/design of the predictive model (see legend for Table 1 for additional details). For some models we also include the value corresponding to the per cent variance in weight loss accounted by the predictor ($R^2 \times 100$), based on a bivariate correlation. These values, which unfortunately were not available in all studies, can generally be compared across predictive models.

Results and discussion

An expert panel for the Institute of Medicine (IOM) has previously identified several pre-treatment individual predictors of weight loss, gathering information from several earlier reviews, book chapters and original research studies (8). In the 1995 peer-reviewed IOM report[1], variables with evidence suggesting the existence of a relationship predictive of weight loss were initial weight and eating self-efficacy (positive association with weight loss) and repeated weight loss attempts and perceived stress (negative association). Other variables such as binge eating, restricted eating, psychopathology and personality factors were listed as non-predictors.

Initial weight/BMI[2]

Sixteen studies reviewed in this article addressed the association between initial weight or BMI and change in weight/BMI after treatment. Six studies reported a positive association (i.e. higher initial BMI, larger weight losses) and two studies reported a negative association, with the eight remaining studies showing no association. Two additional studies appeared to show a significant association but the direction of the relationship could not be ascertained (58,59). Previous reviews have generally indicated that an higher initial weight is associated with higher absolute losses during treatment (8).

There was a slight tendency for longer duration studies to show either no association or for subjects who were initially heavier to be less successful; of the 10 models with a weight maintenance phase, only two showed a positive impact of a higher initial BMI on long-term results. Across studies, the sample's overall degree of obesity seemed to be of influence. The weighted average for initial (mean) BMI for models showing a positive association (i.e. heavier individuals losing more weight) was ~37 kg m^{-2} while for all other models (negative or no association) the average initial (mean) BMI was ~31 kg m^{-2}. Thus, a threshold of initial weight may be necessary to observe initial weight as a significant predictor of results.

Previous dieting and repeated weight loss attempts

Overweight individuals participating in research-based weight loss programmes may have different characteristics than the general overweight population, some of which may make the former group more resistant to successful weight management (34,60). Previous reviews, including the IOM report previously cited, have concluded that while a history of weight cycling is not predictive of weight outcomes, frequent prior participation in weight loss programmes and a history of repeated attempts at weight loss are negative prospective correlates of weight loss (3,6,8). Specific mechanisms have not been identified and it cannot be ruled out that a history of failed attempts may also reflect a physiological resistance to weight loss, whether it developed through the years or it is the expression of a particular genetic trait.

For the present review, five studies published since 1995 were identified that reported on the association of previous weight loss attempts, participation in previous programmes, or a history of repeated weight loss with weight changes during treatment. Of these, two studies showed no association and the three remaining reports showed a negative association between previous dieting and weight loss success. Of the two studies showing no association, one asked for past participation in organized weight loss programmes in a dichotomous yes/no fashion (61) while the other showed no effect of the number of 'previous weight loss attempts' on weight loss at the 1- and 2-year time points (62). Kiernan and colleagues observed that a history of weight cycling was part of an unsuccessful profile for BMI change at 1 year (49), while Pasman *et al.* used a four-item Likert scale (never to always) to classify individuals regarding their self-reported frequency of previous dieting,

[1]Table 2 includes a reference to the evidence collected in the IOM review (indicated by the letters 'IOM').

[2]Considering the potentially very large number of studies reporting on the association between baseline weight/BMI and change in weight/BMI, we did not specifically searched for such studies. Instead, we report these associations only when they were found in studies containing information on other predictors also reported in this study.

Table 2 Individual predictors/correlates of success in subsequent weight loss and/or maintenance and predictive models

Construct	Number of Models	No association	Significant association	
			Positive	Negative
Binge/emotional eating	19	IOM, Cargill_VL (211), Cuntz_BM (131), Gladis_BL (50), Gladis_BM (50), Gladis_BLM (50), Leibbrand_BLM (120), Pekkarinen_VLM, 2.0 (62), Raymond_VL (209), Raymond_VM (209), Sherwood_BL (71), Smith_BL, 1.7 (207), Smith_BL2, 1.7 (207)[1], Smith_BLM, 1.7 (207), Teixeira_BL, 0.3 (17), Teixeira_BLM, 0.5 (64)	Bryan_BL, 11.6 (107), Gladis_BL (50)	Fogelholm_VL (18), Sherwood_BLM (71)
Initial weight/BMI	16	Cuntz_BM (131), Jeffery_BLM (93), Kiernan_BL (49), Pekkarinen_VLM (62), Poston_BM (205), Teixeira_BL (17), Teixeira_BLM, 2.0 (64), Westerterp-Platenga_VM (212)	IOM, Foster_VL (75), Gladis_BL (50), Gladis_BLM (50), Leibbrand_BLM (120), Traverso_BL (87), Wing_BL (61)	Nir_BLM (123), Pasman_VM, 5.8 (63)
Depression/mood, psychopathology	10	IOM, Bryan_BL (107), Cargill_VL (211), Cuntz_BM (131), Gladis_BL (50), Leibbrand_BLM (120), Poston_BL (205), Poston_BM (205), Teixeira_BL, 2.3 (17), Teixeira_BLM, 1.7 (64)		Eldredge_BL (124)
Eating disinhibition, external eating	10	Bryan_BL (107), Cuntz_BM (131), Foster_VL (75), Leibbrand_BLM (120), Pekkarinen_VLM, 3.2 (62), Teixeira_BL, 0.4 (17), Teixeira_BLM, 0.3 (64), Traverso_BL (87), Westerterp-Platenga_VM (212)	Pasman_VM, 6.8 (63)	
Body image, body size satisfaction	9	Leibbrand_BLM (120), Teixeira_BL, 3.2 (17), Teixeira_BLM, 1.2 (64), Traverso_BL (87)[2]	Kiernan_BL (49), Teixeira_BL, 6.8 (17), Teixeira_BLM, 4.8 (64), Traverso_BL (87)	Traverso_BL (87)
Perceived hunger	9	Cuntz_BM (131), Foster_VL (75), Leibbrand_BLM (120), Pekkarinen_VLM, 0.1 (62), Teixeira_BL, 0.5 (17), Teixeira_BLM, 0.2 (64), Traverso_BL (87)	Fogelholm_VL (18)	Pasman_VM, 5.3 (63)
Cognitive (eating) restraint, chronic dieting	9	IOM, Bryan_BL (107), Cuntz_BM (131), Leibbrand_BLM (120), Pekkarinen_VLM, 0.2 (62), Teixeira_BL, 0.5 (17), Teixeira_BLM, 0.3 (64), Traverso_BL (87), Westerterp-Platenga_VM (212)		Foster_VL, 2.3 (75)
Eating self-efficacy	7	Cargill_VL (211), Fontaine_BL2, 0.4 (86), Smith_BLM (207)[3], Smith_BL2 (207)[3], Teixeira_BL, 0.8 (17),	IOM, Smith_BL (207)[3], Teixeira_BLM, 4.4 (64)	
Previous dieting/weight loss attempts	6	Pekkarinen_VLM (62), Wing_BL (61)		IOM, Kiernan_BL (49), Pasman_VM, 21.2 (63), Teixeira_BL, 13.7 (17), Teixeira_BLM, 5.8 (64)
Personality, general cognitive style	6	IOM, Bryan_BL, 13.7 (107)[5], Fontaine_BL, 0.5 (206)[4], Traverso_BL (87)[6]	Bryan_BL (107)[5], Poston_BM (205)[6], Traverso_BL (87)[712]	
Self-esteem	5	Bryan_BL (107), Eldredge_BL (124), Teixeira_BLM, 1.0 (64)	Nir_BLM, 4.4 (123)[8], Teixeira_BL, 4.4 (17)	
Internal locus of control[9]	5	Bryan_BL, 12.3 (107)[10], Williams_VL, 0.3 (59), Williams_VLM, 1.4 (59)	Bryan_BL (107)[10], Nir_BLM (123)	
Self-motivation, autonomy orientation, general efficacy	5	Williams_VL, 0.3 (59)	Dennis_BL (83)[11], Teixeira_BL, 7.8 (17), Teixeira_BLM, 2.3 (64), Williams_VLM, 10.2 (59)	
Perceived social support	4	Kiernan_BL (49)[12], Teixeira_BL, 0.3 (17), Teixeira_BLM, 0.6 (64), Wing_BL2 (61)[13]		
Weight loss goals/expectations, outcomes evaluation	4	Jeffery_BLM (93), Linné_BL (208)		Teixeira_BL, 7.8 (17), Teixeira_BLM, 7.3 (64)

Table 2 *Continued*

Construct	Number of Models	No association	Significant association	
			Positive	Negative
Cognitive style regarding diet lapses	2	Smith_V3L (210)[14]		Drapkin_VL (58)[15]
Exercise self-efficacy	2		Teixeira_BL, 3.6 (17), Teixeira_BLM, 6.3 (64)	
Exercise perceived barriers	2			Teixeira_BL, 4.4 (17), Teixeira_BLM, 4.8 (64)
Exercise social support	2	Teixeira_BL, 2.3 (17), Teixeira_BLM, 0.4 (64)		
Quality of life (obesity-specific)	2		Teixeira_BL, 3.6 (17), Teixeira_BLM, 2.3 (64)	
Quality of life (general, SF-36)	2	Teixeira_BL, 2.9 (17), Teixeira_BLM, 1.4 (64)		
Perceived stress, anxiety	1	Kiernan_BL (49)		
Cognitive performance	1	Bryan_BL (107)		
Perceived autonomy (social) support	1		Williams_VLM (59)	
Bulimic behaviour	1		Traverso_BL (87)	

IOM, relationship reported in a comprehensive report by the Institute of Medicine published in 1995 (8). See legend in Table 1 for more details on letters/numbers used to identify predictive models. Whenever present, the number after each model represents the bivariate association with weight change, expressed as per cent variance accounted by the predictor variable ($R^2 \times 100$). Whenever the same model is listed in different columns within the same construct, different scales were used for similar constructs (see numbered footnotes).

[1]The interaction between binge eating and perceived control was a significant predictor. It appears that binge eating loaded negatively and control positively, regarding weight loss.

[2]Except the Feeling Fat scale, all other five dimensions of the Body Attitudes Questionnaire (113), namely Disparagement, Fitness and Strength, Salience of Shape, Attractiveness, and Lower Body Fatness, were not associated with weight loss.

[3]Questions represented perceived behavioural control, as the 'likelihood to overcoming specific barriers to losing weight and eating in healthy manner', which are phrased similarly to eating self-efficacy questionnaires.

[4]General optimism, assessed by the revised Life Orientation Test (213).

[5]The Impression Management and Vulnerability scales of the Dysfunctional Attitudes Scale (214) positively predicted weight loss; the remaining scales (Approval, Catastrophising, Imperatives, Need to Success, and Pleasing Others) were not significant predictors.

[6]Muscular Tension (positive), Monotony Avoidance (positive), Suspicion (negative) and Guilt (negative) were the only significant ('modest') predictors of weight loss, from all 15 scales present in the Karolinska Scales of Personality (215)

[7]The Body Dissatisfaction and Interpersonal Distrust dimensions of the Eating Disorders Inventory (112) were the only scales associated with weight loss; all other six scales (Bulimia, Drive for Thinness, Interoceptive Awareness, Ineffectiveness, Maturity Fears, and Perfectionism) were not.

[8]Baseline self-esteem was a positive predictor of months of weight stability, not overall weight loss.

[9]Although locus of control was not mentioned in the IOM review, an internal locus of control has been identified in other reviews as a positive and significant predictor of weight loss (5,7).

[10]The Dieting Beliefs Scale (104) was related with weight loss while the Weight Locus of Control Scale (105) was not.

[11]Items in this questionnaire started with 'When it comes to my weight . . .', but were phrased in a general sense, representing an overall sense of confidence and self-motivation (e.g. 'I'm confident in my ability to reach my goal', 'I make decisions as well as anyone else') and did not include reference to any specific weight-control behaviour such as eating or exercise.

[12]Did not enter prediction model using signal detection methodology and thus assumed as non-significant predictor.

[13]In three of the four experimental groups in study; in fourth group, a modest negative association was observed.

[14]Attitudes regarding diet lapses with three groups were defined: objective, quantitative thinkers ('matter-of-degree'), rational thinkers and rigid, dichotomous thinkers ('all-or-nothing').

[15]The perceived number of high-risk situations (for a dietary lapse) in which a participant generated a coping response was a positive predictor.

showing that the higher the score (i.e. the more frequent the previous dieting) the larger the weight regain during 14 months after treatment was over (63). Finally, two related studies reported a negative association between the number of diet attempts during the 12 months prior to treatment and weight change at 4 months (17) and at a 16-month follow-up (64). Four to five attempts in the year prior to treatment was a good cut-off point, with very few successful participants reporting such a high level of previous dieting (64). Thus, most results published before (46,65–67) and after 1995 suggest that previous participation in weight loss programmes and previous dieting attempts are predictive of worse weight loss outcomes during and after treatment for obesity.

Binge, restricted and disinhibited eating

Binge eating and (cognitive) eating restraint and disinhibition are among the most studied variables in the context of weight loss and management. In this review, with only a few exceptions, data show little or no association between weight changes during treatment and baseline binge eating [most frequently assessed by the Binge Eating Scale (68)], or variables derived from the popular Eating Inventory (69). Perhaps the findings regarding binge/disordered eating, high levels of which are commonly reported by many weight loss candidates (70), are the most counter-intuitive. Emotional overeating (and cognitive disinhibition of eating), especially in the presence of binge eating episodes, is commonly viewed as a negative factor in weight control and is associated with more perceived barriers to weight loss (71). Two factors may account for the non-significant relationships observed. First is the high heterogeneity within any of the particular eating characteristics measured, regarding other relevant variables that may work as confounders or mediators. Restrained eating, for instance, has been found to be present in flexible vs. rigid patterns in groups presenting for treatment (72), with distinct implications for long-term weight loss (more flexible control, better results). Restrictive dieting may exacerbate a tendency to counter-regulatory overeating, but only in susceptible overweight individuals (73). Second, normalization of eating behaviours, for example, by addressing emotional triggers to eating or improving cognitive control over external situations likely to induce overeating, is a central intervention goal in the majority of lifestyle treatment programmes [e.g. (74)]. To the extent improvements in this area do occur during treatment (75), and assuming that subjects with the worst initial values will improve the most, then pre-treatment scores may not carry a strong influence on outcomes; an equalizing phenomenon concerning disordered eating may take place during the programme, rendering baseline scores largely irrelevant for overall results.

Some evidence indicates that individuals with the highest binge eating scores may drop out at a higher rate than non-binge eaters (71,75–77). Differences in the assessment of binge eating notwithstanding, this suggests that some binge eaters who cannot adhere to the new eating patterns proposed by the behavioural interventions may leave the programme before its completion, whereas the remaining individuals within this subgroup are on average as successful as their non-binging counterparts. In contrast, other studies have shown similar attrition rates between subjects with binge eating disorder (clinical or subclinical) and without this disorder, using different measures to characterize binge eating patterns (50).

Self-efficacy and self-motivation

Eating self-efficacy has been frequently assessed with the Eating Self-Efficacy Scale [ESES (78)] and the Weight Efficacy Life-Style Questionnaire [WEL (79)]. Studies previous to 1995 (46,80,81) have led to the general conclusion that high self-efficacy towards eating behaviours is perhaps the only reliable predictor of subsequent weight loss (39). However, the collective evidence since 1995 does not entirely confirm the earlier findings (see Table 2). It is noteworthy that in the original validation study for one of the more popular self-efficacy questionnaires (the ESES), Glynn & Ruderman had already shown that eating self-efficacy, whether assessed at baseline or at any other time point, was not predictive of *subsequent* weight loss (78).

Confounding factors (e.g. sample characteristics, intervention features) and the relatively small number of studies with comparable methodologies limit general conclusions. For example, the extent to which treatment is successful in actually increasing participants' self-efficacy during the programme could reduce the impact of pre-treatment self-efficacy on weight loss. However, *changes* in both eating and exercise self-efficacy during treatment are consistently associated with weight reduction (65,78,82,83). It is possible that earlier reviews have considered eating self-efficacy more generally (e.g. as a *mediator* of success; changes in self-efficacy predicting changes in weight) rather than exclusively as a pre-treatment predictor.

When addressing self-efficacy, it is important to distinguish between self-regulatory efficacy specific to a particular situation or behaviour (e.g. resisting overeating when feeling depressed) and more general constructs such as an overall sense of assurance or self-confidence. Although a high level of generalized efficacy and autonomy could positively influence situation-specific self-efficacy, these constructs are not interchangeable (47). Interestingly, several studies in the present review seem to indicate that generalized measures of efficacy may be more predictive of outcomes (17,59,64,83–85) than scales that target perceived self-efficacy for specific behaviours, especially eating-

related (17,65,78,86,87). Although self-efficacy theory endorses the importance of task specificity for the predictive ability of self-efficacy measures (88), self-motivation, often assessed by the Self-motivation Inventory [SMI (89)], and an autonomous orientation to one's motivation, both of which are general attributes, have shown consistently positive results as predictors of subsequent success in weight control (17,59,64,84). In the case of the SMI, it has also been shown to correlate with eating-related variables during weight loss (90) and to significantly predict subsequent exercise behaviour (89).

A more in-depth discussion of the mixed findings for eating self-efficacy as a predictor in weight management is beyond the scope of this article. Nevertheless, it is possible that the true details about the eating behaviours in question (e.g. what it *really* takes to consistently limit intake of certain foods or eat less in certain situations) are largely unknown to participants at the time of initial assessments, leading to wrongly formed efficacy expectations; these would weaken the predictive ability of the eating-related measures in question (80). It may also be that the specific eating behaviours covered by the self-efficacy items questionnaires (e.g. cognitive restriction of eating in a variety of situations) are in themselves not strongly related to weight control, particularly in the long term. Conversely, more general measures (e.g. self-motivation) may be sufficiently broad to cover the various dimensions involved in weight control (behavioural, environmental, psychological) and well-suited to predict compliance to the multitude of behaviours *actually* necessary for long-term success.

Outcome expectancies

Before a weight loss programme, participants are sometimes asked 'how much weight do you expect to lose?' (47) or 'how likely are you to reach your goal weight?' (91). Other questions have also been used in this context, namely 'what would an acceptable (or unacceptable, or "happy") weight be for you, by the end of this program?' (92) or 'how much would you *like* to weigh?' (93). Although these related questions refer to somewhat different types of expectations/evaluations, they are henceforth addressed together.

Studying outcome expectancies as a predictor of weight outcomes is particularly relevant in the context of the debate concerning the role of realistic (vs. unrealistic) expectations for weight loss prior to treatment (94–97). Excessively optimistic expectations are the norm in obesity treatment-seeking individuals, at least in American samples (92) and a great value is placed on reaching desired weights (98). Jeffery and colleagues showed that men and women with more modest absolute weight loss goals were more likely to achieve their goals, and that those who achieved their weight goals had better weight maintenance 2.5 years after beginning the trial (93); however, desired weight loss did not directly predict actual weight loss. Using the Goals and Relative Weights Questionnaire (92) it was recently observed that overweight/obese women with less demanding pre-treatment evaluations of what 'acceptable' or 'happy' weights would be after treatment (relative to initial weight) lost significantly more weight than women indicating they would only find larger weight losses as acceptable/'happy' ones (17,64). Others have shown that positive expectations (i.e. higher reported likelihood of reaching goal weight) predict short-term weight loss, especially when subjects reveal a low level of fantasizing and daydreaming about potential beneficial consequences of large weight loss; in the long-run, positive initial expectations, low/negative fantasy thoughts and the interaction of the two were all predictive of weight loss (91). Still other studies have shown positive outcome expectations (i.e. larger weight loss goals) to positively precede better weight reduction results (47,85). More research is needed to clarify the impact of outcome expectancies/evaluations on and during weight reduction efforts. At this moment, it appears that positive *and* realistic expectations foretell the best results, especially if accompanied by a strong sense of self-assurance (85).

Locus of control

Locus of control refers to the degree to which people believe their own behaviours determine the outcomes of their lives (internal locus of control), as opposed to chance or the impact of other people and external events (external locus of control). Several instruments are available to measure this construct: general, non-specific measures such as the popular Internal-External scale [I-E (99)] or adaptations of it (100,101), and more specific scales, such as the Health Locus of Control scale [HLC (102)], the Multidimensional Health Locus of Control scale [MHLC (103)], the Dieting Beliefs Scale [DBS (104)] and the Weight Locus of Control Scale [WLOC (105)]. All have been used to predict weight loss in the past.

Despite being one of the most frequently studied variables among predictors of weight loss, especially in the 1970–80s, locus of control was not specifically mentioned in some of the previous reviews on this topic (3,8), possibly because it was included in the category of personality factors and classified as a non-predictor (8). Nevertheless, locus of control has a good theoretical rationale (99) and acceptable empirical support as a correlate of weight loss. In a 'mini meta-analysis' of locus of control as a predictor of weight change, Allison & Engel reviewed 11 studies published prior to 1995, concluding that locus of control was significantly related to weight loss (mean for all studies, adjusted for sample size, was 0.19) and that health- and weight-specific locus of control appeared to be more predictive than more general measures (7).

We identified three more recent studies that have used locus of control measures to predict weight loss results, one of which used two different scales for that purpose, thus yielding a total of four predictive models (see Table 2). Two models showing non-significant associations used the MHLC and the WLOC scale, a four-item instrument developed specifically for weight control, whereas the DBS and an I-E general scale resulted in significant predictive models. Given the heterogeneity of programme characteristics and the diversity of scales utilized, it is not surprising that conflicting results have been reported. Nevertheless, a previous review (7) and results from some of the more recent trials indicate that an internal locus of control is a beneficial trait regarding weight management; not one study to date has shown external (as opposed to internal) beliefs to be predictive of better results. Additionally, the importance or the *value* that individuals place on the expected outcomes may be a relevant concurrent assessment with locus of control, as its effect on behaviour (i.e. the effect of locus of control) may be mediated by value cognitions (99,105). Whether general or specific measures result in closer relationships with weight outcomes is not clear, especially considering the very few published studies that have used weight-specific locus of control measures. The DBS in particular is a promising tool (104,106,107), deserving further validation and investigation as a predictor of weight loss. Additionally, exercise-specific locus of control is also in its exploration phase (108,109) and could be used in weight management in the future.

Body image and self-esteem

Whether low starting levels of self- and body-esteem limit or ease weight management efforts has been investigated before, with mixed findings. While general self-esteem is a relatively well-defined construct, most frequently measured with the Rosenberg Self-esteem/Self-concept scale [RSE (110)], body image is considered a multidimensional trait, involving cognitive/attitudinal, perceptual and behavioural dimensions (111). Five recent studies have examined associations of initial body image variables and subsequent weight loss. In some cases, multiple measures were used within the same study (17,64,87). Six psychometric instruments were used to assess body image, namely the Eating Disorders Inventory [EDI (112)], the Body Attitude Questionnaire [BAQ (113)], the Body Shape Questionnaire [BSQ (114,115)], the Physical Self-Perception Scale [PSPP (116)], the Body Cathexis questionnaire (117) and the Body Image Assessment Questionnaire (118). As could be expected from such a broad measurement setting, results were mixed, with some predictive models showing no association, some showing a positive association (better body image, more weight loss) and one model showing a negative relationship (see Table 2).

Several studies show that the BSQ, one of the most psychometrically sound instruments for the assessment of distress related to body image (119), does not significantly predict subsequent weight loss (17,64,87,120). In contrast, significant relationships were found for the EDI's Body Dissatisfaction scale (49,87) for the Body Image Assessment Questionnaire (difference between self and ideal silhouettes representing a range of body shape/sizes) and for the Body Cathexis questionnaire (17,64). For example, Kiernan and colleagues used a novel statistical procedure (signal detection methodology) to identify baseline characteristics of successful vs. unsuccessful weight *losers* after 1 year, and found lower body dissatisfaction (from the EDI) and no history of repeated weight loss to significantly predict success (49).

The diversity of assessments for this construct (in fact, the 'diversity' of the construct itself) makes a summary conclusion difficult to reach. Collectively, it appears that elevated levels of body distress do hinder attempts to weight loss in some cases, although the degree to which these issues are addressed during treatment, as well as other factors, may confound this association. Some studies have also shown that age of onset on obesity and depression may affect the impact of negative body image on obesity (121,122).

Regarding self-esteem, recent evidence is scarce. A relationship with subsequent weight loss, which was significant in the short term (17) but not in the long term (64), has been reported. Nir & Neumann found baseline self-esteem to be correlated with the duration of weight loss maintenance but not with weight loss *per se* (123). Two other studies have found non-significant associations (107,124). While previous review papers have not highlighted a statistically significant role of self-esteem as a predictor of weight loss (4,8), more current data and some previous studies (125) lend support, albeit modest, to a positive influence of self-esteem in weight management outcomes.

Psychological health and perceived stress

In virtually all studies analysed for this review measures of psychological well-being or psychopathology (mood, depression, personality disorders, etc.) were not found to significantly predict weight loss. The Beck Depression Inventory [BDI (126,127)] is by far the most commonly used measure in this domain and it is safe to assert that it does not adequately identify subjects with low likelihood of success for weight management. The adoption of exercise (128), improvements in body image (e.g. following some initial weight loss) (13) and the regular social contact with a supportive group and intervention team (61) are some factors likely to improve mood and psychological adjustment during weight loss. As mentioned for other variables (e.g. self-efficacy, binge eating), improvements in

depressive symptoms during weight loss treatment occur (50,129) and tend to covary with weight changes (130,131). Consequently, baseline assessments may lack an important or lasting impact.

Considering the face-validity of high levels of stress and anxiety as limiting factors in obesity behavioural treatment (which has lead to the inclusion of stress reduction components into treatment programmes), it was surprising to find only one study published since 1995 evaluating the impact of pre-treatment levels of perceived stress on outcomes (49). One logical explanation may be that stress is looked upon as a transient state and considered primarily as a *process* factor (3); its influence assumed the strongest as subjects go through weight loss, not as a relevant pre-treatment aspect (when optimism is generally the highest). Trait anxiety is a more stable construct but it has largely been ignored in the context of weight loss predictors. In the past (132), pre-treatment anxiety (and depression) has yielded some significant predictive results, using the Minnesota Multiphasic Personality Inventory [MMPI (133)] and the Taylor Manifest Anxiety Scale (134), but these results have not since been confirmed or refuted.

Our interpretation of the literature on psychological health and subsequent weight loss is that mood and depression, as well as general indicators of psychopathology, are generally not appropriate measures to predict subsequent weight loss, at least considering heterogeneous clinical samples; some subgroups may be particularly vulnerable (135). This said, many studies initially screen out subjects with clinical depression or clinically diagnosable psychopathology, which may render some analyses inappropriate because of lack of variance in the variable of interest. Regarding state and especially trait anxiety and stress, no informed conclusion can be made from the available evidence. Cross-sectionally, higher levels of stress have been shown to predict unhealthier behaviours that can contribute to obesity such as a higher fat diet and less exercise (136). More studies are encouraged, especially regarding the most stable traits, which may impact behaviours in the long run.

Social support

Despite its apparent face-validity and some suggestive results (137,138), we found no evidence that social support measured before treatment is predictive of subsequent weight outcomes. Williams and colleagues observed that the perceived *type* of support (provided by the intervention team, not by family/peers as more commonly assessed) measured 5–10 weeks into the programme was important for later success (59); when support was viewed as fostering autonomy as opposed to being controlling, participants obtained significantly better results. This distinction between types of support may be important for other types of social influences, such as those arising from close family and significant others. It has been our experience that spouses' attitudes (and their behaviours) towards their partners' treatment process can be very influential but are largely unpredictable. Many women we have worked with have reported surprise by their spouse's reactions (positive *or* negative) during the programme. This suggests that baseline assessments of social support, as opposed to measurements during or after treatment, may be assessing support too generally or measuring wrong estimations of future support. A questionnaire to measure social support specifically for weight management has been recently developed (139) but no data for its association with weight loss are available.

Quality of life

As with social support, health-related quality of life (HRQL) variables have been analysed as pre-treatment predictors of weight management in only a limited number of studies. HRQL measures psychological, physical and inter-individual functioning in daily life and can be divided into general (context-unspecific) measures and those that target quality of life associated with a particular condition. Several instruments are available to measure both general (e.g. SF-36) and specific HRQL, including various obesity-specific instruments (140,141). We are aware of only two studies that have measured HRQL before obesity treatment and reported associations between these scores and subsequent weight outcomes (17,64). Results from these related studies suggest that the Impact of Weight on Quality of Life-lite (IWQOL-lite) may have potential as a predictor of weight loss and maintenance, and particularly as a correlate of early drop-out. Women reporting lower HRQL at programme start, particularly in the areas of work, health and self-esteem, were more likely to finish the study among the least successful group or to drop out. These results were essentially the same when predicting short- and longer-term weight loss (17,64).

Exercise-related variables

The adoption of physical activity is regarded as critically important in the process of weight management, particularly for long-term success (142). Besides its direct contribution to energy expenditure during and after the activity bout, exercise may also contribute to improved dietary compliance (143), possibly through decreased feelings of hunger and eating disinhibition and improved psychological well-being (144). However, research on exercise-related psychosocial variables in the context of obesity treatment is considerably scarcer when compared to other areas such as exercise and eating behaviours, body image, or psychological health. In non-obese samples, exercise participation

can be predicted by several questionnaire-based variables such as self-efficacy, perceived barriers, social support, perceived stress and feelings of enjoyment and competence in physical activities (145–147). In fact, motivational models for exercise intention and behaviour have been developed to some detail and with relative success (148), and psychological correlates of exercise behaviours have been easier to establish than comparable constructs for eating behaviours [cf. (149–152)].

Despite the sound rationale, whether exercise psychosocial pre-treatment variables are able to predict exercise behaviour or actual weight loss during obesity treatment has been investigated in only a few studies (17,64). These recent studies have analysed scores from the Exercise Self-efficacy Scale [ESES (153)], the Exercise Perceived Barriers Scale [EPBS (154)] and the Exercise Social Support Scale [ESSS (153)] as predictors of weight loss. Higher perceived self-efficacy for exercise, measuring an individual's conviction that he/she can 'stick with' an exercise programme for at least 6 months under varying circumstances (e.g. when time is short, when undergoing a major life change, etc.) and lower perceived barriers to exercise were significantly associated with short- and long-term weight loss results (17,64). Baseline social support for exercise behaviours did not predict subsequent weight loss.

The questionnaires used for exercise psychosocial variables are relatively short, have generally displayed good psychometric properties, are simple to interpret and can easily be used in the context of obesity treatment at baseline, concurrently with the intervention (e.g. to monitor exercise attitudes throughout the programme), or as retrospective correlates of weight loss and exercise behaviours (44). More research is needed to analyse attitudes and cognitions regarding exercise and physical activity behaviours, in the context of obesity treatment.

Summary of predictors of weight control

Table 3 shows all predictors, organized based on the strength and consistency of their association with weight outcomes and also considering the relative amount of evidence available for each case (i.e. number of published studies). Less previous dieting or little history of repeated weight loss attempts, low self-reported self-motivation (or general efficacy) and autonomy were the most consistent predictors of subsequent weight loss. There is clearly more evidence for previous dieting than for the latter variables, but the consistency of recent findings (all positive and significant) and a sound theoretical rationale led us to classify a self-motivated, autonomous style among the strongest predictive traits. The SMI in particular, for general motivation/efficacy attributions, and instruments that assess causality orientations [v (59)] deserve more research regarding eating and physical activity adherence, and overall success rates in weight loss. A number of other variables, including poor body image, low eating self-efficacy and unrealistic weight loss expectations may correlate negatively with subsequent weight loss, though not as consistently. A high initial BMI may be associated with more absolute weight loss but only in samples including more obese individuals (i.e. mean BMI > 35 kg m^{-2}). Finally, there are several variables for which preliminary studies suggest the existence of an association, but at the moment too few studies are available. Exercise variables and weight-specific quality of life are two examples.

Table 3 Summary of pre-treatment variables reviewed as potential predictors of weight management

	Predictors	Non-predictors
Consistent evidence	Less previous dieting, fewer weight loss attempts Self-motivation, general efficacy, autonomy	Binge/emotional eating Depression, psychopathology, mood Eating disinhibition, external eating Cognitive (eating) restraint, chronic dieting Perceived hunger
Mixed evidence	Initial BMI/weight Body image, body size satisfaction Self-esteem Eating self-efficacy Realistic weight loss goals/expectations Internal locus of control	Personality, general cognitive style Perceived social support
Suggestive evidence	Exercise self-efficacy Few exercise perceived barriers Quality of life (obesity-specific) Perceived autonomy (social) support Absence of bulimic behaviour Cognitive style regarding diet lapses	Low perceived stress, anxiety Exercise social support Cognitive performance Quality of life (general, SF-36)

A similar logic was applied to non-predictors, for whom conclusions should be seen as more dependable at the top on the table (e.g. binge eating and perceived hunger are reliable non-predictors) and less dependable on the bottom (e.g. there is only preliminary/suggestive evidence that scores from the SF-36 quality of life questionnaire do not predict weight loss).

With the exception of suggestive results for initial weight (described before), we were unable to detect differential effects for each of the various predictors when contrasting VLCD vs. HBD/LCD programmes. This is not surprising considering the small number of predictors for which several studies were available for the different dietary interventions. More importantly, not a single study was identified that directly (i.e. within the same research design) compared the two/three types of dietary approaches regarding effects of pre-treatment variables, which further limits our conclusions. In any case, it should be considered that many VLCD studies also included a subsequent phase without VLCD. Thus, it is conceivable that a pre-treatment variable could influence outcomes by affecting adherence to the VLCD phase or alternatively by affecting compliance with the non-VLCD phase that frequently follows. Both would be reflected on long-term weight loss results.

Matching treatments to participants

The rationale for studying predictors of weight loss is as strong today as it was in the past, when the following statement, now almost 20 years old, was written: 'the search continues because the potential benefits of identifying reliable predictors are great. Such information could provide an index for prognosis of treatment so that clinical efforts could be targeted to those most likely to succeed. In the likely possibility that some treatments are more effective for certain subgroups of patients, predictor variables would permit a match between individuals and treatments' (p. 543) (1). Many authors have since expressed similar opinions (11,16,34,37,155–159). However, considering the large heterogeneity of individuals presenting for weight loss programmes and also the diversity of treatment modalities available it is perhaps the *interaction* (i.e. the effective match) between individual and treatment characteristics, an aspect largely ignored in the present obesity treatment literature, that holds the highest hope for critical answers to the problem of low success rates in obesity treatment. Certain individual profiles (biological, psychological, etc.) may show positive results only under particular types of treatment.

For example, Dennis & Goldberg showed that several self-efficacy profiles can be identified before and during treatment, and concluded that 'the distinct differences in the types of self-efficacy beliefs (. . .) indicates that it is not appropriate to place all obese women in the same kind of treatment and expect them to have similar outcomes' (p.114) (83). Rodin *et al*. observed that an interaction term between confidence to reach weight loss goals and programme type (medication plus cognitive-behavioural therapy) was a significant predictor of weight change both after treatment (20 weeks) and after a 6-month follow-up (160). Kiernan *et al*. showed that a particular programme type (diet and physical activity, as opposed to diet-only) combined with specific individual characteristics (better body image and no history of repeated weight loss) produced the best overall weight loss results (49). In another study, VLCD (as opposed to behavioural treatment only) was shown to be more effective in men than in women, and especially beneficial in persons living in households with fewer family members (159). Finally, Beliard and coworkers reported impressive treatment results (of 173 starting participants, 65% achieved moderate to high success after 30–70 weeks), using an intensive pre-treatment testing protocol, including individual interview and questionnaires, to match participants to one of three treatment modalities (individual counselling, group therapy, or a combined approach) (51). Although these and more recent findings (161) have direct relevance to the study of predictors of weight loss outcomes, few studies have been designed and conducted under this conceptual framework, and not all have showed matching to be a successful strategy (54).

A moderator of treatment is a particular type of predictor defined as a pre-treatment variable that interacts with treatment modality to produce significantly improved results (162,163)[3]. Analysing individual moderators of weight control is especially important when we consider the large and increasing number of treatment modalities available, which vary in caloric restriction, structure, type and level of support, philosophy and conceptual model and in several other ways (33). Low-carbohydrate diets (19), meal replacement plans (164), exercise-only (20) and non-dieting approaches (165) are available, as are self-help (166), Internet- (167) and doctor-delivered modalities (168,169), individual, psychologically intense programmes (170), short-term interventions (171), long-term care (172) and various combinations of the above [e.g. (173)]. It is likely that each of these approaches will be beneficial for some participants; knowing who will benefit from each approach is the challenge.

[3]Besides moderators of obesity treatment (correlated with outcomes only under specific treatments), other variables may predict weight loss for all individuals irrespective of treatment type. These have been named *non-specific pre-treatment predictors* (162). Since the large majority of the studies reviewed here did not analyse the interaction between predictors and treatments to produce weight loss, this distinction is not critical for this review; the term pre-treatment predictor was used generically to describe all variables analysed.

The problem of attrition

Lack of completion with treatment and/or follow-up measurements represents an important limitation in weight management trials. Generalizability of results is particularly sensitive to bias caused by analysing data only for participants who complete the study, a subgroup of all starting participants sometimes reaching only 40–50% of the initial sample (see Table 1). In studying baseline determinants of weight loss success, completer-only analyses are particularly inadequate as participants presenting with the most barriers to success (i.e. lower readiness) are also likely to drop out. Dropping out of treatment is often associated with lower weight loss, before participants drop out, compared with later completers (82,85,174). Hence, to the extent that predictors of weight loss and of attrition are similar, not using baseline data for non-completers can cause a substantial reduction in the variance, and predictive ability, of pre-treatment variables regarding weight loss, resulting in lower statistical power.

Procedures have been proposed to decrease drop-out rates, which is undoubtedly the best possible solution (175), and to account for missing data in statistical analyses [e.g. (176)]. The latter can be accomplished through various data imputation methods, such as baseline or last observation carried forward, multiple imputation methods, or using mixed effects models (which do not require data imputation). More information on this topic, which is beyond the scope of the present article, can be found elsewhere (177,178). At a minimum, the most common intent-to-treat model, where baseline (or last observation) values are used as final scores for missing subjects, should be used in predictor studies, in addition to reporting data for completers only.

Evaluating predictors of programme completion (vs. dropping out) is an alternative or complementary procedure (37,179–182). Dropping out of a study is often the worse case scenario for any given participant, who is unlikely to achieve substantial weight loss and who will not benefit from the exposure to the full treatment. Because attrition and smaller weight changes are related and because current statistical methods can include drop-outs' data in analyses and partially mitigate the impact of attrition, it is likely that some redundancy is present when comparing pre-treatment predictors of drop-out and predictors of weight loss (3,64). In addition, when the initial sample size is small (and/or drop-out rates are low) the reduced number of non-completers may render statistical comparisons between completers and non-completers underpowered and uninformative.

Conclusions and future research directions

Our major goal was to review the most recent studies on prospective predictors of weight loss, with the aim of improving the understanding of the impact of pre-treatment factors in weight control. After a thorough review of the available data, only a few variables emerged as significant pre-treatment predictors of subsequent weight management results in behavioural interventions. Conversely, sufficient evidence exists for a larger number of additional constructs, which do not appear to predict weight outcomes. For a majority of variables, however, published research data are not sufficient for a valid conclusion one way or the other. Thus, based on current evidence, it appears inappropriate to refuse treatment to overweight/obese candidates who so desire, if they are in good physical and psychological health, considering baseline information alone. As so few data are available analysing true moderators of success (i.e. patient–treatment interactions), no definitive conclusion can be drawn from this review regarding the future matching of subjects to treatments. This notwithstanding, some qualifications to the present findings should be highlighted, suggesting different interpretations of, and implications from the current evidence. We now address some of them.

First, predicting levels of success may be different than predicting individual weight lost. In other words, anticipating if a person, or a group presenting similar characteristics, will likely be among the most or, more critically, among the least successful participants by treatment's end may be easier to accomplish than estimating exactly how weight will change. In fact, some evidence suggests categories of success can be predicted from baseline data (17,49,53,64,131). This could also facilitate a simple matching of treatment to patients, where, for instance, treatment groups containing pre-defined numbers of the most *and* least likely to succeed would be set up to work together throughout the programme (or separately, if deemed more appropriate), instead of the common procedure of having randomly assigned intervention groups. Very recent studies have started to use similar approaches of manipulating *a priori* group formation, with promising results (183).

Second, broader definitions of success in weight management should be considered (184–186). By considering additional biological (e.g. body composition, cardio-respiratory fitness), behavioural (e.g. programme completion, meeting activity and dietary intake goals) and psychosocial outcomes (e.g. quality of life, self-worth, mental health), it is conceivable that models based on these bio-psycho-social profiles stand a better chance of statistical and clinical significance, than what has been achieved thus far.

Third, we have informally observed that many participants in weight reduction programmes, mostly female adults, seem to enjoy and/or benefit personally from the process of filling out questionnaires regarding their attitudes, perceptions and knowledge on issues such as body image, emotional eating, exercise, social connectedness,

among others. Subjects often mention increased awareness, motivation and improved understanding of personal factors critical to their obesity status (and potentially to treatment) upon filling out the psychometric battery. Taking participants' subjective views into greater account when making treatment decisions in obesity treatment (personal preferences, attitudes regarding the best course of treatment, specific goals and reasons to present for treatment, etc.) can be a worthy avenue of investigation. Pre-treatment psychosocial assessments could be used to prompt participants to reflect upon issues related to available treatment choices or decisions where their input would be used.

Fourth, although at this time elaborate evidence-based matching decisions regarding psychosocial profiles cannot be recommended, this does not mean some degree of individualization (or tailoring) cannot be incorporated immediately and tested against less individualized approaches. One example is the pre-treatment identification of individuals with the most unrealistic expectations for weight loss, who could benefit from a more directed intervention aimed at addressing weight and other goals, their origins and their implications for treatment (170). This particular cognitive restructuring protocol would not have to be used with participants with more realistic goals, for whom intervention resources could be used in different ways. The same logic could be applied for other characteristics that evidence suggests may be detrimental to long-term success, such as having many perceived exercise barriers, low levels of autonomy and self-motivation, an external locus of control and low self- and body-esteem. In practical terms, this would represent a middle way along the continuum from individual therapy (170) to the most common group, 'one-size-fits-all' approaches. Even if not wholly successful, some examples on how to improve the degree of individualization within formal obesity treatment programmes are available and can lead the way (51,53–55,156,187–189).

Fifth, we recommend the evaluation of pre-treatment assessments within predictive models that include pre-treatment *as well as* process factors, particularly events and variables assessed early in the programme (i.e. first 4–6 months, roughly corresponding to the extent of programmes' most intense phase or active weight loss period). Predictive models including baseline and process variables, such as early weight change, attendance, changes in exercise and eating attitudinal/behavioural measures, body image, among others, may predict long-term success or failure better than models with pre-treatment data only (18,71,190). If this proves correct, important implications could be derived in terms of resource allocation, intervention design (duration, focus, etc.), matching criteria and other decisions regarding long-term weight maintenance programmes, rather than having indefinite treatment as the only (partially) effective solution (172).

Sixth, although this review deliberately focused on psychosocial and other easily accessible variables, investigators should continue to explore less accessible prognostic markers of effective weight control (genetic, neuroendocrine, metabolic, environmental, etc.). This has been attempted before with some success (48,191) and it should proceed, in the hope that less-accessible variables become increasingly available to researchers, clinicians, dietitians and other professionals.

Next, a frequent criticism of research using psychological predictors of behaviour is the lack of a sound theoretical background (7). Theory-based formulations in behavioural weight loss research are clearly needed and are progressively being investigated and applied (59,192,193). However, the remarkable difficulty in producing a single theoretical representation predictive of an outcome as complex as human weight change over time must be recognized, and it should not stand in the way of continuing to pursue more exploratory research lines, if well-justified and methodologically sound (162,194). This is an area where *both* hypotheses-testing and hypotheses-generating studies are needed.

Eighth, most constructs are clearly understudied as predictors of weight loss, especially considering the large variability in methodologies among the studies that are available (e.g. psychometric instruments, treatment modalities). For about half of the predictors we identified, only one to four studies/predictive models are available in the literature (that we could identify, see Table 2), which is insufficient for a firm conclusion to be drawn.

Ninth, it is likely that many studies in this review were underpowered to detect significant correlations. In the behavioural sciences, effect sizes (in terms of $R^2 \times 100$ or % variance accounted) for *moderate* and *strong* associations can be set at 5% and 10%, respectively, the equivalent of correlation coefficients between 0.22 and 0.31 (194,195). Sample sizes required to detect these associations as significant ($\alpha = 0.05$ level, $1 - \beta = 0.8$) would be 160 and 79 subjects respectively. In Table 1, the majority of studies had a low level of power to detect significant *moderate* associations (r around 0.2), and many might not detect correlations around 0.3 as significant, attributed to sample size alone.

Tenth, the issue of appropriately using cumulative evidence to test the strength of association for single predictors, when a sufficient number of studies are available, should also be raised. As Allison pointed out (7), it may be that more research is *not* needed in some cases, but instead a more efficient way to analyse all the evidence available is required. Meta-analytical and related procedures may be able to detect significant associations between a predictor and an outcome, even when a majority of isolated studies show non-significant associations. For example, initial BMI, depression (e.g. with the BDI), eating behaviours (e.g.

with scales from the Eating Inventory) and binge eating (e.g. with the Binge Eating Scale) could now be explored in this fashion.

Lastly, in the reality of weight management programmes, the association between baseline psychosocial factors and weight loss success, particularly over longer periods of time, is probably moderated and mediated by a series of factors, most of which this review could not adequately address. It is apparent that more studies on the various predictor–treatment combinations are needed for a more accurate evaluation. Other potentially important treatment variables were not considered or not properly analysed, such as treatment group size, type of exercise recommendations, occurrence/characteristics of maintenance programmes, among others. Also, potential moderators such as gender, genetic/biological factors, family/work circumstances and other psychosocial factors were not reviewed here. Moreover, as the large majority of the studies reviewed used a 'bivariate model' to study predictors, it is likely that important interactions among predictors exist. For example, the effects of depression on success rates may be contingent on the presence of a binge eating pattern [or vice versa (135)], on attitudes/behaviours regarding physical activity [which improves depression (196)], or other factors such as external stressors or social support. Similarly, there is increasing evidence for interacting effects between body image, psychological distress and eating behaviours (121,197–199).

Summary of limitations and recommended research directions

The following points highlight some of the most salient limitations in the literature on predictors of weight management, and summarize possible lines of investigation to overcome them. Many have been alluded to in previous sections and are described henceforth in brief format.

Large heterogeneity in intervention programmes

More studies are needed with standardized behavioural approaches, which can be adequately compared relative to variables assessed at baseline.

Few studies available for a large number of constructs

More research is particularly recommended for: self-motivation and autonomy, body image and self-esteem, goals and expectations, general and weight-specific locus of control, social support, exercise, quality of life, and stress/anxiety.

Lack of studies evaluating the interaction between individual and programme characteristics

More such studies are encouraged, preferably using clearly distinct treatment modalities (e.g. individual vs. group; treatments with vs. without drugs/meal replacements; aggressive dieting vs. non-dieting, etc.), comprehensive psychosocial batteries, and studying the interaction among biological, psychological and behavioural individual variables.

Homogeneity of current research design paradigms

Studies where profile-based or more individualized interventions are tested against one-size-fits-all approaches are strongly encouraged. More qualitative research [e.g. (29)], an area not covered in this review, is also strongly supported as are retrospective investigations that analyse subjects' subjective perceptions and attitudes as potential moderators of success.

Too many instruments for similar constructs

Researchers are encouraged to use only the most psychometrically sound and previously used instruments. Guidelines are provided throughout this review and are also available elsewhere (140,200–203).

Lack of statistical power

Appropriate *a priori* power analyses are encouraged, considering the low-to-moderate effect sizes typically observed in the behavioural sciences. Some solutions include using imputation techniques for missing data, collapsing databases from different research centres (or from multiple comparable published studies) to maximize sample size, more adequate/powerful statistical procedures and decreasing attrition.

(The assumption of high need for) very large sample size and very long follow-up periods

The need for appropriate sample size and power are not contradictory with smaller-scale studies testing very specific variables in well-defined settings, innovative working hypotheses and alternative/creative research models. Fresh ideas are needed and many types of studies can be useful.

Too high attrition rates and completers-only analyses

New ideas are also needed to improve rates of completion, which are too small in many obesity treatment studies. At a minimum, strategies to ensure weight changes can be captured over time for non-compliers, even in less-than-ideal conditions that should be attempted (e.g. self-report by phone or email).

Too simple statistical analyses

Meta-analytical, multivariate and other more powerful/alternate statistical procedures (e.g. structural equations models, recursive partitioning techniques) are encouraged to complement more common techniques. Outcomes and change variables can also be explored and expressed in

alternative ways such as evaluating data in a disaggregated fashion (e.g. looking at subgroups based on multiple-point individual change vectors) rather than focusing exclusively on group mean outcomes (204).

Theoretical limitations

Theory-based and theory development work is particularly important and strongly encouraged, including psychosocial as well as physiological and other (genetic, environmental, socio-cultural) variables. Extensions of the Theory of Planned Behaviour and social ecological models are two areas that have been highlighted as particularly promising (194).

Lack of body composition data

Whenever possible, accounting for body composition, in addition to weight changes is recommended, if the analytical methods used are sensitive to intraindividual change.

Exclusive or excessive focus on weight as an outcome

Weight and other body habitus changes are only a part of the many health-related effects of weight management programmes. Outcome variables can also include quality of life, specific healthy behaviours, body image, self-esteem, social functioning and many other variables.

Weight loss and weight maintenance outcomes not differentiated

Predictive models should be time-specific, in recognition of the differences that exist between losing weight and keeping it off. Also, investigation into demographic and other types of treatment moderators (age, gender, socio-economic status, etc.) should be supported.

Multidisciplinary, international, cross-ethnicity and cross-cultural studies underrepresented

A wide gap in information exists regarding cultural, ethnic and cross-country differences in response to obesity treatment and factors that correlate with success. Also, studies that cross disciplinary fields (e.g. cognitive science and evolutionary psychology, anthropology, sociology, molecular and evolutionary biology) would be welcomed in obesity research.

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