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IDENTIFYING EARLY PREDICTORS OF SUCCESS AND VALID MEASURES OF EATING BEHAVIOR AND DIET SATISFACTION IN A PORTION-CONTROL WEIGHT LOSS TRIAL

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ABSTRACT

Controlling portion size has been shown to have a significant impact on energy intake in experimental work and on weight management in longer-term studies. However, there is little evidence directly comparing different portion-control strategies in the context of a behavioral weight loss trial. Identifying the factors that can have a long-term impact on weight management could have a beneficial role in improving long-term outcomes.

Study 1 focused on identifying early predictors of weight loss as a key part of developing personalized treatment to promote long-term success. Few individual factors/characteristics have been identified that predict weight loss during intervention, other than early weight loss itself. Women with overweight or obesity (n=186, mean±SD age 50.0±10.6 y, BMI 34.0±4.2 kg/m^2) participated in a one-year randomized controlled trial examining the effect of portion-control strategies on weight loss. Repeated assessment allowed evaluation of early change in eating behaviors and psychological factors in the first month of intervention as predictors of weight-loss trajectory from baseline to Month 3 and Month 12. Across all participants, greater increases in dietary restraint and healthy lifestyle ratings after one month predicted more rapid weight loss from baseline to Month 3. Greater increases in restraint and healthy lifestyle ratings also predicted more rapid weight loss and slower regain from baseline to Month 12. Restraint remained a significant predictor after controlling for early weight loss. Initial improvement in psychological and behavioral measures predicted 3-month and 12-month weight loss. For individuals with less improvement, early additional support or tailored treatment could promote long-term success.

Study 2 honed in on eating behavior measurement, an area that is often associated with weight loss. Using data from the same one-year weight loss trial, the Three-Factor Eating Questionnaire (TFEQ), a valid 51-item measure of restraint, disinhibition, and hunger subscales, was compared to the newer 16-item Weight-Related Eating Questionnaire (WREQ), which measures routine and compensatory restraint and external and emotional eating. In the trial, both questionnaires were administered five times to 186 women (mean±SEM, age 50±0.35 y, BMI 34±0.14 kg/m^2). Confirmatory factor analysis was conducted on baseline WREQ data and correlations were calculated between TFEQ and WREQ subscales. Multilevel models evaluated the relationship between each subscale and weight change over time. Factor analysis revealed a WREQ structure consistent with previous research, and corresponding subscales on the TFEQ and WREQ were correlated. Lower baseline TFEQ restraint predicted greater weight loss. Across five administrations, TFEQ and WREQ restraint scores were positively related to weight loss ($p<0.01$) and TFEQ disinhibition and WREQ external and emotional eating scores were negatively related ($p<0.001$). Thus, with one baseline administration, only TFEQ restraint was significantly related to weight change, but multiple administrations showed relationships between all TFEQ and WREQ subscales and weight change. The WREQ offers a shorter alternative to the TFEQ when repeatedly assessing eating behaviors related to weight change.

Study 3 focused on validating a new tool for measuring diet satisfaction. Satisfaction with the prescribed diet likely affects adherence to weight loss treatment, one of the strongest correlates of weight outcomes. However, currently there are no validated measures to directly assess diet satisfaction. The 45-item, seven-scale Diet Satisfaction Questionnaire (DSat-45) was developed in previous work to fill this need and was further examined for potential refinement in this study. It measures seven scales identified from the literature that likely affect satisfaction

with the current diet: Healthy Lifestyle, Convenience, Cost, Family Dynamics, Preoccupation with Food, Negative Aspects, and Planning & Preparation. It was administered five times during the same one-year weight loss trial and one time as part of an online survey in a separate sample (n=510 women and men). Questionnaire structure was determined using confirmatory factor analysis, and reliability and internal consistency estimates were compared for the two samples. Associations between DSat-45 scales and weight loss over one year were examined. The Healthy Lifestyle, Preoccupation with Food, and Planning & Preparation scales were associated with weight loss across time, as was Total Diet Satisfaction ($p<0.05$). Confirmatory factor analysis revealed a five-scale structure provided a better fit, and this revised, 28-item questionnaire showed strong internal consistency (α range 0.73-0.91) and reliability in both samples. The new DSat-28 retained the Healthy Lifestyle, Cost, Preoccupation with Food, and Planning & Preparation scales as they were and shortened the Convenience scale to the restaurant-specific items, renamed "Eating Out". The DSat-28 is a reliable, valid questionnaire of diet satisfaction that can consistently identify correlates of weight loss. The revised five-scale structure should be used in future work.

These studies combine to offer guidance for future work in identifying predictors of weight loss success and for measuring key factors before, during, and after treatment that impact that success.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

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CHAPTER 1
INTRODUCTION

Trends in rates of overweight/obesity and portion size

The majority of adults in the United States have either overweight or obesity (1), making the study of weight loss and weight loss maintenance paramount to improving overall population health. Rates of overweight and obesity have increased substantially over the last few decades as a result of a complex set of behavioral, environmental, and biological influences. Determining which of these factors have the largest impact, particularly of those that can be changed, could have large-scale beneficial effects. The portion sizes of food and beverages offer one potential target for change. Portion sizes have increased in parallel with rates of overweight and obesity over the last few decades (2), but it is unclear if portion size is actually causing weight gain over time. Determining the impact of increasing portion size on weight management is key to understanding the extent to which portion size is driving increases in weight, and subsequently the potential effectiveness of targeting portion size change.

The connection between portion size and weight change stems both from observational reports and from short-term controlled studies evaluating the impact of increasing portion size on energy intake. Observationally, a study by Young and Nestle (2002) (2) examining portion sizes of commonly available foods such as cookies, pizza, and hamburgers compared to historical offerings found that overall portion sizes began to increase in the 1970s followed by a steep increase in the 1980s and a then continued growth that paralleled rates of overweight and obesity in the decades since. The vast majority of specific foods they assessed were substantially larger than historical portions, and most exceeded the portions recommended by federal guidelines.

The portion size effect in controlled feeding studies

In controlled feeding studies, increasing portion size has consistently been shown to increase energy intake. Most of these studies are short term, but they show a clear link in how individuals respond on average to the availability of larger portion sizes. Rolls and colleagues (2002) determined that varying the portion size of the entrée served at a lunch meal over four experimental days resulted in a 30% increase in energy intake when served the largest compared to the smallest portion (3). This effect was

true for both men and women and remained regardless of whether the portion was pre-served or the served by the participant. In determining if this effect persists over multiple, consecutive meals, another study evaluated the effect of increasing portion size for all meals over two days. For two consecutive days on three separate testing occasions, participants were fed all meals in a controlled setting at a 100%, 150%, or 200% portion size conditions. Results showed a consistent increase in energy intake in both men and women in response to an increase in portion size, with an average energy increase of 16% in the 150% condition and 26% in the 200% condition, well exceeding their energy needs (4). In a longer-term study, participants were given all meals over two separate 11-day periods, one with 100% portion sizes of all items and the other with 150% portion sizes. Both men and women showed a significant increase in energy intake in the larger portion condition compared to the smaller, and this increase was sustained over 11 days with no trend toward convergence. For women, this difference resulted in > 5000 kcal increase in energy intake between conditions and > 4600 kcal increase in men over 11 days (5).

As a result of these and other findings, policy makers have recognized the link between portion size and weight management and have issued guidance on healthy eating in relation to portion control. The 2010 Dietary Guidelines for Americans recommended that individuals balance calories by "enjoying your food, but eating less" and to "avoid oversized portions" (6). Updated recommendations in the 2015 Dietary Guidelines for Americans (7) recommend focusing on "variety, nutrient density, and amount…within calorie limits" when selecting foods, taking into account both the nutrient and energy density of foods selected in the context of "appropriate amounts" or portion size.

Portion control in weight loss treatment

The observational and short-term controlled feeding studies detailed above provide compelling evidence for a role of portion size in driving energy intake. However, the long-term ability of portion control to reduce energy intake and thereby aid in weight loss is less clear. To determine the impact of portion control on weight loss, researchers have developed longer-term weight management programs centered on controlling portion size through a variety of means. Strategies for doing so include the use of

liquid meal replacements, pre-portioned solid foods, or portion size tools such as measuring cups and food scales.

Multiple studies have incorporated the use of liquid meal replacements as a means of managing energy intake. For instance, the large-scale Look AHEAD trial found that the use of meal replacements in the context of intensive lifestyle intervention over the first year was associated with greater weight loss outcomes (8) and improved overall diet quality (9). The use of liquid meal replacements has also been shown to be an effective tool in weight loss maintenance when combined with physical activity and self-monitoring (10). Therefore, liquid meal replacements have been established as an effective and easily implemented strategy for controlling energy intake. However, the controlled trials evaluating liquid meal replacements often do not compare them to the use of solid pre-portioned foods, limiting the ability to compare the benefit they each confer. It is also often difficult to determine the unique influence of meal replacement use itself, as it is often only one component of a larger behavior change program. Furthermore, the long-term sustainability of this strategy and the potential for the development of feelings of deprivation during use, or risk of weight regain once the strategy is abandoned, is unknown (10).

The utility of incorporating pre-portioned foods has also been tested in the context of weight loss trials (Table 1.1). The structure provided by incorporating pre-portioned ready to eat meals or other structured meal plans seems to aid many individuals in losing weight. Hannum and colleagues conducted two separate trials, one in women (11), one in men (12), both eight weeks in duration, evaluating the specific efficacy of using portion-controlled entrées in weight loss. Participants were instructed to meet the same calorie and macronutrient distribution goals by either self-selecting their diet or using pre-portioned foods. The pre-portioned foods group in both studies achieved greater weight loss at eight weeks than the self-selected diet, lending evidence to the effectiveness of using portioned controlled foods, albeit for a short time period. In a recent study, pre-portioned lunch and dinner entrées were provided to participants as part of a three-month weight loss intervention. Participants either self-selected their diet (control group) or received commercially available pre-portioned entrées with either moderate

or high levels of protein. Weight loss at 12 weeks was significantly greater for those consuming pre-portioned entrées compared to the control group, but it did not differ significantly between the low and high-protein conditions (13).

In a longer-term randomized controlled trial, participants were randomized to one of four groups: standard behavioral treatment, standard treatment with meal plans and grocery lists, standard treatment with meal plans and cost-sharing food provision, or standard treatment with meal plans and free food provision. At six months and one year the three latter groups had lost significantly more weight than the treatment alone group, and they did not differ from one another, suggesting that the structure provided by meal plans, grocery lists, or food provision is likely driving the effect (14). The type of structure provided by pre-portioned foods and meal plans may be necessary for some individuals, especially when initiating behavior change and jump-starting weight loss. These studies and others show consistent effectiveness for using solid pre-portioned food in weight loss (15-21).

Additional evidence adds nuance to the portion control message. Instead of the consistent message of eating less of all foods, if the energy density (kilocalories per gram) of the specific foods is taken into account, it is possible to eat larger portions of specific, lower energy dense foods and smaller of higher energy dense foods without reducing overall volume eaten. The overall amount of food could stay consistent while the energy intake is substantially reduced. Maintaining a consistent volume of food eaten could aid in preventing feelings of deprivation or hunger that are often associated with trying to lose weight, while also helping to achieve a calorie deficit. Previous research has shown that altering the energy density of a food has a significant impact on energy intake and that when portion size and energy density are both altered, they have independent, significant effects on intake and weight loss (22-26). For example, in one lunchtime study, participants were fed six different conditions of a single entrée served at one of two energy density levels and one of three portion sizes. Both portion size and energy density had independent effects on intake, with individuals consuming more energy in the large portion size and highest energy density conditions, resulting in a 56% increase in energy intake when served the largest

portion, high energy density condition compared to the smallest portion size, low energy density condition (27). In a longer-term weight loss trial, those individuals whose dietary energy density decreased most in response to treatment lost the most weight (28). Therefore, if this behavior change can be sustained over time, targeting energy density in conjunction with portion size could have a substantial impact on lowering energy intake when trying to lose weight.

One additional, common method for controlling portion size is to use portion tools such as measuring cups, food scales, or plate guides to educate individuals about appropriate portion sizes (29-32) (Table 1.2). In the context of weight loss treatment, one recent 18-month in individuals with obesity found that the provision of a portion-controlled meals combined with fruits and vegetables during the first six months resulted in greater weight loss and weight loss maintenance so that those receiving portion-controlled foods had lost 15% at month 6 and 9% at month 18 (33). Government health organizations also often provide portion tools such as measurement guides and education on how to use measuring cups and scales. However, there is little consistency in recommendations or in types of tools used. A recent position paper called for the standardization of portion control tools used as well as consistency in metrics so that consumer education can proceed in a more systematic manner (34).

To aid the goal of having more consistent recommendations, it is important to understand which portion control strategies are most effective and how they can best be implemented and sustained. The majority of weight management trials to date have only used one portion control strategy, and even though it may be effective, its utility cannot be directly compared to other types of tools or strategies. Research is needed directly comparing effective portion-control strategies to one another to develop the best methods for helping individuals achieve and maintain and healthy weight.

The Portion-Control Strategies Trial—Design

The Portion-Control Strategies Trial (34) was a randomized controlled trial evaluating the impact of usual care and two different portion control strategies on weight loss over one year. Participants were randomly assigned to one of the three groups: a Standard Advice (usual care) group, a Pre-portioned

Foods group, or a Portion Selection group. The Standard Advice group received education based on the 2010 Dietary Guidelines that focused on making healthy selections from all food groups. The Pre-portioned Foods group received meal vouchers for commercially available pre-portioned meals and were taught to use these meals and other already portioned foods (e.g., yogurt, individual fruits) to manage intake. Vouchers were given at a rate of 14/week for the first month then gradually decreased to 4/month in months 3-12 in an effort to transition participants to a self-sustaining behavior pattern. The Portion Selection group was educated about energy density as a means of strategically increasing portions of healthier, low-energy-dense foods and reducing portions of high-density foods. They were also given a food scale and other portion control tools such as placemats showing appropriate plate proportions for creating healthy meals. All participants received similar instruction on increasing physical activity, keeping records for self-monitoring, and managing behavior change. There was not a specific calorie goal for any of the groups.

All participants received equal face time consisting of 19 1-on-1 educational visits with a trained interventionist and five assessment visits, where they returned self-monitoring forms assessing step counts and hunger/satiety, completed computer-based questionnaires, and had blood drawn (full questionnaires in Appendices A-G). Body weight measurements were taken at all education and assessment visits. Visits occurred weekly during Month 1, biweekly during Months 2-6, and monthly during Months 7-12.

It was hypothesized that both groups incorporating portion size education would have better weight loss outcomes than the Standard Advice group, and that the Portion Selection group, with its added emphasis on energy density, would have the largest weight losses at the end of one year.

The Portion-Control Strategies Trial—Main Outcomes

Participants were 186 women with overweight or obesity (mean±SD age 50.0±10.6. y, BMI 34.0±4.2 kg/m^2) recruited from the State College, PA area. Table 1.1 details their baseline characteristics broken down by group. On average, participants in all three groups lost weight and maintained that

weight loss throughout the full year of the trial. Weight loss trajectories were modeled using a random coefficients model with maximum likelihood to handle missing data. Data were modeled for all randomized participants regardless of number of visits attended in an intention-to-treat analysis.

Weight loss trajectories diverged between groups in the initial months of the trial. Figure 1.1 illustrates how the Pre-portioned Foods group lost weight at a significantly faster rate than the Standard Advice group during Months 1-4 and greater than the Portion Selection group during Months 2-3. However, average weight loss amounts did not differ significantly between groups at Month 6 (mean±SD 5.2±0.4 kg) or Month 12 (4.5±0.5 kg). Weight was measured for 81% (n = 151) of participants at Month 12. At Month 12, 45% of participants had achieved a clinically significant weight loss of ≥5%. On average, participants also saw improvements in multiple cardiometabolic risk factors. Diastolic blood pressure, waist circumference, fasting glucose and insulin, total cholesterol, triglycerides, and insulin resistance all decreased in the first three months, and HDL cholesterol increased across the year. Table 1.2 details these outcomes. There were no between-group differences in these outcomes. The follow three chapters detail secondary analyses conducted on data from this one-year trial.

Early predictors of weight loss success

In addition to identifying the strategies that are most effective for countering environmental contributions to overweight, such as portion size, it is important to understand what factors at the individual level drive differences in weight loss to the specific strategies or treatments. Identifying individual characteristics early in treatment, or even before treatment begins, that can predict weight outcomes offers the potential to tailor programs from the start or intervene early to increase probability of success.

Extensive research has focused on developing effective weight loss treatments, but weight loss outcomes still vary substantially between individuals. No single intervention will ever work well for everyone, so in developing successful interventions, it is important to understand what individual differences predict how successful a certain treatment will be. Identifying these differences early on in

treatment could allow for additional support and tailored intervention to be provided for individuals who initially do not respond well, and this support could potentially benefit longer-term weight outcomes. Unfortunately, interventions are not always designed to evaluate early individual differences. Many factors are only assessed at baseline or at baseline and post-intervention, limiting the ability to look at the type of early change that might drive weight loss. Intervention itself is expected to change behavior and attitudes, so repeat assessment is important for understanding if these changes are occurring and how they impact weight loss.

The evidence identifying early predictors of later weight outcomes is limited. However, a few predictors are consistently found. For instance, early weight loss has been shown to be a consistent predictor of later weight loss. Longitudinal data demonstrate that weight loss in the first two months of a behavioral intervention predicts clinically significant weight loss up to eight years later with those individuals who lost at least 2% of their body weight in the initial two months achieving a weight loss maintenance of >5% body weight at the later time point (36). Multiple shorter-term studies and reviews summarizing the literature have found similar effects, showing that larger initial weight loss predicted greater long-term weight loss (37-39). Little is known, however, about what predicts this early weight loss.

Higher initial weight or BMI have been shown to result in greater absolute weight loss, though it is less clear if this also equals a greater percent weight loss overall compared to individuals at a lower initial BMI. Short-term studies of two or three months often find associations between initial weight or BMI and post-intervention weight, with individuals who have higher BMI losing more weight overall (40), but this may be an effect of the short duration and fairly linear weight change in that period of time. Studies of longer duration often find a weaker connection between initial weight status and overall weight outcomes, perhaps reflecting a greater tendency in individuals with higher initial BMI to experience slower weight loss or weight regain toward the end of treatment (41).

Outside of weight loss itself, certain psychological and behavioral factors are associated with weight loss during intervention (42). Self-efficacy has been found to predict successful weight loss. For instance, in a four-month weight loss intervention program, researchers found baseline levels of self-efficacy—or the belief that lifestyle changes are feasible and maintainable—predicted weight loss at study end (43). Although it is not often measured early in treatment, both diet and physical activity self-efficacy have been shown to predict subsequent weight loss, with the majority of change in self-efficacy occurring in the first three months of treatment (44). It is rarely assessed earlier in treatment, however. Thus, it could be an area where adding assessments could show predictive ability at an even earlier time point.

Dietary restraint, or the restriction of caloric intake as a means of controlling weight, and disinhibition, or the tendency to overeat in response to environmental or emotional cues, both appear to be more important as process factors, with the magnitude of change in these factors during treatment affecting both weight loss and weight regain. Both restraint and disinhibition have a large body of literature examining their relationship with weight loss. Higher restraint has been associated both with greater weight loss (45) and with weight gain (46,47), demonstrating both a beneficial and a detrimental effect, perhaps depending on the individual or the overall magnitude of restraint. These mixed results have led researchers to divide restraint into subscales that distinguish between different types of restrictive behaviors (48). Relationships found between disinhibition and weight loss are more consistent, with higher disinhibition relating to poorer weight loss outcomes (49-51). These relationships are most often found with baseline or post-intervention levels of these constructs. Repeat assessment rarely occurs at time points earlier than six months. Therefore, little can be said about how they change early in intervention. More frequent assessment may allow for the time course of behavior change to be quantified and its effect on weight loss to be better understood.

Mixed findings have been reported in other areas. Locus of control, for instance, which measures how much control an individual believes they have over their circumstances, specifically whether those

circumstances are determined by internal reasoning and motivation under their control or by external factors such as the environment or other people. Internal locus of control has been found to associate with better weight outcomes, though the findings are mixed. In one short-term study, individuals with high internal locus of control were less likely to say their obesity was caused by medical issues, which reflects the belief they have greater control over health change, and that belief was related to greater weight loss after an 8-week program (52). But in another 10-week weight loss program no difference in weight loss was found between individuals with an internal versus external locus of control (53). Longer-term weight loss studies have also shown mixed findings with locus of control (42).

Additional factors such as diet satisfaction have rarely been assessed due to lack of validated measures, but they theoretically have a substantial impact on the adoption and maintenance of behavior change and subsequently on weight loss.

It is rare to have repeat questionnaire administration before a mid-point such as six months or the end of treatment, which limits the ability to determine how these constructs might change early on in response to treatment. Repeat assessment early in a trial allows these changes to be quantified and mapped onto weight change, providing insight into what factors make an individual more or less likely to achieve weight loss.

Measurement of individual differences during obesity treatment

Recent initiatives are focused on gathering data and opinions on the most accurate and useful measures for evaluating key factors influencing weight change (ADOPT Core Measures Project). The impetus for this initiative stems from leaders recognizing a "critical need to better understand the sources of [weight loss] variability and identify models integrating behavioral, psychosocial, environmental, and biological predictors and moderators of treatment responses. Such models could provide the basis for tailoring treatments to optimize initial weight loss and sustain the weight reduced state."

For some constructs, such as eating behaviors, well-validated measures are in place such as the Three-Factor Eating Questionnaire, (TFEQ) (54), which measures dietary restraint, disinhibition, and

susceptibility to hunger and has been extensively used in weight loss trials and other research. However, these historical scales are rarely without their shortcomings. The TFEQ, in particular is burdened by its length and by inconsistencies in findings since its development about how its scales should be divided (55-57). In clinical settings where weight loss is the goal and these types of measures are not the primary outcome of interest, it may not always be feasible to administer a long questionnaire. More concise, alternate measures are needed to reduce patient burden if a quick overview instead of an intensive evaluation is the goal.

As mentioned previously, there are also areas that likely have a big impact on weight management but for which there are no validated measures. Developing and disseminating measures for factors such as diet satisfaction and other individual-level factors impacting weight management will continue to build the evidence base in determining drivers of weight change.

Administering these questionnaires in the context of a weight loss trial, especially when they are administered repeatedly, will allow researchers to home in on the particular constructs that have the greatest impact. That in conjunction with understanding how we can respond to and alter environmental influences that impact weight, such as portion size, will allow for a comprehensive view of weight management that leads to increasingly effective weight loss treatments.

Specific Aims and Hypotheses

Specific Aim 1: To identify early predictors of weight change in a weight loss program. Specifically, using questionnaires and anthropometric measurements collected at baseline, one month, and three months to predict early weight change as well as longer-term weight change across 12 months. Analyses will focus first on those constructs that have shown predictive ability in previous research such as restraint, disinhibition, and locus of control.

It is hypothesized that certain constructs previously shown in the literature to have predictive value when measured at later time points, such as six months into a weight loss program, will show predictive ability from earlier time points as well. Specifically, the levels of these constructs at one and three months—and potentially their magnitude of change from baseline, as well—will help predict the amount of weight loss and weight loss maintenance at the later time points.

Specific Aim 2: To assess the factor structure and predictive ability of the four-factor Weight-Related Eating Questionnaire (WREQ) in a sample of 186 overweight and obese middle-aged women enrolled in a weight loss trial. In particular, the WREQ will be compared to the well-validated Three-Factor Eating Questionnaire (TFEQ) to aid in determining its validity.

It is hypothesized that the WREQ will show acceptable confirmatory fit indices due to the small number of items in each factor. This may also limit the predictive ability of those factors on outcomes such as weight change.

Specific Aim 3: To assess the psychometric properties of a measure developed by our lab, the 45-item Diet Satisfaction Questionnaire (DSat-45). This questionnaire is currently in use. However, there is not currently a publication detailing its reliability and validity. The goal of these analyses is to identify factor structure as well as removing any poor items that fail to significantly load on any factor. These analyses

will include data collected in this weight loss trial, as well as potentially including data previously collected on this questionnaire.

It is hypothesized that the DSat-45 will produce a seven-factor structure identifying the following diet satisfaction constructs: healthy lifestyle, convenience, cost, family dynamics, preoccupation with food, negative aspects, and meal planning and preparation.

Table 1.1: Portion size and weight management— solid pre-portioned foods

Author(s)	Sample	Design	Results
Rock, et al., Obesity, 2016	N = 183 Men and women	12-week RCT—provision of portion-controlled lunch and dinner entrees (normal or high-protein compared to control) as part of behavioral weight loss program	Normal and high protein intervention groups lost more weight and body fat than control. Intervention groups did not differ
Metz, et al., Arch Intern Med, 2000	N = 302 Men and women	1-year—in participants with hypertension, nutrient-fortified food provision compared to usual care with equal calorie and macronutrient content	Food provision resulted in significantly better weight loss over one year
Wing, et al., Obes Res, 2001		18-month RCT—provision of proportioned breakfast/dinner compared to standard behavioral therapy, SBT with financial incentive, or food provision with financial incentive	Both food provision groups showed better weight loss than SBT alone or SBT+financial incentives
Hannum, et al., Obes Res, 2004	N = 60 women with overweight or obesity	8-week study; randomized to portion control using 2 frozen entrees/day or self-selected diet. Both with recommended food servings from food guide pyramid	Portion control group lost more weight and fat mass and had greater reductions in total cholesterol and insulin than the self-selected group
Hannum, et al., Diabetes Obes Metab, 2006	N = 60 men with overweight or obesity	8-week study; randomized to portion control using 2 frozen entrees/day or self-selected diet. Both with recommended food servings from food guide pyramid	Portion control group decreased more in weight, BMI, fat mass, waist circumference, and diastolic blood pressure than self-selected group
Raynor, et al., J Am Diet Assoc, 2009	N = 19 adults with obesity	8-week provision of foods as proportioned or nonportioned packages to eat at breakfast	Single-serving packages reduced energy intake of those foods compared to nonportioned versions of the same foods
Foster, et al., Nutr Diabetes, 2013	N = 100 with obesity and T2DM	6-month, 9-session group treatment including either a portion-controlled diet or a diabetes self-management education program EI goal: 1250-1500kcal Activity goal: 200min/week	Both groups lost weight and improved HbA1c levels at 6 months. Those receiving portion control lost 3x more than other group
Mattes, et al., Am Coll Nutr, 2002		6-week intervention; 4 groups: single cereal 2x/day for 2 weeks then Volumetrics diet for weeks 3-6; choice of cereal 2x/day for 2 weeks then Volumetrics diet for	Both cereal groups and the Volumetrics without cereal groups lost weight and did not differ from one another. Weight loss continued for

		weeks 3-6; no instruction for weeks 1-2 then Volumetrics diet for weeks 3-6; or no dietary instruction for the full 6 weeks	weeks 3-6. All three groups lost more weight than the no-instruction group.
Rock, et al., JAMA, 2010	N = 442 women with overweight or obesity	2-year weight loss counseling program either via telephone or in-person with the goals of reducing EI, increased physical activity, and the inclusion of prepackaged food items in a planned menu during the initial weight loss phase	In person and telephone groups lost weight over 2 years and did not differ from one another. Both did better than a usual care control group
Levitsky, et al., Appetite, 2011	N = 17	All foods consumed in research lab M-F for 5 weeks; Week 1: all ate from a buffet Weeks 2-3: half chose from pre-portioned meal options for lunch Weeks 4-5: other half chose from pre-portioned meal options for lunch	Pre-portioned lunches resulted in a 250kcal/day reduction in EI. Participants lost weight on average due to a lack of compensation for this decrease
Wing RR, et al., Int J Obes Relat Metab Disord, 1996	N = 163 Women with overweight	Randomized to 1 of 4 conditions for 6 months: SBT; SBT + structured meal plans & grocery lists; SBT + meal plan + food provision w/ participants paying some; SBT + free food provision	Subjects in group 1 lost more weight than the other 3 groups, suggesting it is the meal plans and grocery lists that provide the structure necessary for success more than the food provision itself

Table 1.2: Portion size and weight management—portion control tools

Author(s)	**Sample**	**Design**	**Results**
Almiron-Roig, et al., Br J Nutr, 2016	N = 29 Adults with obesity	2-week use of portion control tools in the context of a 12-week community weight loss program. Tools were a guided crockery set or calibrated serving spoon set.	Ratings of acceptance, ease of use, and perceived effectiveness were equal for both tools. On most days, 55% used crockery, 21% used spoons. Reported self-served portion sizes increased for vegetables and decreased for chips and potatoes.
Byrd-Bredbenner, Schwartz, J Hum Nutr Diet, 2004	N = 113 Young adults	Participants randomized to use either 2-D or 3-D portion size measurement aids to estimate portion sizes of 3 food sets (36 foods). No aids were used for set 1, then aids were used for set 2, then none for set 3.	Estimation accuracy improved significantly after short-term exposure to portion size measurement aids, both when the aids were available (food set 2) and afterward (food set 3), though they were only ~60% accurate on average
Pederson, Kang, Kline, Arch Intern Med, 2007	N = 130 Adults with obesity and T2DM	Randomized to either use commercially available portion control plate or to receive usual care (control) for 6 months	Intervention participants lost more weight and used fewer T2DM medications at 6 months than control group. Median compliance for tool use was 70.8%
Kesman, et al., BMC Res Notes, 2011	N = 65 Adults with obesity	Randomized to counseling with a dietitian (BL, 1, 3, & 5 months) and use of a portion control plate or usual care (control) for 6 months	Intervention participants lost more weight at 6 months, but retention was only 65% and amount of face-to-face contact was not equivalent

Table 1.3: Portion size and energy density for weight management

Author(s)	**Sample**	**Design**	**Results**
Ello-Martin, et al., Am J Clin Nutr, 2007	N = 98 Women with obesity	1-year weight loss trial. Participants randomized to either reduce fat intake or to increase intake of water-rich foods, particularly fruits and vegetables	Weight decreased for both groups. Those instructed to increase water-rich food also decrease comparable amounts of dietary fat but decreased energy density of diet by eating more volume. They also reported lower hunger levels.
Rolls, et al., Obes Res, 2005	N = 200 Adults with overweight or obesity	1-year weight loss trial. 4 groups: 1 serving low-ED soup, 2 servings low-ED soup, 2 servings high-ED snacks, or no special food (control) for 1 year	All 4 groups lost weight and maintained through 12 months. Weight loss in the 2 soup and control groups were greater than the snack group. Weight loss was correlated with decreasing dietary energy density
Ledikwe, et al., Am J Clin Nutr, 2007	N = 658 Adults with prehypertension or hypertension	Randomly assigned to 18-session established (behaviors to reduce hypertension), established+DASH, or advice group (control) Not matched for face time.	All groups lost weight and reduced dietary energy density. The intervention groups lost more than the control group. Those who reduced ED most lost more weight

Table 1.4: Early predictors of weight loss

Author(s)	Sample	Design	Results
Teixeira, et al., Obes Rev, 2005	Review paper	Identify consistent patterns of prediction in pre-treatment variables to improve weight loss treatment outcomes (1995-2005)	Best predictors are having few previous weight loss attempts and being self-motivated. Baseline or pre-treatment levels of binge eating, disinhibition, restraint, and depression do not predict outcomes. Evidence is mixed or too small to be conclusive for self-efficacy, body image, self-esteem, and quality of life.
Unick, et al. Obesity, 2015	N = 2,290 Look AHEAD participants with T2DM	Evaluate predictors of weight loss for participants receiving the intensive behavioral weight loss component of the Look AHEAD intervention	Those who had lost >2% body weight at month 1 and more than >3% at month 2 were more likely to have maintained ≥5% at the 8-year follow up. Losing >6% at month 2 conveyed the largest benefit for long-term weight loss maintenance.
Miller, et al., J Acad Nutr Diet, 2015	N = 32 Adults with prediabetes	16-week worksite intervention; group-based; adapted from the DPP; weighed weekly during intervention and at 4 and 7 months	Percent weight loss at week 5 predicted weight loss at 4 and 7 months, with being over or under a weight loss threshold of 2.5% in the first month predicting ≥5% maintenance at 4 and 7 months
Nackers, et al., Int J Behav Med, 2010	N = 262 Women with obesity from the TOURS trial	6-month lifestyle intervention followed by 1-year extended care Categorized as “fast”, “moderate”, or “slow” depending on weight loss speed during first month of treatment	The fast group had lost more weight at 6 months than the moderate or slow groups and more than the slow group at 18 months; the fast group was 5x more likely to achieve 10% weight loss at 18 months than the slow group
Elfhag, Rossner, Patient Educ Couns, 2010	N = 247 Adults with obesity	Predicting weight loss during 3 weight loss phases: after screening but pre-treatment, during 5-week treatment, after treatment (2 semesters)	Pre-treatment weight loss predicted during treatment loss; history of a larger number of successful weight loss attempts predicted treatment losses
Carels, et al., Eat Behav, 2003	N = 44 Women with obesity	24-session weight loss intervention Goal: identify baseline and treatment predictors of poor	Higher baseline BMI, higher fat intake, lower CHO intake, poor body image, and greater expectations of success were associated with poorer

		weight outcomes	outcomes. Poorer attendance, early weight loss, weight-related quality of life, and self-control were also associated with poorer outcomes

References

1. Flegal KM, Kruszon-Moran D, Carroll MD, Fryar CD, Ogden CL. Trends in obesity among adults in the United States, 2005 to 2014. *JAMA*. 2016;21:2284-2291.
2. Young LR, Nestle M. The contribution of expanding portion sizes to the US obesity epidemic. *Am J Public Health*. 2002;92:246-249.
3. Rolls BJ, Morris EL, Roe LS. Portion size of food affects energy intake in normal-weight and overweight men and women. *Am J Clin Nutr*. 2007;76:1207-1213.
4. Rolls BJ, Roe LS, Meengs JS. Larger portion sizes lead to sustained increase in energy intake over two days. *J Am Diet Assoc*. 2006;106:543-549.
5. Rolls BJ, Roe LS, Meengs JS. The effect of increased portion size on energy intake is sustained for 11 days. *Obes Res*. 2005;13:A36.
6. U.S. Department of Agriculture and U.S. Department of Health and Human Services. Dietary Guidelines for Americans, 2010. 7th ed. Washington, DC: U.S. Government Printing Office, 2010.
7. U.S. Department of Agriculture and U.S. Department of Health and Human Services. 2015-2020 Dietary Guidelines for Americans. 8th ed. Washington, DC: U.S. Government Printing Office, 2015.
8. Wadden TA, West DS, Neiberg RH, Wing RR, Ryan DH, Johnson KC, et al. One-year weight losses in the Look AHEAD study: factors associated with success. *Obesity (Silver Spring)*. 2009;17:713-722.
9. Raynor HA, Anderson AM, Miller GD, Reeves R, Delahanty LM, Vitolins MZ, et al. Partial Meal Replacement Plan and Quality of the Diet at 1 Year: Action for Health in Diabetes (Look AHEAD) Trial. *J Acad Nutr Diet*. 2015;115:731-742.
10. Ames GE, Patel RH, McMullen JS, Thomas CS, Crook JE, Lynch SA. Improving maintenance of lost weight following a commercial liquid meal replacement program: a preliminary study. *Eat Behav*. 2014;15:95-98.
11. Hannum SM, Carson L, Evans EM, Canene KA, Petr EL, Bui L *et al.* Use of portion-controlled entrees enhances weight loss in women. *Obes Res*. 2004;12:538-546.
12. Hannum SM, Carson LA, Evans EM, Petr EL, Wharton CM, Bui L *et al.* Use of packaged entrees as part of a weight-loss diet in overweight men: an 8-week randomized clinical trial. *Diabetes Obes Metab*. 2006;8:146-155.
13. Rock CL, Flatt SW, Pakiz B, Barkai HS, Heath DD, Krumhar KC. Randomized clinical trial of portion-controlled prepackaged foods to promote weight loss. *Obesity (Silver Spring)*. 2016;24:1230-1237.
14. Wing RR, Jeffery RW, Burton LR, Thorson C, Nissinoff KS, Baxter JE. Food provision vs structured meal plans in the behavioral treatment of obesity. *Int J Obes Relat Metab Disord*. 1996;20:56-62.
15. Metz JA, Stern JS, Kris-Etherton P, Reusser ME, Morris CD, Hatton DC, et al. A randomized trial of improved weight loss with a prepared meal plan in overweight and obese patients: impact on cardiovascular risk reduction. *Arch Intern Med*. 2000;160:2150-2158.
16. Wing RR, Jeffery RW. Food provision as a strategy to promote weight loss. *Obes Res*. 2001;9:271S-275S.
17. Raynor HA, Van Walleghen EL, Niemeier H, Butryn ML, Wing RR. Do food provisions packaged in single-servings reduce energy intake at breakfast during a brief behavioral weight-loss intervention? *J Am Diet Assoc*. 2009;109:1922-1925.
18. Foster GD, Wadden TA, Lagrotte CA, Vander Veur SS, Hesson LA, Homko CJ et al. A randomized comparison of a commercially available portion-controlled weight-loss intervention with a diabetes self-management education program. *Nutr Diabetes*. 2013;3:e63.

19. Mattes RD. Ready-to-eat cereal used as a meal replacement promotes weight loss in humans. *J Am Coll Nutr*. 2002;21:570-577.
20. Rock CL, Flatt SW, Sherwood NE, Karanja N, Pakiz B, Thomson CA. Effect of a Free Prepared Meal and Incentivized Weight Loss Program on Weight Loss and Weight Loss Maintenance in Obese and Overweight Women: A Randomized Controlled Trial. *JAMA*. 2010;304:1803-1810.
21. Levitsky DA, Pacanowski C. Losing weight without dieting. Use of commercial foods as meal replacements for lunch produces an extended energy deficit. *Appetite*. 2011;57:311-317.
22. Ello-Martin JA, Ledikwe JH, Rolls BJ. The influence of food portion size and energy density on energy intake: implications for weight management. *Am J Clin Nutr*. 2005;82:236S-241S.
23. Kral TV, Rolls BJ. Energy density and portion size: their independent and combined effects on energy intake. *Physiol Behav*. 2004;82:131-138.
24. Rolls BJ, Roe LS, Beach AM, Kris-Etherton PM. Provision of foods differing in energy density affects long-term weight loss. Obes Res 2005;13:1052-1060.
25. Ello-Martin JA, Roe LS, Ledikwe JH, Beach AM, Rolls BJ. Dietary energy density in the treatment of obesity: a year-long trial comparing 2 weight-loss diets. Am J Clin Nutr 2007;85:1465-1477.
26. Rolls BJ, Roe LS, Beach AM, Kris-Etherton PM. Provision of foods differing in energy density affects long-term weight loss. *Obes Res*. 2005;13:1052-1060.
27. Kral TV, Roe LS, Rolls BJ. Combined effects of energy density and portion size on energy intake in women. *Am J Clin Nutr*. 2004;79:962-968.
28. Ledikwe JH, Rolls BJ, Smiciklas-Wright H, Mitchell DC, Ard JD, Champagne C *et al.* Reductions in dietary energy density are associated with weight loss in overweight and obese participants in the PREMIER trial. *Am J Clin Nutr* 2007;85:1212-1221.
29. Almiron-Roig E, Dominguez A, Vaughan D, Solis-Trapala I, Jebb SA. Acceptability and potential effectiveness of commercial portion control tools amongst people with obesity. *Br J Nutr*. 2016;116:1974-1983.
30. Byrd-Bredbenner C, Schwartz J. The effect of practical portion size measurement aids on the accuracy of portion size estimates made by young adults. *J Hum Nutr Diet*. 2004;17:351-357.
31. Pedersen SD, Kang J, Kline GA. Portion control plate for weight loss in obese patients with type 2 diabetes mellitus: a controlled clinical trial. *Arch Intern Med*. 2007;167:277-1283.
32. Kesman RL, Ebbert JO, Harris KI, Schroeder DR. Portion control for the treatment of obesity in the primary care setting. *BMC Res Notes*. 2011;4:346.
33. Ptomey LT, Willis EA, Goetz JR, Lee J, Szabo-Reed AN, Sullivan DK, et al. Portion-controlled meals provide increases in diet quality during weight loss and maintenance. *J Hum Nutr Diet*. 2016;29:209-216.
34. Bucher T, Rollo ME, Smith SP, Dean M, Brown H, Sun M, et al. Position paper on the need for portion-size education and a standardised unit of measurement. *Health Promot J Austr*. 2016;ePub.
35. Rolls BJ, Roe LS, James BL, Sanchez CE. Does the incorporation of portion-control strategies in a behavioral program improve weight loss in a one-year randomized controlled trial?. *Int J Obes*. 2017;41:434-442.
36. Unick JL, Neiberg RH, Hogan PE, Cheskin LJ, Dutton GR, Jeffery R, et al. Weight change in the first 2 months of a lifestyle intervention predicts weight changes 8 years later. *Obesity (Silver Spring)*. 2015;23:1353-1356.
37. Miller CK, Nagaraja HN, Weinhold KR. Early weight-loss success identifies nonresponders after a lifestyle intervention in a worksite diabetes prevention trial. *J Acad Nutr Diet*. 2015;115:1464-1471.

38. Nackers LM, Ross KM, Perri MG. The association between rate of initial weight loss and long-term success in obesity treatment: does slow and steady win the race? *Int J Behav Med*. 2010;17:161-7.
39. Elfhag K, Rössner S. Initial weight loss is the best predictor for success in obesity treatment and sociodemographic liabilities increase risk for drop-out. *Patient Educ Couns*. 2010;79:361-366.
40. Handjieva-Darlenska T, Handjiev S, Larson TM, et al. Initial weight loss on an 800-kcal diet as a predictor of weight loss success after 8 weeks: the Diogenes study. *Eur J Clin Nutr*. 2010;64:994-9.
41. Teixeira PJ, et al. Pretreatment predictors of attrition and successful weight management in women. *Int J Obes Relat Metab Disord*. 2004;28:1124-33.
42. Teixeira PJ, Going SB, Sardinha LB, & Lohman TG. A review of psychosocial pre-treatment predictors of weight control. *Obes Rev*. 2005;6:43-65.
43. Annesi JJ, Mareno N. Psychosocial changes as correlates of weight regain vs. continued loss within 2-year trials of a self-regulation-focused community-based intervention. *Clin Obes*. 2017;7:22-33.
44. Nezami BT, Lang W, Jakicic JM, Davis KK, Polzien K, Rickman AD, et al. The effect of self-efficacy on behavior and weight in a behavioral weight-loss intervention. *Health Psychol*. 2016:ePub.
45. Urbanek JK, Metzgar CJ, Hsiao PY, Piehowski KE, Nickols-Richardson SM. Increase in cognitive eating restraint predicts weight loss and change in other anthropometric measurements in overweight/obese premenopausal women. Appetite 2015;87:244-250.
46. Drapeau V, Provencher V, Lemieux S, Despres J-P, Bouchard C, Tremblay A. Do 6-y changes in eating behaviours predict changes in body weight? Results from the Quebec Family Study. Int J Obes Relat Metab Disord 2003;27:808-814.
47. Stice E, Cameron RP, Killen JD, Hayward C, Taylor CB. Naturalistic weight-reduction efforts prospectively predict growth in relative weight and onset of obesity among female adolescents. *J Consult Clin Psychol*. 1999;67:967-974.
48. Westenhoefer J. Dietary restraint and disinhibition: is restraint a homogeneous concept? *Appetite*. 1991;16:45-55.
49. Hays NP, Roberts SB. Aspects of eating behaviors "disinhibition" and "restraint" are related to weight gain and BMI in women. *Obes Res*. 2008;16:52-58.
50. JaKa MM, Sherwood NE, Flatt SW, et al. Mediation of weight loss and weight loss maintenance through dietary disinhibition and restraint. *J Obes Weight Loss Ther*. 2015;5:253.
51. Bryant EJ, Caudwell P, Hopkins ME, King NA, Blundell JE. Psycho-markers of weight loss. The roles of TFEQ disinhibition and restraint in exercise-induced weight management. *Appetite*. 2012;58:534-541.
52. Wamsteker EW, Geenen R, Iestra J, Larsen JK, Zelissen PM, van Staveren WA. Obesity-related beliefs predict weight loss after an 8-week low-calorie diet. *J Am Diet Assoc*. 2005;105:441-4.
53. Nir Z, Neumann L. Relationship among self-esteem, internal-external locus of control, and weight change after participation in a weight reduction program. *J Clin Psychol*. 1995;51:482-90.
54. Stunkard AJ, Messick S. The three-factor eating questionnaire to measure dietary restraint, disinhibition and hunger. J Psychosom Res 1985;29:71-83.
55. Karlsson J, Persson LO, Sjöström L, Sullivan M. Psychometric properties and factor structure of the Three-Factor Eating Questionnaire (TFEQ) in obese men and women. Results from the Swedish Obese Subjects (SOS) study. Int J Obes Relat Metab Disord 2000;24:1715-1725.
56. Tholin S, Rasmussen F, Tynelius P, Karlsson J. Genetic and environmental influences on eating behavior: The Swedish Young Male Twins Study. Am J Clin Nutr 2005;81:564-569.

57. Cappelleri JC, Bushmakin AG, Gerber RA, Leidy NK, Sexton CC, Lowe MR et al. Psychometric analysis of the Three-Factor Eating Questionnaire-R21: results from a large diverse sample of obese and non-obese participants. Int J Obes (Lond) 2009;33:611-620.

CHAPTER 2*

STUDY 2: EARLY PREDICTORS OF WEIGHT LOSS IN A ONE-YEAR BEHAVIORAL WEIGHT LOSS PROGRAM

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Introduction

Extensive research has focused on identifying effective weight loss treatments to benefit adults with excess weight or obesity.[1,2] Despite this work, long-term outcomes vary substantially across individuals.[2,3] No single intervention works well for everyone, so identifying changes in individual factors, such as eating behaviors, that predict success is key for developing effective personalized interventions. Assessment of these changes in the initial months of intervention would allow treatment tailoring through provision of additional support for individuals who are less responsive and reinforcement for those who respond well. However, interventions are seldom designed to evaluate such early changes, and many factors are assessed only at baseline or baseline and post-intervention.[4] This study repeatedly assessed individual factors during a year-long weight-loss intervention to determine whether changes early in treatment predicted subsequent weight loss across individuals.

The evidence identifying early predictors of subsequent weight outcomes is limited; however, early weight loss itself has consistently been shown to predict later weight loss. One trial found that weight loss after two months of behavioral intervention was correlated with weight loss eight years later, and that individuals who did not achieve a given weight loss in this initial period failed to respond to treatment long term.[5] Multiple shorter-term weight loss trials have also found that greater initial weight loss predicts greater long-term weight loss.[6-9]

In addition to weight loss itself, certain psychological and behavioral factors have been associated with weight loss during intervention, such as program attendance[10,11], self-efficacy[12,13], dietary restraint[14], and disinhibition.[15] However, assessment of changes early in treatment is rare. Thus, in a secondary analysis, early measures of behavior change were tested to determine whether they predicted weight loss in a year-long trial of different dietary strategies.[16]

Specifically, analyses focused on changes in ratings of eating behaviors and psychological factors from baseline to Month 1 and their ability to predict either early weight loss (baseline to Month 3) or longer-term weight loss (baseline to Month 12). It was hypothesized that early, beneficial change in eating behaviors such as disinhibition and restraint would predict success in short- and longer-term weight loss.

Methods

Study design

The Portion-Control Strategies Trial was a one-year randomized controlled trial in women with overweight and obesity comparing two portion-control strategies to standard dietary advice for weight loss. The trial design and main outcomes have been previously reported.[16]

Participants

Eligible women were aged 20-65 y with a body mass index (BMI) of 28-45 kg/m^2. They were recruited through local advertisements and websites in State College, PA and surrounding areas. Exclusion criteria included blood pressure >160/100 mm Hg; following a special diet or weight-loss program; weight change >4.5 kg in the past three months; a medical condition that prevented participation; pregnancy or lactation; or scoring > 19 on the Eating Attitudes Test[17] or > 25 on the Beck Depression Inventory.[18] Inclusion required completion of three daily food and activity diaries and a two-week run-in period. Participants provided signed informed consent and were financially compensated for their time. The trial protocol was approved by the Office for Research Protections at The Pennsylvania State University.

Interventions

Participants were randomly assigned to one of three parallel intervention groups.[16] The Standard Advice group was instructed to follow dietary recommendations that focused on eating less and selecting healthy options from different food groups. The Portion Selection group was taught to choose food portions based on energy density and was given portion-control tools such as food scales. The Pre-portioned Foods group was taught to use pre-portioned foods to structure meals; they were also given vouchers for single-serving main dishes. The instructional sessions focused on applying the principles of the assigned program when selecting the types and amounts of food at meals and snacks. The principles were reinforced in individual lessons on specific food groups, meal planning, and eating away from home. Participants in all groups received similar instruction on increasing physical activity, keeping records for self-monitoring, and managing behavior change.

All participants met individually with trained interventionists weekly during Month 1, biweekly during Months 2-6, and monthly during Months 7-12. In addition to 19 instructional sessions, there were assessment sessions at baseline and Months 1, 3, 6, and 12 that included computer-administered questionnaires. Body weight was measured at baseline and all 23 sessions.

Measures

This study examined four questionnaires, which assess eating behaviors and psychological factors that have been suggested in the literature to be related to weight loss. The questionnaires are summarized in Table 2.1 and described further below.

The Three-Factor Eating Questionnaire (TFEQ)[19] assesses three cognitive and behavioral aspects of eating behavior: dietary restraint, disinhibition, and susceptibility to hunger. Dietary

restraint measures the tendency to restrict food intake as a means of weight management, disinhibition evaluates overeating in response to palatable foods or negative emotions, and hunger assesses susceptibility to feelings of hunger. Since the development of the TFEQ, other researchers have proposed subscales of the main scales, such as flexible and rigid restraint[20] and internal and external disinhibition[21], which were also assessed in this study.

The Diet Satisfaction Questionnaire (D-Sat)[22] evaluates satisfaction with the current diet and identifies potential barriers to change by assessing seven aspects: healthy lifestyle, convenience, cost, family dynamics, preoccupation with food, negative aspects, and meal planning and preparation. For example, the healthy lifestyle scale assesses the degree to which the current diet supports a healthy lifestyle and promotes positive feelings about life, using agreement with statements such as "I am satisfied with my diet" and "I believe that I am reducing my risk for disease by the way that I eat".

The Dieting Beliefs Scale[23] measures three types of beliefs about weight-related locus of control: internal locus, which is controlled by internal factors (e.g., willpower), external locus, which is controlled by individual characteristics outside that individual's influence (e.g., genetics), and external locus, which is controlled by factors outside the individual (e.g., environment).

The Weight-Efficacy Lifestyle Questionnaire[24] assesses the ability to resist eating in response to certain environmental situations or emotional states. It evaluates self-efficacy in five contexts: negative emotions, food availability, social pressure, physical discomfort, and positive activities.

Attendance was determined by summing the total number of instructional and assessment visits attended by each participant during the first month of treatment (a maximum of four).

Statistical Analysis

Weight loss from baseline was modeled as a polynomial curve incorporating multiple measurements across time using a random coefficients model. The linear coefficient of the trajectory characterized the initial rate of weight loss, and the quadratic coefficient characterized the deceleration of weight loss and the beginning of weight regain.[16] Questionnaire completion rates were 100% at baseline and Month 1, 94% at Month 3, 83% at Month 6, and 76% at Month 12. In an intention-to-treat analysis, the model included all available data for randomized participants and used maximum likelihood methods to handle missing data.

Changes in individual factors from baseline to Month 1 were tested for influence on the weight-loss trajectories from baseline to Month 3 (10 measurements) and from baseline to Month 12 (23 measurements). Baseline levels and initial change in each of the questionnaire scales, initial participant attendance, and initial weight loss were tested in individual, univariate models. The predictors found to significantly associate ($P < 0.05$) with weight loss were used to build the subsequent, hierarchical models. Those variables that no longer remained significant or marginally significant in the multivariate model were removed in a stepwise fashion before building the subsequent model. For Month 3 weight loss, three models were built: the first paralleling the model used in the main trial paper[16] and used to establish a reference for testing additional predictors, the second adding the main effects of the covariates of interest and their interactions with linear rate of weight loss, and the third which added Month 1 weight loss as a fixed effect. For Month 12 weight loss, four models were built: the first paralleling the model used in the main trial paper, the second adding the main effects of the covariates of interest and their interactions with linear rate of weight loss, the third adding the interactions between these covariates and quadratic change (deceleration) in weight loss, and the fourth adding Month 1

weight loss as a fixed effect. The TFEQ subscales were evaluated in the same set of multivariate, hierarchical models, but in order to streamline the models and enable comparison across a larger literature base, the overall restraint and disinhibition scales were retained in the final models and the tables shown here. Results for the subscales are reported in the text.

The reference model for both time points included the fixed effects of intervention group, baseline BMI, age, and the linear and quadratic effects of time (trial week). The effects for intercept and linear coefficient were included as random effects in all models to account for within-subject correlation across assessments. The data were analyzed using SAS software (version 9.4, 2013, SAS Institute Inc., Cary, NC). Results are reported as mean±SD for demographic data and mean±SEM for modeled data.

Results

Participant characteristics and overall weight loss

There were 186 women with overweight and obesity enrolled in the trial (age 50.0±10.6 y). The majority of participants had obesity (BMI 34.0±4.2 kg/m^2), were white (98%), and had at least some college education (88%). As reported previously[16], there were differences in weight-loss trajectories across intervention groups. The Pre-Portioned Foods group lost weight at a faster rate than the other groups during the initial months and then regained at a faster rate than the other groups during later months. Consequently, no differences were found in weight loss between groups at Month 6 or Month 12. On average, participants had lost 5.2±0.4 kg at Month 6 and 4.5±0.5 kg at Month 12. None of the effects reported below differed significantly across groups, nor were there significant effects of baseline age or BMI on the weight-loss trajectory.

Early predictors of weight loss

After a month of treatment, initial changes in several individual factors were found to predict the trajectory of weight loss at both Month 3 and Month 12 (Tables 2.2 and 2.3). As described below, changes in TFEQ and D-Sat questionnaire scales (Figure 2.1) were significantly associated with the rate of weight loss, as was initial weight loss. No significant relationships to weight loss were found for the Dieting Beliefs Scale or the Weight-Efficacy Lifestyle Questionnaire.

None of the baseline levels of the questionnaire scales were found to predict subsequent weight loss in the hierarchical model. The same was true for attendance in Month 1, which was not a significant predictor, likely due to the lack of variability in attendance rates across participants in the first month of treatment.

Month 3 Weight Loss

Initial change in multiple scales predicted the trajectory of weight loss during the first three months of the trial. As shown in Table 2.2, increases in TFEQ dietary restraint during the first month of intervention were associated with faster weight loss from baseline to Month 3 ($P<0.01$). The Diet Satisfaction Questionnaire also showed associations with early weight loss. Specifically, increases in the healthy lifestyle scale predicted weight loss at Month 3 ($P<0.001$).

When the flexible and rigid subscales of restraint were analyzed in the multivariate model, positive change in flexible restraint in the first month correlated with a greater rate of weight loss in the first three months ($\beta = 0.03 \pm 0.01$, $P = 0.01$); in contrast, rigid restraint was not a significant predictor of weight loss ($\beta = -0.004 \pm 0.01$, $P = 0.75$). Change in disinhibition in the first month was not related to subsequent weight loss, nor was change in the internal and external

disinhibition subscales when examined individually. The change in the susceptibility to hunger scale did not show associations with weight loss.

Month 12 Weight Loss

In general, the same covariates that predicted Month 3 weight loss also predicted Month 12 weight loss (Table 2.3). Increases in restraint during Month 1 predicted both a greater rate of weight loss and a slower rate of regain for the full 12 months of the trial (both $P<0.05$). Participants in the highest tertile of increase in restraint score (6-16 points) lost 6.1±4.0% body weight at Month 3 and 7.9±8.2% at Month 12, while those in the lowest tertile (-5-2 points) lost 3.4±3.8% at Month 3 and 3.3±5.3% at Month 12. The flexible and rigid restraint subscales did not significantly predict Month 12 weight loss.

Increases in the healthy lifestyle scale of the D-Sat predicted both a greater rate of weight loss and a slower rate of regain for the full 12 months of the trial (both $P<0.001$). Individuals in the highest tertile of increase (1.63-3.25 points) lost 6.2±4.2% body weight at Month 3 and 7.1±8.2% at Month 12 compared to those in the lowest tertile (-1.0-0.75 points) who lost 2.8±3.0% at Month 3 and 3.4±4.5% at Month 12.

Neither early change nor baseline levels of the six other scales on the D-Sat were significant predictors of weight loss.

Early weight loss

As expected, the amount of weight loss in the first month predicted the rate of weight loss from baseline to Month 3, and the rate of loss and slower regain from baseline to Month 12 (all $P<0.001$). Participants in the highest tertile of initial weight loss (2.9-7.3 kg) lost 8.1±3.4% at Month 3 and 10.4±8.2% at Month 12 compared to those in the lowest tertile (ranged from a 1.4 kg gain to a 1.5 kg loss) who lost 1.4±2.4% at Month 3 and 1.6±4.2% at Month 12. Neither

TFEQ restraint nor D-Sat healthy lifestyle remained significant once early weight loss was included in the models.

Discussion

In this one-year weight loss trial among women, changes over the first month in several psychological factors and eating behaviors predicted weight loss in the first three months and across the year. Participants who exhibited greater initial improvements in dietary restraint and healthy lifestyle rating had a greater rate of weight loss.

Frequent weight measurement in this trial facilitated the modeling of the associations between these factors and weight loss during intervention. The relationship between dietary restraint and weight loss was consistent with associations previously reported in the literature[14]; furthermore, these results extend those findings by quantifying early improvement in these scores and demonstrating their predictive ability. The finding that weight loss was associated with an early increase in restraint suggests a beneficial effect of adopting eating behaviors such as consciously limiting the amount of food served, or increasing awareness of the kind and amount of food eaten. These findings parallel changes seen in the bariatric surgery field where increased restraint shortly following surgery was associated with greater long-term weight loss[25], as well as other long-term weight loss trials where lifestyle modification corresponds to both increases in restraint and greater weight loss.[26] Therefore, overall findings with restraint support evidence that it represents positive behaviors that reflect self-regulation and promote weight loss.[14]

Analysis of the subscales of the TFEQ showed that an increase in flexible restraint was advantageous for long-term weight loss in this trial. Flexible restraint is characterized by a

tendency to allow "forbidden" foods to be eaten in small amounts with adjustment of subsequent intake, in contrast to rigid restraint, which represents an approach to eating characterized by strict dieting and avoidance of high-calorie foods.[20] These results agree with other weight loss trials showing that flexible restraint has benefits for weight loss.[27] Differences in these two types of restraint may explain the conflicting results of previous studies, which have found both positive and negative associations with weight loss when the overall restraint scale was examined.[14] Thus, individuals who show an increase in restraint, particularly flexible restraint, early in weight loss treatment are more likely to experience long-term success.

An unexpected finding was the lack of relationship between early change in disinhibition and subsequent weight loss. Decreasing disinhibition, or reducing the tendency to overeat in response to emotional and environmental cues, was hypothesized to result in a greater rate of early weight loss. While these findings are unexpected, disinhibition changed more gradually than restraint in this trial, suggesting that looking at it as a predictor later on, such as the change in disinhibition from baseline to Month 3, might have shown a stronger effect on predicting long-term weight loss. This theory is supported by other work showing that change in disinhibition over a longer period of treatment predicted later weight loss.[28]

The influence of diet satisfaction deserves additional study, as it was shown here that weight loss was related to an initial increase in one rating of diet satisfaction, namely that the diet supports a healthy lifestyle. A recent analysis of weight loss trial data showed that a decrease in perceived barriers to healthy eating was associated with better response to treatment over 18 months.[29] These Portion-Control Strategies Trial findings also parallel more general findings for the effects of satisfaction on weight loss. Previous studies have found that initial satisfaction with the type of intervention predicted subsequent weight loss[30-32] and that overall satisfaction with

initial weight loss predicted long-term weight loss and maintenance.[32] Satisfaction with a prescribed diet may affect the likelihood of adopting and maintaining dietary changes, and thus could have a substantial impact on weight loss. In weight-loss treatment, consideration should be given to emphasizing the quality of the prescribed diet and identifying personal and environmental barriers to changes in eating behavior since a participant's agreement with statements such as, "I am satisfied with my diet" and "I believe that I am reducing my risk for disease by the way that I eat" was associated with better outcomes. These findings show that an individual's assessment of how well their diet supports a healthy lifestyle compared to their pre-treatment diet bears a relationship to long-term weight loss, more so than other facets of diet satisfaction.

In this trial, one-month weight loss was a strong predictor of subsequent weight loss, which confirms extensive prior research demonstrating that initial weight loss predicts longer-term success in behavioral weight-loss treatments.[5-9] These findings make sense given the fact that a subset of the outcome data (early weight loss) is used to predict the outcome (overall weight loss). Even though initial weight loss largely overpowers the effects of other variables on longer-term weight loss, the findings prior to entering early weight loss in the models are informative for identifying factors that might predict early weight loss and offer potential intervention targets for improving outcomes.

It should not be assumed based on these findings that treatment could be stopped after early weight loss was achieved and long-term weight loss would still be equivalent to that resulting from longer-term treatment. Even for individuals who respond well to treatment by losing weight in the initial months, there is little evidence that their response would continue should treatment end. Therefore, future work should focus on both enhancing treatment for

individuals initially identified as less responsive and on reinforcing behaviors in those responding well. Early assessment of the factors related to weight loss could be useful in tailoring treatment to accomplish these goals.

Although early assessment of individual factors associated with weight loss could facilitate individualized intervention, only a few studies have examined the impact of tailored treatment on later outcomes. One study found that individuals allowed to choose their weight-loss diet at the start of treatment did not differ in weight loss at one year compared to those given no choice.[33] However, little is known about the benefit of allowing individuals to change programs after an initial lack of response. A recent study provided extra support for individuals identified in the first month as unresponsive to treatment[34]; the results showed improvement in weight loss at 12 weeks for those who received extra support compared to those who did not. Follow-up work is needed to determine whether this benefit continues in the longer term.

These findings raise the question of whether individual characteristics should be assessed only to predict subsequent weight loss or if they should also be the focus of intervention. Improvements in restraint often result from behavioral weight loss treatments, but this factor could be targeted by building the necessary tools and support structure for change. It is often assumed that these factors are driving weight loss, but few interventions have focused on them directly in an effort to prove causality, and future work should do so.

Program attendance is often shown to influence long-term weight loss, as it did when examined across the year in this trial.[16] However, attendance in the first month did not predict subsequent weight loss, likely due to little variability in the measure. The trial population consisted of women who were predominantly white and well-educated, which limits

generalizability but also creates a basis for these findings that can be tested in more diverse populations.

In summary, little research has investigated the predictive value of early changes in individual eating behaviors and psychological factors during intervention that are predictive of long-term weight loss. By identifying early predictors beyond initial weight loss itself, these findings provide a more comprehensive picture of the many factors associated with weight loss. As such evidence emerges, so does the potential to identify unresponsive participants and to tailor treatment to each individual based on early levels of factors such as restraint and healthy lifestyle. This personalization based on early changes could benefit long-term outcomes, but work remains to be done on the most effective methods for accomplishing this. Incorporating additional early measurements such as those identified in this trial will provide a more complete picture of each individual, determine which factors have the greatest impact, and identify what type of treatment could best promote and maintain long-term weight loss.

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References

1. Flegal KM, Kruszon-Moran D, Carroll MD, Fryar CD, Ogden CL. Trends in obesity among adults in the United States, 2005 to 2014. *JAMA*. 2016;21:2284-2291.
2. Alamuddin N, Wadden TA. Behavioral treatment of the patient with obesity. *Endocrinol Metab Clin North Am*. 2016;45:565-580.
3. MacLean PS, Wing RR, Davidson T, et al. NIH working group report: innovative research to improve maintenance of weight loss. *Obesity (Silver Spring)*. 2015;23:7-15.
4. Teixeira PJ, Going SB, Sardinha LB, & Lohman TG. A review of psychosocial pre-treatment predictors of weight control. *Obes Rev*. 2005;6:43-65.
5. Unick JL, Neiberg RH, Hogan PE, et al. Weight change in the first 2 months of a lifestyle intervention predicts weight changes 8 years later. *Obesity (Silver Spring)*. 2015;23:1353-1356.
6. Casazza K, Brown A, Astrup A, et al. Weighing the evidence of common beliefs in obesity research. *Crit Rev Food Sci Nutr*. 2015;55:2014-2053.
7. Miller CK, Nagaraja HN, Weinhold KR. Early weight-loss success identifies nonresponders after a lifestyle intervention in a worksite diabetes prevention trial. *J Acad Nutr Diet*. 2015;115:1464-1471.
8. Nackers LM, Ross KM, Perri MG. The association between rate of initial weight loss and long-term success in obesity treatment: does slow and steady win the race? *Int J Behav Med*. 2010;17:161-7.
9. Elfhag K, Rössner S. Initial weight loss is the best predictor for success in obesity treatment and sociodemographic liabilities increase risk for drop-out. *Patient Educ Couns*. 2010;79:361-366.
10. Moroshko I, Brennan L, O'Brien P. Predictors of dropout in weight loss interventions: a systematic review of the literature. *Obes Rev*. 2011;12:912-934.
11. Carels RA, Cacciapaglia HM, Douglass OM, Rydin S, O'Brien WH. The early identification of poor treatment outcome in a women's weight loss program. *Eat Behav*. 2003;4:265-282.
12. Annesi JJ, Mareno N. Psychosocial changes as correlates of weight regain vs. continued loss within 2-year trials of a self-regulation-focused community-based intervention. *Clin Obes*. 2017;epub.
13. Nezami BT, Lang W, Lakicic JM, et al. The effect of self-efficacy on behavior and weight in a behavioral weight-loss intervention. *Health Psychol*. 2016;35:714-722.
14. Schaumberg K, Anderson DA, Anderson LM, Reilly EE, Gorrell S. Dietary restraint: what's the harm? A review of the relationship between dietary restraint, weight trajectory and the development of eating pathology. *Clin Obes*. 2016;6:89-100.
15. Bryant EJ, King NA, Blundell JE. Disinhibition: its effects on appetite and weight regulation. *Obes Rev*. 2008;9:409-419.
16. Rolls BJ, Roe LS, James BL, Sanchez CE. Does the incorporation of portion-control strategies in a behavioral program improve weight loss in a one-year randomized controlled trial?. *Int J Obes*. 2017;41:434-442.
17. Garner DM, Olmsted MP, Bohr Y, Garfinkel PE. The Eating Attitudes Test: psychometric features and clinical correlates. *Psychological Medicine* 1982;12:871-878.
18. Beck AT, Ward CH, Mendelson M, Mock J, Erbaugh J. An inventory for measuring depression. *Arch Gen Psychiatry.* 1961;4:561-571.
19. Stunkard AJ, Messick S. The three-factor eating questionnaire to measure dietary restraint, disinhibition and hunger. *J Psychosom Res* 1985;29:71-83.
20. Westenhoefer J. Dietary restraint and disinhibition: is restraint a homogeneous concept? *Appetite*. 1991;16:45-55.
21. Niemeier HM, Phelan S, Fava JL, Wing RR. Internal disinhibition predicts weight regain following weight loss and weight loss maintenance. *Obesity (Silver Spring)*. 2007;15:2485-2494.

22. Ello-Martin JA. *Reducing dietary energy density for the treatment of obesity: the long-term effects on weight loss, hunger, and diet satisfaction*. [dissertation]. University Park, PA: The Pennsylvania State University; 2006.
23. Stotland S, Zuroff DC. A new measure of weight locus of control: the Dieting Beliefs Scale. *J Pers Assess*. 1990;54:191-203.
24. Eaton CA, Rossi JS. Self-efficacy in weight management. *J Consult Clin Psychol*. 1991;59:739-744.
25. Sarwer DB, Moore RH, Spitzer JC, et al. A pilot study investigating the efficacy of postoperative dietary counseling to improve outcomes after bariatric surgery. *Surg Obes Relat Dis*. 2012;8:561-568.
26. Volger S, Wadden TA, Sarwer DB, et al. Changes in eating, physical activity and related behaviors in a primary care-based weight loss intervention. *Int J Obes*. 2013;Suppl 1:S12-S18.
27. Westenhoefer J, Engel D, Holst C, et al. Cognitive and weight-related correlates of flexible and rigid restrained eating behaviour. *Eat Behav*. 2013;14:69-72.
28. JaKa MM, Sherwood NE, Flatt SW, et al. Mediation of weight loss and weight loss maintenance through dietary disinhibition and restraint. *J Obes Weight Loss Ther*. 2015;5:253-258.
29. Zheng Y, Sereika SM, Danford CA, et al. Trajectories of weight change and predictors over 18-month weight loss treatment. *J Nurs Scholarsh*. 2017;ePub ahead of print.
30. Gupta S, Wang Z. Treatment satisfaction with different weight loss methods among respondents with obesity. *Clin Obes*. 2016;6:161-170.
31. Shapiro JR, Koro T, Doran N, et al. Text4Diet: a randomized controlled study using text messaging for weight loss behaviors. *Prev Med*. 2012;55:412-417.
32. Finch EA, Linde JA, Jeffery RW, Rothman AJ, King CM, Levy RL. The effects of outcome expectations and satisfaction on weight loss and maintenance: correlational and experimental analyses—a randomized trial. *Health Psychol*. 2005;24:608-616.
33. Coles LT, Fletcher EA, Galbraith CE, Clifton PM. Patient freedom to choose a weight loss diet in the treatment of overweight and obesity: a randomized dietary intervention in type 2 diabetes and pre-diabetes. *Int J Behav Nutr Phys Act*. 2014;11:64-72.
34. Unick JL, Dorfman L, Leahey TM, Wing RR. A preliminary investigation into whether early intervention can improve weight loss among those initially non-responsive to an internet-based behavioral program. *J Behav Med*. 2016;39:254-261.

Table 2.1: Questionnaires, scales, score ranges, and time points administered

Questionnaire (total number of items)	Scale	Scale number of items	Score range	Time points administered
Three-Factor Eating Questionnaire (TFEQ)[19] (51 items)	Dietary Restraint	21	0-21	Baseline and Months 1, 3, 6, & 12
	Disinhibition	16	0-16	
	Susceptibility to Hunger	14	0-14	
Diet-Satisfaction Questionnaire (D-Sat)[22] (45 items)	Healthy Lifestyle	8	1-5	Baseline and Months 1, 3, 6, & 12
	Convenience	9	1-5	
	Cost	5	1-5	
	Family Dynamics	6	1-5	
	Preoccupation with Food	6	1-5	
	Negative Aspects	6	1-5	
	Meal Planning and Preparation	5	1-5	
Dieting Beliefs Scale [23] (16 items)	Internal Locus of Control	6	6-36	Baseline and Months 6 & 12
	External (individual) Locus of Control	5	5-30	
	External (environmental) Locus of Control	4	4-24	
Weight-Efficacy Lifestyle Questionnaire[24] (20 items)	Negative Emotions	4	0-36	Baseline and Months 6 & 12
	Food Availability	4	0-36	
	Social Pressure	4	0-36	
	Physical Discomfort	4	0-36	
	Positive Activities	4	0-36	

Figure 2.1: Mean (±SEM) change in scores over time for (A) the Three-Factor Eating Questionnaire[19] and (B) the Diet Satisfaction Questionnaire[22] in 186 women in a weight-loss trial. Significant relationships with weight change were found for the scales shown in bold: the Dietary Restraint and Disinhibition scales of the Three-Factor Eating Questionnaire and the Healthy Lifestyle scale of the Diet Satisfaction Questionnaire.

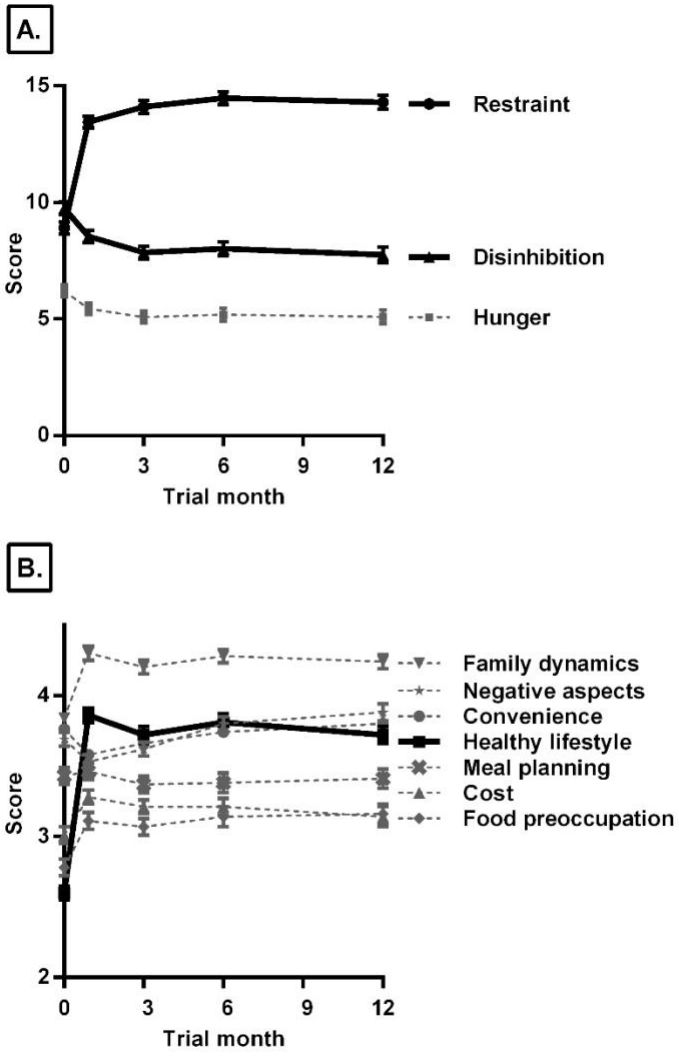

Table 2.2: Hierarchical random coefficients models of the influence of individual factors[1] of 186 women on the trajectory of weight loss across the first three months of a one-year trial.

	Model 1		Model 2		Model 3	
	Coefficient ± SEM	P-value	Coefficient ± SEM	P-value	Coefficient ± SEM	P-value
Age	0.01 ± 0.01	P = 0.01	0.01 ± 0.01	P = 0.01	-0.002 ± 0.003	P = 0.55
BMI	0.04 ± 0.02	P < 0.01	0.04 ± 0.02	P < 0.01	0.006 ± 0.007	P = 0.37
Group Assignment	-0.27 ± 0.15	P = 0.08	-0.27 ± 0.15	P = 0.08	-0.12 ± 0.07	P = 0.07
Week	0.43 ± 0.03	P < 0.001	0.24 ± 0.04	P < 0.001	0.11 ± 0.03	P < 0.01
Week*Week	-0.01 ± 0.002	P < 0.001	-0.01 ± 0.002	P < 0.001	-0.01 ± 0.002	P < 0.001
TFEQ Restraint change in Month 1			0.02 ± 0.02	P = 0.35	-0.01 ± 0.02	P = 0.46
TFEQ Restraint change*week			0.02 ± 0.01	P < 0.01	0.005 ± 0.004	P = 0.22
TFEQ Disinhibition change in Month 1			-0.01 ± 0.02	P = 0.82	0.001 ± 0.02	P = 0.60
TFEQ Disinhibition change*week			-0.003 ± 0.007	P = 0.66	-0.003 ± 0.005	P = 0.43
D-Sat Healthy Lifestyle change in Month 1			0.16 ± 0.08	P = 0.04	-0.03 ± 0.07	P = 0.69
Healthy Lifestyle change*week			0.09 ± 0.02	P < 0.001	0.02 ± 0.02	P = 0.43
Weight loss in Month 1					0.17 ± 0.02	P < 0.001
Weight loss in Month 1*week					0.06 ± 0.005	P < 0.001
Model Fit Indices	AIC: 3983.4 BIC: 4028.5		AIC: 3951.5 BIC: 4016.0		AIC: 3558.7 BIC: 3629.6	

Table 2.3: Hierarchical random coefficients models of the influence of individual factors[1] of 186 women on the trajectory of weight loss across the full year of a one-year trial.

	Model 1		Model 2		Model 3		Model 4	
	Coefficient ± SEM	P-value	Coefficient ± SEM	P-value	Coefficient ± SEM	P-value	Coefficient ± SEM	P-value
Age	0.01 ± 0.01	P = 0.24	0.01 ± 0.01	P = 0.20	0.01 ± 0.008	P = 0.19	-0.003 ± 0.003	P = 0.27
BMI	0.07 ± 0.02	P < 0.01	0.05 ± 0.02	P = 0.01	0.05 ± 0.02	P = 0.01	0.003 ± 0.008	P = 0.67
Group Assignment	-0.30 ± 0.21	P = 0.17	-0.28 ± 0.20	P = 0.16	-0.27 ± 0.20	P = 0.17	-0.13 ± 0.79	P = 0.11
Week	0.27 ± 0.02	P < 0.001	0.23 ± 0.03	P < 0.001	0.06 ± 0.04	P = 0.14	-0.03 ± 0.04	P = 0.50
Week*Week	-0.004 ± 0.00	P < 0.001	-0.004 ± 0.00	P < 0.001	-0.001 ± 0.00	P =0.06	0.0001 ± 0.0006	P = 0.82
TFEQ Restraint change in Month 1			0.02 ± 0.02	P = 0.38	0.01 ± 0.02	P = 0.57	-0.04 ± 0.02	P < 0.05
TFEQ Restraint change*week			0.007 ± 0.003	P < 0.01	0.02 ± 0.006	P < 0.001	0.01 ± 0.005	P = 0.06
TFEQ Disinhibition change in Month 1			-0.06 ± 0.03	P = 0.07	-0.06 ± 0.03	P = 0.06	-0.04 ± 0.02	P = 0.08
TFEQ Disinhibition change*week			0.0001 ± 0.003	P = 0.98	0.006 ± 0.007	P = 0.46	0.008 ± 0.007	P = 0.23
D-Sat Healthy Lifestyle change in Month 1			0.36 ± 0.11	P < 0.01	0.31 ± 0.11	P < 0.01	-0.03 ± 0.09	P = 0.76
D-Sat Healthy Lifestyle change*week			0.004 ± 0.01	P = 0.75	0.09 ± 0.03	P < 0.001	0.02 ± 0.02	P = 0.41
TFEQ Restraint					-0.0002 ± 0.00	P = 0.01	-0.00 ± 0.00	P = 0.40

change*week*week					
TFEQ Disinhibition change*week*week			-0.00 ± 0.0001	P = 0.42	-0.0001 ± 0.0001	P = 0.20
D-Sat Healthy Lifestyle change*week*week			-0.002 ± 0.0004	P < 0.001	-0.0004 ± 0.0004	P = 0.25
Weight loss in Month 1					-0.24 ± 0.02	P < 0.001
Weight loss in Month 1*week					0.05 ± 0.006	P < 0.001
Weight loss in Month 1*week*week					-0.0007 ± 0.00	P < 0.001
Model Fit Indices	AIC: 10731.9	AIC: 10706.3	AIC: 10686.5		AIC: 10291.5	
	BIC: 10777.1	BIC: 10770.8	BIC: 10760.7		BIC: 10375.4	

[1]Questionnaire coefficients are not directly comparable due to differences in scoring ranges.
TFEQ: Three-Factor Eating Questionnaire; D-Sat: Diet Satisfaction Questionnaire

CHAPTER 3*

STUDY 3: THE WEIGHT-RELATED EATING QUESTIONNAIRE OFFERS A CONCISE ALTERNATIVE TO THE THREE-FACTOR EATING QUESTIONNAIRE FOR MEASURING EATING BEHAVIORS RELATED TO WEIGHT LOSS

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James BL, Loken E, Roe LS, Rolls BJ. The Weight-Related Eating Questionnaire offers a concise alternative to the Three-Factor Eating Questionnaire for measuring eating behaviors related to weight loss. *Appetite*. 2017;116:108-114.

Introduction

The high prevalence of overweight and obesity in the United States (Flegal, Kruszon-Moran, Carroll, Fryar, & Ogden, 2016) indicates that many individuals have a history of energy imbalance that is likely related to eating behaviors. The cognitive and behavioral factors that drive energy intake are key components of energy balance regulation and have been shown to associate with weight change (Filiatrault, Chaput, Drapeau, & Tremblay, 2014; Teixeira, Going, Sardinha, & Lohman, 2005). Multiple questionnaires that measure eating behaviors, however, show inconsistent findings as to which factors have the greatest impact on weight and weight change, especially over the longer term (Bryant, King, & Blundell, 2007; Johnson, Pratt, & Wardle, 2012). Additionally, these questionnaires are often only administered once, precluding the investigation of behavior change over time and the relationship of that change to body weight. In order to support effective interventions, it is important to determine reliable measures of the eating behaviors and attitudes that influence weight change. In this study, two eating behavior questionnaires were administered repeatedly during a one-year weight loss trial (Rolls, Roe, James, & Sanchez, 2017) in order to identify correlates of weight change.

The Three-Factor Eating Questionnaire (TFEQ; Stunkard & Messick, 1985) is a well-validated measure of three eating-related constructs: dietary restraint, disinhibition, and susceptibility to hunger. Dietary restraint refers to the tendency to consciously restrict food intake as a means of controlling weight, disinhibition refers to a tendency to overeat in response to negative emotional states or the presence of highly palatable foods, and the hunger subscale assesses susceptibility to feelings of hunger. Extensive research has been conducted with the TFEQ in relation to body weight (Bryant et al., 2007; Dykes, Brunner, Martikainen, & Wardle, 2004; Hays & Roberts, 2008; Thomas, Bond, Phelan, Hill, & Wing, 2014; Urbanek, Metzgar,

Hsiao, Piehowski, & Nickols-Richardson, 2015), although it has often examined only baseline levels or baseline and post-intervention. Some studies have reported that a greater increase in restraint during intervention relates to greater weight loss (Urbanek et al., 2015) and a decrease in restraint is a risk factor for weight regain (Thomas et al., 2014), but others have found that higher restraint at baseline correlates with weight gain (Drapeau et al., 2003; Stice, Cameron, Killen, Hayward, & Taylor; 1999). Higher disinhibition, more consistently than restraint, has been correlated with increased risk of weight gain and poorer weight loss outcomes (Hays & Roberts, 2008; JaKa et al., 2015; Bryant, Caudwell, Hopkins, King, & Blundell, 2012). The hunger subscale has received little attention in the literature and is rarely found to associate with weight change (Bryant et al., 2007).

Currently, the TFEQ is the standard for measuring eating behaviors. However, research aimed at identifying problematic eating behaviors has been hampered by the participant burden produced by repeatedly administering the 51-item TFEQ. The Weight-Related Eating Questionnaire (WREQ; Schembre, Greene, & Melanson, 2009) is a shorter, 16-item instrument that incorporates new findings in eating behavior research since the development of the TFEQ. The WREQ combines existing items from the TFEQ and the Dutch Eating Behavior Questionnaire (DEBQ; Van Strien, Frijters, Bergers, & Defares, 1986) with several new questions in order to assess two types of restraint (routine and compensatory) and two types of disinhibition (external and emotional). External and emotional eating, while combined in the construct of disinhibition in the TFEQ, are separately assessed in the DEBQ and have been found to have independent associations with body weight (Wardle, 1987). Thus, the WREQ aims to combine the strengths of both questionnaires.

At present, data validating the WREQ are limited. A single administration of the instrument has been shown to distinguish the four subscales across different age groups and ethnicities, although most of these studies were conducted in college-aged samples (Byrd-Bredbenner, Quick, Koenings, Martin-Biggers, & Kattelmann, 2016; Schembre & Geller, 2011; Schembre, Nigg, & Albright, 2011). It has also been administered in short-term weight loss studies (Bouhaidar et al., 2013) twice within a short time range, but results from these longitudinal analyses were not reported. Therefore, the utility of the WREQ in identifying eating behaviors related to weight loss has not been demonstrated in the longer term.

The present study explores whether the WREQ provides a valid alternative to the TFEQ, particularly in the context of a longer-term weight loss intervention. To provide additional validation for the WREQ, the first aim was to evaluate its psychometric properties in the previously untested setting of a year-long weight loss trial. The second aim was to use multilevel models to investigate how longitudinally measured TFEQ and WREQ scores were related to changes in body weight across the trial.

Methods

Study design

The Portion-Control Strategies Trial was a randomized controlled trial that investigated the effects of two portion-control interventions and standard dietary advice for weight loss. The trial examined weight change over a one-year period in women with obesity and overweight. An overview of trial participants and design is presented below. Further details of the trial design and main outcome data are presented elsewhere (Rolls, Roe, James, & Sanchez, 2017).

Participants

Eligible participants were women aged 20 – 65 y with a body mass index (BMI) of 28 – 45 kg/m^2. Potential participants were excluded if they had blood pressure >160/100 mm Hg, reported a weight change >4.5 kg in the past three months, had a medical condition that prevented participation or that limited physical activity, were following a special diet or weight-loss program, were pregnant or lactating, scored > 19 on the 26-item Eating Attitudes Test (Garner, Olmsted, Bohr, & Garfinkel, 1982), or > 25 on the Beck Depression Inventory (Beck, Ward, Mendelson, Mock, & Erbaugh, 1961). To be enrolled in the trial, potential participants were required to complete three daily food and activity diaries and a two-week run-in period.

A total of 186 women with overweight and obesity were enrolled in the trial. Participants had mean (±SEM) age of 50±0.35 y, mean BMI of 34±0.14 kg/m^2, and were predominantly white (98%). At baseline, participants reported a mean of 2.1±0.2 attempts at weight loss in the previous year, thus they were experienced dieters. Table 3.1 provides additional demographic information. Participants provided signed informed consent and were financially compensated for their time. The trial protocol was reviewed and approved by the Office for Research Protections at The Pennsylvania State University.

Interventions

Participants were randomly assigned to one of three groups: a standard advice group (usual care) or one of two portion-control intervention groups. Participants in the Standard Advice group were instructed to follow dietary guidelines that emphasized eating less while making healthy choices from all food groups. Those in the Portion Selection group were instructed to choose food portions based on energy density and were given food scales and other portion-control tools. Participants in the Pre-portioned Foods group were taught to structure their

meals around pre-portioned foods and were given vouchers for single-serving main dishes. Participants in all groups received similar instruction on increasing physical activity, keeping records for self-monitoring, and managing behavior change.

All participants met individually with trained interventionists weekly during Month 1, biweekly during Months 2-6, then monthly during Months 7-12. In addition to 19 instructional sessions, there were assessment sessions at baseline and Months 1, 3, 6, and 12. At the five assessment sessions, weight was measured to the closest 0.1 kg and participants completed computer-administered questionnaires including the Three-Factor Eating Questionnaire (TFEQ) and the Weight-Related Eating Questionnaire (WREQ).

Measures

Table 3.2 provides an overview of the eating behavior constructs measured by the two questionnaires. The TFEQ assesses restraint, disinhibition, and hunger. The WREQ assesses two types of restraint: routine and compensatory, and two eating behaviors associated with disinhibition: external eating and emotional eating. TFEQ subscale scores are sums of the item scores of 0 or 1, while WREQ subscale scores are averages of the item scores on a 5-point Likert scale, and thus have a range of 1-5. Questionnaire completion rates were 100% at baseline and Month 1, 94% at Month 3, 83% at Month 6, and 76% at Month 12.

Statistical Analysis

To assess the fit of the WREQ structure, confirmatory factor analysis was applied to the baseline data. Standard cutoffs for acceptability in goodness-of-fit indices were used: standardized root mean square residual (SRMR), root mean square error of approximation (RMSEA), comparative fit index (CFI), and normed fit index (NFI) (Hu & Bentler, 1999; Smith, 2015). Cronbach's alpha levels were used to determine internal consistency within each WREQ

factor at baseline. To establish concurrent validity, Pearson correlation coefficients were calculated between the baseline values of the three TFEQ subscales and the four WREQ subscales.

Relationships with weight loss over the five assessment time points of the trial were analyzed for all randomized participants by multilevel models using maximum likelihood to handle missing data. Individual trajectories were modeled for all randomized subjects using the available data. The trajectory of weight change was modeled by including linear and quadratic effects of time (trial week) as fixed factors, and all models were controlled for group assignment and baseline BMI and age. The time effects were also included as random effects to model the individual trajectories. Separate models were run with each of the TFEQ and WREQ subscales as a covariate, in order to determine their individual impact on the weight change trajectory. Each subscale was tested both as the baseline level alone and as a time-varying covariate. The data were analyzed using SAS software (version 9.4, 2013, SAS Institute Inc., Cary, NC).

Results

On average, participants in all groups lost weight during the first six months of intervention and maintained most of this loss at the end of the trial. As previously reported, however, there were significant differences in weight loss trajectories across groups (Rolls et al., 2016). Between Months 1 and 4, the Pre-portioned Foods group lost weight at a greater rate and then regained weight at a faster rate. As a result, there were no significant differences in mean (± SEM) weight loss across groups at Month 6 (5.2 ± 0.4 kg) or Month 12 (4.5 ± 0.5 kg).

Table 3.3 reports mean WREQ and TFEQ subscale scores for the five assessment time points of the trial. Mean scores for TFEQ restraint and WREQ routine and compensatory

restraint increased from baseline during intervention; in contrast, scores for TFEQ disinhibition and WREQ external and emotional eating decreased. TFEQ hunger also decreased. For both TFEQ and WREQ subscales, all significant changes occurred in the first 3 months of the trial. There was no further change in mean subscale scores at Months 6 or 12, and none had returned to baseline levels at Month 12.

WREQ Confirmatory Factor Analysis

The four-factor structure of the WREQ was reproduced in the confirmatory factor analysis of the baseline data (Table 3.4). The model fit was acceptable (SRMR: 0.05, RMSEA: 0.07, CFI: 0.95, NFI: 0.89). Further analyses showed some minor misfit on the restraint subscales: one routine restraint item (Item 1) loaded with the compensatory restraint items, and Item 3 had a weak loading (< 0.50). When constrained to three factors, all restraint items loaded onto a single factor, and the model fit indices were comparable (SRMR: 0.06, RMSEA: 0.07, CFI: 0.94, NFI: 0.88). For both models, fit indices were within or approaching the thresholds for acceptable fit.

WREQ Reliability

The baseline administration of the WREQ demonstrated good internal consistency for the four-subscale model: Cronbach's alpha values were 0.82 for external eating, 0.93 for emotional eating, 0.61 for routine restraint, and 0.80 for compensatory restraint. Combining the two restraint subscales into one subscale produced an alpha value of 0.78 for overall restraint.

WREQ Validity

Baseline correlations between WREQ and TFEQ subscales. Correlations between the WREQ and TFEQ subscales at baseline are presented in Table 3.5. The two restraint subscales on the WREQ correlated as expected with the TFEQ restraint score; for example, WREQ routine

restraint correlated positively with TFEQ restraint ($r = 0.66$, $p < 0.0001$). Both external and emotional eating on the WREQ correlated strongly with TFEQ disinhibition as well as marginally with TFEQ hunger.

Correlations with weight change across the year. Table 3.6 shows the coefficients of the model using polynomial effects of time to characterize weight change and controlling for group assignment and baseline BMI and age. The trajectory had a significant positive linear coefficient (0.57 kg/week, $p < 0.001$) and a negative quadratic coefficient (-0.01 kg/week^2, $p < 0.001$), corresponding to weight loss in the initial months of the trial and some weight regain in the latter months. Baseline BMI positively influenced weight loss; participants with higher initial BMI tended to lose weight at a faster rate during the trial. Group assignment was not related to the trajectory of weight loss across the five assessment time points, unlike the finding for all 23 time points in the trial (Rolls et al., 2016). Lower baseline TFEQ restraint predicted greater weight change over the year (regression coefficient -0.01, $p < 0.05$). Baseline levels for all other subscales were not significantly related to weight change over one year.

Examining multiple administrations of the questionnaires revealed that subscales from both the TFEQ and the WREQ were related to weight change during the trial (Table 3.6). For the WREQ, routine restraint and compensatory restraint were both positively related to weight loss (both $p < 0.001$), indicating that on average across all time points, individuals with higher scores on these restraint subscales had greater weight loss. Conversely, WREQ external eating and WREQ emotional eating were negatively related to weight loss across time (both $p < 0.01$), with lower levels of these eating behaviors correlating with greater weight loss. For the TFEQ, restraint was positively related to greater weight loss across 12 months while disinhibition was

negatively related to these outcomes (both $p < 0.0001$), showing the same pattern as the WREQ. TFEQ hunger was also negatively related to weight loss ($p < 0.0001$).

Discussion

This study evaluated repeated administrations of two eating behavior questionnaires, the Three-Factor Eating Questionnaire (TFEQ) and the Weight-Related Eating Questionnaire (WREQ), in the context of a year-long weight loss trial. Using data collected at baseline, the factor structure of the newer WREQ was confirmed, and strong correlations with the subscales of the standard TFEQ were demonstrated, specifically between WREQ and TFEQ restraint scales and between WREQ eating scales and TFEQ disinhibition. In addition, both external and emotional eating on the WREQ correlated with TFEQ hunger, demonstrating that higher levels of behaviors associated with overeating are also related to greater overall feelings of hunger in general. Longitudinal analyses found consistent correlations with weight change for the related subscales on the two questionnaires. This is the first study to analyze how weight change over a year relates to multiple measurements of the WREQ subscales, and these analyses provide support for the use of the WREQ as an alternative to the TFEQ.

Analyses of the reliability and validity of the WREQ showed that the psychometric properties of the questionnaire were consistent with previous research demonstrating strong internal consistency for the subscales (Schembre & Geller, 2011; Schembre et al., 2009); these previous findings were extended by demonstrating robust concurrent correlations with the TFEQ subscales. Confirmatory factor analysis showed an acceptable fit for the original four-factor structure of the WREQ. Since the WREQ subscales of routine and compensatory restraint appear to measure a very similar construct, combining those items into one subscale could create a

stronger factor structure; alternatively, adding items to each subscale could improve the ability to discriminate between different aspects of dietary restraint. Notably, the internal consistency shown for the two restraint scales in these findings are comparable to those found in participants with overweight or obesity in the previous validation paper (Schembre & Geller, 2011). However, internal consistency for the two restraint scales was considerably higher in the normal weight participants in that study. Therefore, additional work is needed to determine how weight status affects how individuals interpret and respond to the restraint items.

The TFEQ may be preferable to the WREQ in some situations because it includes a larger number of items, thus providing a better measure of the different facets of these eating behaviors as well as the variability between individuals. The use of the TFEQ also allows direct comparison with the large number of weight loss trials in which it has been administered. However, the original four-factor structure of the WREQ provides a useful assessment of eating behavior constructs, and in settings where a less burdensome measure is required, the WREQ offers an efficacious alternative to the TFEQ.

Associations with weight change during the trial were found with only one of the baseline subscale scores, TFEQ restraint. The finding that lower baseline restraint predicted greater weight loss likely reflects a greater opportunity to increase the restrained eating behaviors that affect weight. Previous research in women with obesity showed a similar pattern in which lower baseline restraint predicted greater weight loss, while baseline disinhibition and hunger were not related to weight change (Foster et al., 1998). The results from the present trial also support the literature showing higher baseline restraint is associated with increased risk of weight gain (Drapeau et al., 2003; Hill, 2004; Stice, et al., 1999). In contrast, data evaluating the WREQ in relation to weight are limited. One past study using a single administration of the WREQ found

that routine restraint and emotional eating were associated with self-reported, retrospective weight change (Schembre & Geller, 2011). However, we did not replicate those findings with baseline WREQ scores when weight change was measured in a population of experienced dieters during intervention.

Repeated administration of the questionnaires revealed a stronger pattern of correlation between eating behaviors and weight change than a single administration at baseline. The relationships found between weight change and the TFEQ subscales are consistent with previous literature showing that increases in dietary restraint and decreases in disinhibition are associated with greater weight loss (Dalle Grave, Calugi, Corica, Di Domizio, & Marchesini, 2009; Johnson et al., 2012; Pliner & Saunders, 2008). The finding that the relationship between restraint and weight change was negative at baseline and was positive when examined over time indicates that both lower initial restraint and increases in restraint during intervention can promote weight loss. Multiple assessments of the WREQ, as in previous findings with the TFEQ (Pliner & Saunders, 2008; Schur et al., 2010), were also more strongly related to weight change than a single baseline measurement, adding further support for its validity as a measure of weight-related eating behaviors when administered repeatedly.

Based on the findings of this study, it is advisable to administer either the TFEQ or the WREQ at least twice over the course of an intervention. If one administration is the only option, it is preferable to use the TFEQ if it is not too burdensome to participants. However, in the context of an intervention, administering these measures only at baseline may have limited utility for predicting weight change. Data from this trial show the value in frequent, early measurement for evaluating these eating behaviors. The greatest magnitude of change in mean eating behavior scores occurred in the first three months, suggesting not only that repeat assessment is important

but that frequent measurement at early time points may be key for capturing behavior change. Additional work could inform its longitudinal validity in samples not represented here, such as men or those individuals with conditions such as an eating disorder or depression. Since these eating behaviors are related to weight change, a future direction could be to intervene early in an intervention based on these subscale scores to help benefit longer-term weight outcomes.

It should be noted that shorter versions of the original 51-item TFEQ have been proposed and have data supporting their validation. They comprise an initial 18-item version measuring restraint, emotional eating, and uncontrolled eating (Karlsson, Persson, Sjöström, & Sullivan, 2000); a 21-item version adding three additional emotional eating items (Tholin, Rasmussen, Tynelius, & Karlsson, 2005); and a final 18-item version that removes three of the restraint items (Cappelleri et al., 2009). The utility of these shorter versions of the TFEQ in comparison to the WREQ cannot be assessed with the trial data presented here, but they may offer an equally efficacious alternative since they address some criticisms of the original TFEQ such as the limited range of responses. Other weaknesses remain in these shorter versions, however, including a tendency toward floor and ceiling effects in the subscales with fewer items (Cappelleri et al., 2009). There is also a lack of consensus on which shorter version to use; as a result, there is limited literature assessing the validity of any specific version (Cappelleri et al., 2009; Tholin et al., 2005). The WREQ offers an alternative that combines the strengths of the TFEQ with the more specific external and emotional eating assessment of the DEBQ in a shorter, updated form that is simple to administer.

Overall, the WREQ in its current form demonstrates utility for identifying cognitive and behavioral correlates of weight change in a long-term weight loss trial. Combining its restraint items into one subscale or adding additional items could strengthen its utility to accurately assess

restraint across time. In a context where minimizing participant burden is important, the WREQ provides an acceptable alternative for measuring eating behavior.

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Table 3.1: Baseline characteristics of women in The Portion-Control Strategies Trial

Characteristic	(n = 186)
Age (y)	50.0 (10.6)
Body weight (kg)	91.2 (12.7)
Body mass index (kg/m^2)	34.0 (4.2)
Weight loss attempts in past year, n	2.1 (2.5)
Race, n (%)	
White	184 (98%)
African-American	2 (1%)
More than one race	1 (1%)
Ethnicity, n (%)	
Not Hispanic	184 (99%)
Hispanic	2 (1%)
Education, n (%)	
High school graduate	27 (15%)
Some college education	56 (30%)
College degree	57 (31%)
Professional or graduate degree	25 (27%)
Employment, n (%)	
Employed full-time	114 (61%)
Employed part-time	32 (17%)
Not employed	40 (22%)

Values are mean (SD) unless otherwise noted.

Table 3.2: Definition of TFEQ and WREQ subscales with related subscales displayed in the same row

Three-Factor Eating Questionnaire (TFEQ)*		Weight-Related Eating Questionnaire (WREQ)**	
Restraint (21 items, Range 0-21)	Restriction of food intake as a means of controlling weight	Routine Restraint (3 items, Range 1-5)	Perceived restriction of energy intake as a way to manage weight; more rigid overall
		Compensatory Restraint (3 items, Range 1-5)	Perceived overconsumption followed by a restrained period to compensate; more flexible overall
Disinhibition (16 items, Range 0-16)	Removal of eating inhibition in response to environmental or emotional states	External Eating (5 items, Range 1-5)	Eating in response to external cues such as the smell or sight of food regardless of any internal hunger or satiety cues
	Heightened response to food cues	Emotional Eating (5 items, Range 1-5)	Eating in response to negative emotions
Hunger (14 items, Range 0-14)	Susceptibility to feeling hungry in general	[No corresponding subscale]	

*TFEQ scoring: Item responses are scored as 0 or 1 and summed for each subscale.

**WREQ scoring: Item responses are scored as 1 to 5 and averaged for each subscale.

Table 3.3: TFEQ and WREQ subscale scores at the 5 assessment time points of the trial

Subscale	Baseline (n = 186)	Month 1 (n = 186)	Month 3 (n = 175)	Month 6 (n = 154)	Month 12 (n = 142)
TFEQ Restraint	8.90 (0.27)[a]	13.44 (0.25)[b]	14.09 (0.28)[b,c]	14.47 (0.28)[c]	14.29 (0.31)[c]
TFEQ Disinhibition	9.74 (0.26)[a]	8.54 (0.27)[b]	7.84 (0.27)[c]	8.01 (0.30)[b,c]	7.75 (0.33)[b,c]
TFEQ Hunger	6.20 (0.25)[a]	5.44 (0.25)[b]	5.08 (0.25)[b]	5.19 (0.28)[b]	5.09 (0.29)[b]
WREQ Routine Restraint	1.83 (0.04)[a]	2.37 (0.06)[b]	2.50 (0.06)[b]	2.48 (0.06)[b]	2.37 (0.06)[b]
WREQ Compensatory Restraint	2.30 (0.06)[a]	2.66 (0.06)[b]	2.78 (0.07)[b]	2.82 (0.08)[b]	2.78 (0.08)[b]
WREQ External Eating	2.98 (0.07)[a]	2.61 (0.07)[b]	2.51 (0.07)[b,c]	2.50 (0.08)[b,c]	2.48 (0.08)[c]
WREQ Emotional Eating	2.92 (0.09)[a]	2.59 (0.09)[b]	2.49 (0.09)[b]	2.51 (0.10)[b]	2.44 (0.11)[b]

TFEQ, Three-Factor Eating Questionnaire; WREQ, Weight-Related Eating Questionnaire.

All values are mean scores (SEM).

[a,b,c] Means for the same subscale with different letters are significantly different ($p < 0.05$).

Table 3.4: Confirmatory factor analysis of the WREQ using baseline data from the trial (n = 186)

Subscale	Item #	Factor 1	Factor 2	Factor 3	Factor 4
External Eating	5	0.60			
	8	0.72			
	9	0.83			
	11	0.52			
	13	0.80			
Emotional Eating	2		0.83		
	4		0.82		
	6		0.90		
	14		0.84		
	15		0.87		
Routine Restraint	1			0.71	
	3			0.50	
	7			0.48	
Compensatory Restraint	10				0.68
	12				0.87
	16				0.71

All values are standardize regression weights representing factor loadings.

WREQ, Weight-Related Eating Questionnaire.

Table 3.5: Correlations between TFEQ and WREQ subscales at baseline of the trial (n = 186)

Subscale	TFEQ Restraint	TFEQ Disinhibition	TFEQ Hunger	WREQ Routine Restraint	WREQ Compensatory Restraint	WREQ External Eating	WREQ Emotional Eating
TFEQ Restraint	1.00						
TFEQ Disinhibition	0.02	1.00					
TFEQ Hunger	0.01	0.51*	1.00				
WREQ Routine Restraint	**0.66***	0.10	-0.03	1.00			
WREQ Compensatory Restraint	**0.39***	**0.08**	-0.17	0.50*	1.00		
WREQ External Eating	**0.02**	**0.71***	**0.49***	0.08	0.13	1.00	
WREQ Emotional Eating	**0.06**	**0.68***	**0.30***	0.18	0.17	0.44*	1.00

TFEQ, Three-Factor Eating Questionnaire; WREQ, Weight-Related Eating Questionnaire.

All values are Pearson correlation coefficients ranging from -1 to 1.

*$p < 0.0001$

Table 3.6: Characteristics of random coefficients models of the relationship between TFEQ and WREQ subscales and weight loss (kg) during the trial.

Variable	Base model coefficient (SEM)	Fixed effect coefficient (SEM)
Fixed effects included in all models		
Time, linear (week)	0.57* (0.05)	
Time, quadratic (week*week)	-0.01* (0.00)	
Baseline BMI (kg/m^2)	0.005 (0.006)	
Baseline Age (years)	0.00 (0.00)	
Fixed effects tested individually		
TFEQ Restraint Score		0.30* (0.05)
TFEQ Disinhibition Score		-0.25* (0.05)
TFEQ Hunger Score		-0.28* (0.05)
WREQ Routine Restraint Score		0.88* (0.23)
WREQ Compensatory Restraint Score		0.70* (0.20)
WREQ External Eating Score		-0.77* (0.21)
WREQ Emotional Eating Score		-0.49* (0.17)

*$p < 0.01$

BMI: body mass index; TFEQ: Three-Factor Eating Questionnaire; WREQ: Weight-Related Eating Questionnaire.

Base model coefficients were included in all models. Fixed effects listed in the last column were each modeled separately to determine their individual impact on weight change.

Coefficients for the TFEQ and WREQ subscales represent average change in body weight per unit change in subscale score. The TFEQ and WREQ coefficients are not directly comparable due to different scoring metrics.

References

1. Flegal KM, Kruszon-Moran D, Carroll MD, Fryar CD, Ogden CL. Trends in Obesity Among Adults in the United States, 2005 to 2014. *JAMA* 2016;315:2284-2291.
2. Filiatrault ML, Chaput JP, Drapeau V, Tremblay A. Eating behavior traits and sleep as determinants of weight loss in overweight and obese adults, 2014;4:e140.
3. Teixeira PJ, Going SB, Sardinha LB, & Lohman TG. A review of psychosocial pre-treatment predictors of weight control. *Obes Rev*. 2005;6:43-65.
4. Bryant EJ, King NA, Blundell JE. Disinhibition: Its effects on appetite and weight regulation. *Obes Rev* 2007;9:409-419.
5. Johnson F, Pratt M, Wardle J. Dietary restraint and self-regulation in eating behavior. *Int J Obes (Lond)* 2012:36:665-674.
6. Rolls BJ, Roe LS, James BL, Sanchez CE. Does the incorporation of portion-control strategies in a behavioral program improve weight loss in a one-year randomized controlled trial?. *Int J Obes*. 2017;41:434-442.
7. Stunkard AJ, Messick S. The three-factor eating questionnaire to measure dietary restraint, disinhibition and hunger. *J Psychosom Res* 1985;29:71-83.
8. Dykes J, Brunner EJ, Martikainen PT, Wardle J. Socioeconomic gradient in body size and obesity among women: The role of dietary restraint, disinhibition and hunger in the Whitehall II study. *Int J Obes Relat Metab Disord* 2004;28:262-268.
9. Hays NP, Roberts SB. Aspects of eating behaviors "disinhibition" and "restraint" are related to weight gain and BMI in women. *Obes Res* 2008;16:52-58.
10. Thomas JG, Bond DS, Phelan S, Hill JO, Wing RR. Weight-Loss Maintenance for 10 Years in the National Weight Control Registry. *Am J Prev Med* 2014; 46:17-23.
11. Urbanek JK, Metzgar CJ, Hsiao PY, Piehowski KE, Nickols-Richardson SM. Increase in cognitive eating restraint predicts weight loss and change in other anthropometric measurements in overweight/obese premenopausal women. *Appetite* 2015;87:244-250.
12. Drapeau V, Provencher V, Lemieux S, Despres J-P, Bouchard C, Tremblay A. Do 6-y changes in eating behaviours predict changes in body weight? Results from the Quebec Family Study. *Int J Obes Relat Metab Disord* 2003;27:808-814.
13. Stice E, Cameron RP, Killen JD, Hayward C, Taylor CB. Naturalistic weight-reduction efforts prospectively predict growth in relative weight and onset of obesity among female adolescents. *J Consult Clin Psychol* 1999;67:967-974.
14. JaKa MM, Sherwood NE, Flatt SW, et al. Mediation of weight loss and weight loss maintenance through dietary disinhibition and restraint. *J Obes Weight Loss Ther* 2015;5:253.
15. Bryant EJ, Caudwell P, Hopkins ME, King NA, Blundell JE. Psycho-markers of weight loss. The roles of TFEQ disinhibition and restraint in exercise-induced weight management. *Appetite* 2012;58:534-541.
16. Schembre SM, Greene G, Melanson K. Development and validation of a weight-related eating questionnaire. *Eating Behav* 2009:10:119-124.
17. Van Strien T, Frijters JER, Bergers GPA, Defares PB. The Dutch Eating Behavior Questionnaire (DEBQ) for assessment of restrained, emotional, and external eating behavior. *Int J Eat Disord* 1986;5:295-315.
18. Wardle J. Eating style: A validation study of the Dutch Eating Behaviour Questionnaire in normal subjects and women with eating disorders. *J Psychosom Res* 1987;31:161-169.
19. Byrd-Bredbenner C, Quick V, Koenings M, Martin-Biggers J, Kattelmann KK. Relationships of cognitive load on eating and weight-related behaviors of young adults. *Eat Behav* 2016;21:89-94.
20. Schembre SM, Geller KS. Psychometric properties and construct validity of the weight-related eating questionnaire in a diverse population. *Obesity* 2011;19:2336-2344.

21. Schembre SM, Nigg CR, Albright CL. Race/ethnic differences in desired body mass index and dieting practices among young women attending college in Hawai'i. *Hawaii Med J* 2011;70:32-36.
22. Bouhaidar CM, DeShazo JP, Puri P, Gray P, Robins JL, Salyer J. Text messaging as adjunct to community-based weight management program. *Comput Inform Nurs* 2013;31:469-476.
23. Garner DM, Olmsted MP, Bohr Y, Garfinkel PE. The Eating Attitudes Test: psychometric features and clinical correlates *Psychological Medicine* 1982;12:871-878.
24. Beck AT, Ward CH, Mendelson M, Mock J, Erbaugh J. An inventory for measuring depression. *Arch Gen Psychiatry*. 1961;4:561-571.
25. Hu L, Bentler PM. Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling* 1999 6:1-55.
26. Smith T. *Confirmatory factor analysis for applied research*. 2nd ed. New York, NY: The Guilford Press; 2015.
27. Foster GD, Wadden TA, Swain RM, Stunkard AJ, Platte P, Vogt RA. The Eating Inventory in obese women: clinical correlates and relationship to weight loss. *Int J Obes Relat Metab Disord* 1998;22:778-785.
28. Hill AJ. Does dieting make you fat? *Br J Nutr*. 2004;92(Suppl 1):S15-8.
29. Dalle Grave R, Calugi S, Corica F, Di Domizio S, Marchesini G; QUOVADIS Study Group. Psychological variables associated with weight loss in obese patients seeking treatment at medical centers. *J Am Diet Assoc* 2009;109:2010-2016.
30. Pliner P, Saunders T. Vulnerability to freshmen weight gain as a function of dietary restraint and residence. *Physiol Behav*. 2008;93:76-82.
31. Karlsson J, Persson LO, Sjöström L, Sullivan M. Psychometric properties and factor structure of the Three-Factor Eating Questionnaire (TFEQ) in obese men and women. Results from the Swedish Obese Subjects (SOS) study. *Int J Obes Relat Metab Disord* 2000;24:1715-1725.
32. Tholin S, Rasmussen F, Tynelius P, Karlsson J. Genetic and environmental influences on eating behavior: The Swedish Young Male Twins Study. *Am J Clin Nutr* 2005;81:564-569.
33. Cappelleri JC, Bushmakin AG, Gerber RA, Leidy NK, Sexton CC, Lowe MR et al. Psychometric analysis of the Three-Factor Eating Questionnaire-R21: results from a large diverse sample of obese and non-obese participants. *Int J Obes (Lond)* 2009;33:611-620.

CHAPTER 4*

STUDY 3: VALIDATION OF A NEW QUESTIONNAIRE TO MEASURE SATISFACTION WITH THE DIET PRESCRIBED FOR WEIGHT MANAGEMENT

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James BL, Loken E, Roe LS, Rolls BJ. Validation of the Diet Satisfaction Questionnaire: a new measure of satisfaction with diets for weight management. *Obes Sci Pract* (under review).

Introduction

There is a need in the weight-management field for a measure of an individual's satisfaction with their current diet. In behavioral weight-loss interventions, the degree of adoption and maintenance of the prescribed diet is a strong predictor of the magnitude of long-term weight loss.[1,2] Weight-loss outcomes vary widely across individuals, and although this occurs for multiple reasons, an important cause is lack of adherence to a diet that promotes energy restriction.[3] Often, little is known about how the recommended diet is perceived by those receiving intervention, but dissatisfaction with the effect of the diet on daily life may make it difficult to adopt and sustain the prescribed dietary modifications.[4] Therefore, understanding the characteristics of a dietary program that facilitate or hinder weight management is critical. One possible instrument for this use, the 45-item Diet Satisfaction Questionnaire (DSat-45)[5], measures key aspects such as diet cost and convenience. This paper extends the initial validation of the DSat-45[6-8] by examining the relationship between diet satisfaction and weight loss during a one-year trial and assessing its factor structure in order to offer a refined version of the questionnaire for future use.

Questionnaires concerning satisfaction in weight-loss trials commonly measure general satisfaction or quality of life without specific questions about the diet itself. For example, validated questionnaires have shown the impact of obesity on quality of life as well as the improvements that result from weight loss.[9-11] Additionally, satisfaction with the type of intervention[12,13] and with the initial amount of weight loss[14] have been shown to predict long-term weight loss. These broad measures would be supported by administering a more specific questionnaire related to diet satisfaction, such as the DSat-45.

We examined the associations with weight loss and the factor structure of the DSat-45 using multiple datasets and larger samples than previously assessed in an effort to strengthen preliminary findings and improve the questionnaire. In addition, the DSat-45 has not previously been administered repeatedly in a longer-term trial; such multiple assessments over time would strengthen the conclusions that can be made about the reliability and validity of the measure. Therefore, the purpose of our analyses was to assess the 45-item Diet Satisfaction Questionnaire longitudinally, to evaluate the reliability and validity of the DSat-45 and any proposed revision in two separate samples (a one-year weight-loss trial and a one-time online survey administration), and to offer recommendations for its future use.

Methods

Questionnaire

The Diet Satisfaction Questionnaire was designed to provide specific assessment of satisfaction as it relates to following a particular diet. The questionnaire was originally developed and tested in 97 women participating in a weight-loss trial.[5] Questions were pilot tested, and the scale structure was refined so that the initially larger number of questions was reduced using principal components analysis to eliminate those with poor fit. This process resulted in a validated, 45-item questionnaire measuring characteristics of an individual's lifestyle and attitudes that reflected satisfaction with their current diet. Using principal components analysis[5], the 45 statements were grouped into seven scales of diet satisfaction: Healthy Lifestyle, Convenience, Cost, Family Dynamics, Preoccupation with Food, Negative Aspects, and Planning & Preparation (Table 4.1). The items are assessed using five responses ranging from "Disagree Strongly" to "Agree Strongly", which are scored from 1 to 5. Items are reverse-scored

if necessary, so that higher scores indicate greater diet satisfaction, and scale scores are created by averaging scores across items. A Total Diet Satisfaction score is also calculated by averaging all item scores. Table 4.2 provides the wording of the items for each scale in the DSat-45.

The DSat-45 has been administered several times in different populations. Analysis of the questionnaire among the 97 women in the original weight-loss trial[5] found that compared to baseline diets, satisfaction with both intervention diets improved significantly in supporting a healthier lifestyle, having fewer negative aspects, and leading to less preoccupation with food.[6] Findings from another group showed increases in diet satisfaction during a dietary intervention and correlations with attendance and compliance[7]; however, the only other study looking at factor structure found that a six-factor alternative offered a stronger fit[8], which suggested a need for further refinement. The aim of the present analyses was to evaluate the reliability and validity of the DSat-45 in two separate samples and to identify any improvements in the questionnaire for the purpose of evaluating diet satisfaction in future studies.

Participants and design: Sample 1

Sample 1 consisted of 186 women with overweight or obesity from central Pennsylvania who were enrolled in a one-year randomized controlled trial examining the effect of portion-control strategies on weight management. The women had a mean (±SD) age of 50.0±10.6 y and a mean body mass index (BMI) of 34.0±4.2 kg/m^2. Details of the Portion-Control Strategies Trial design and outcomes are published elsewhere.[15] In brief, participants were randomly assigned to one of three groups. The Standard Advice Group was taught to follow the Dietary Guidelines[16] to eat less and make healthy choices from all food groups. The Pre-portioned Foods Group received vouchers for pre-portioned meals and was taught to use other pre-portioned foods to manage intake. The Portion Selection Group was given tools such as food scales and

taught strategies such as using energy density to select portions. The trial protocol was approved by the Office for Research Protections at The Pennsylvania State University.

All participants received an equal amount of individual time with trained interventionists, consisting of 19 educational sessions and five assessment sessions over the course of one year. Body weight was measured at each session and the Diet Satisfaction Questionnaire (DSat-45) was completed at each of the five assessment sessions: baseline and Months 1, 3, 6, and 12. Questionnaire completion rates were 100% at baseline and Month 1, 94% at Month 3, 83% at Month 6, and 76% at Month 12. The main finding of the Portion-Control Strategies Trial[15] was that there were significant differences across intervention groups in the trajectories of weight loss over the year. In the initial months of intervention, the Pre-portioned Foods Group lost weight at a faster rate than the other two groups, and during later months they regained weight at a faster rate than the other groups. There were no significant differences in mean (±SEM) weight loss across groups at Month 6 (5.2±0.4 kg) or Month 12 (4.5±0.5 kg).

Participants and design: Sample 2

Sample 2 consisted of 510 adults from the United Kingdom who participated in a one-time online survey developed at the University of Leeds. Participants were primarily female (73%) and in the 18-34 y age range (77%). The survey was advertised using social media and on posters placed in and around Leeds. Participants were eligible if they had attempted to lose weight in the last six months, were age 18-65 y, and were not currently pregnant or breastfeeding. Height and weight were self-reported and only 38% complete, and are therefore not evaluated in these analyses. The DSat-45 was completed once by each respondent and there were no missing responses on the questionnaire. The DSat-45 was administered as part of a series of questionnaires aimed at identifying psychological and behavioral characteristics of

adults who had previously attempted weight loss using behavioral strategies. The study was approved by the Institute of Psychological Sciences Ethics Committee of the University of Leeds.

Statistical analyses

Data from both Sample 1 and Sample 2 were used to assess the reliability (internal consistency) and validity of the DSat-45 in order to determine its adequacy and whether to revise its content. Internal consistency among the items of each scale was evaluated by Cronbach's alpha, and correlation between scales was assessed by Pearson correlation coefficients. Confirmatory factor analysis was conducted on Sample 1 data collapsing across all five time points to determine the fit of the seven-scale DSat-45 structure; standard criteria were used to evaluate several goodness-of-fit indices: standardized root mean square residual (SRMR), root mean square error of approximation (RMSEA), comparative fit index (CFI), and normed fit index (NFI).[17,18]

Revisions to the questionnaire were based on the results from the Sample 1 factor analysis and guided by previously defined methods, summarized as follows.[19] Scales with multiple items that loaded poorly (< 0.30) or cross-loaded were considered for refinement or removal. Individual items were also considered for removal if they loaded poorly and if the remaining scale items reflected a clearer theoretical construct. Poorly performing scales were removed from the model before considering individual items for removal; item wording was not revised in this process. Modification indices were used to guide the scale revision process and to improve model fit, but the factor structure indicated by the confirmatory factor analysis results was the primary determinant of any revisions. Internal consistency and correlation between scales were again assessed for the refined questionnaire structure. Finally, confirmatory factor

analysis was conducted with Sample 2 data to compare fit between samples. Sample 2 data served to validate the findings with Sample 1. The strongest fit resulting from questionnaire refinement in Sample 1 was tested on an untouched dataset from Sample 2 to determine if findings in one sample and context would match those in another.

Examining how diet satisfaction ratings changed across time in a weight-loss trial was of interest, as was comparing scores between samples. A linear mixed model with repeated measures was used to evaluate changes in the scale scores of both the DSat-45 and the revised questionnaire across the five assessment points in Sample 1. The Tukey-Kramer method was used to adjust for multiple comparisons between mean scores.

In order to assess the relationship of the questionnaire to a clinically-relevant outcome, relationships between scale scores and weight loss across all time points of the trial were analyzed with random coefficients models, using maximum likelihood methods to handle missing data. In an intention-to-treat analysis, individual trajectories of weight loss were modeled for all randomized subjects using the available data. Linear and quadratic effects of time (trial week) were included as fixed factors, and all models were controlled for intervention group as well as baseline BMI and age. Each scale score was included separately as a covariate, first as a baseline value only and then as a time-varying covariate controlling for the baseline value, to determine the individual relationship of each scale with the weight-loss trajectory. The model was then run with all scales included as covariates to determine the relative strength of the relationships with weight loss. These analyses were run on Sample 1 data for the DSat-45 and for the revised version of the questionnaire that resulted from the factor analytic work. The data were analyzed using SAS software (version 9.4, 2013, SAS Institute Inc., Cary, NC). Outcomes from mixed models are reported as mean ± SEM and were considered significant at $P < 0.05$.

Results

Reliability and questionnaire revision

DSat-45: Reliability (Internal consistency)

In Sample 1, all seven DSat-45 scales showed acceptable internal consistency at each of the five assessment time points. Cronbach's alpha levels ranged from 0.68 for the Negative Aspects scale to 0.91 for the Healthy Lifestyle scale. Data in Sample 2 revealed similar patterns of internal consistency, with alpha levels ranging from 0.65 for the Convenience scale to 0.89 for the Healthy Lifestyle scale.

DSat-45: Changes in scale scores across time

Table 4.3 shows the mean scale scores over time for participants in Sample 1, and mean scores for the single administration in Sample 2. In Sample 1, satisfaction ratings for Healthy Lifestyle, Preoccupation with Food, Family Dynamics, and Total Diet Satisfaction showed a significant initial increase and remained elevated throughout the trial. Sample 2 scale scores were comparable to those seen in Sample 1.

DSat-45: Confirmatory factor analysis

Confirmatory factor analysis of the DSat-45 using the repeated measurements from Sample 1 found unacceptably low fit indices (SRMR: 0.09, RMSEA: 0.07, CFI: 0.78, NFI: 0.74) and multiple items that failed to load on any factor. In particular, two scales (Family Dynamics and Negative Aspects) had poor internal consistency and multiple items that loaded poorly. Even though Family Dynamics scores changed across time, it was eliminated due to poor fit. The Negative Aspects scale showed no change nor consistent item loading. On a third scale (Convenience), only four of the nine items loaded together. Items on the remaining four scales showed acceptable factor loading and internal consistency.

DSat-28: Revision and confirmatory factor analysis

The factor analysis of the DSat-45 in Sample 1 led to the removal of the scales with poor internal consistency (Family Dynamics and Negative Aspects). The scale related to convenience was truncated to the four related items, and based on their content, the scale was renamed "eating out". This process resulted in a revised 28-item questionnaire with five scales (DSat-28). Table 4.2 identifies the revised scales and items that were retained in the new version of the questionnaire, which was not independently administered in either sample.

Confirmatory factor analysis of the five-scale questionnaire in Sample 1 showed that fit indices for the revised structure were improved (SRMR: 0.07, RMSEA: 0.07, CFI: 0.87, NFI: 0.85). Table 4 shows the factor loadings for the revised, five-scale model using the data from Sample 1. The revised questionnaire was cross-validated in Sample 2, yielding a similar pattern of fit indices (SRMR: 0.08, RMSEA: 0.08, CFI: 0.86, NFI: 0.83). Thus, the cross-validation in a different sample showed that the questionnaire performed comparably across different populations and contexts.

DSat-28: Internal consistency and reliability of the new questionnaire

The internal consistency measures for the revised questionnaire are shown in Table 4.5 for the two samples. Overall, in Sample 1 internal consistency improved for the revised structure, ranging from 0.75 for the eating out scale to 0.91 for the Healthy Lifestyle scale. A similar pattern was seen for Sample 2, with alpha levels ranging from 0.73 to for the eating out scale to 0.89 for the Healthy Lifestyle scale, indicating a consistent, improved fit for the revised structure. The same patterns of correlation between scales of the DSat-28 were observed in both samples (Table 4.5), including between Cost and Preoccupation with Food, Cost and Planning & Preparation, and Preoccupation with Food and Healthy Lifestyle.

Validation and intervention effects

DSat-45: Relationships with weight across time

The DSat-45 baseline scale scores, which reflect pre-intervention diet, were not related to the trajectory of weight loss over time. However, three of the seven DSat-45 scales, which reflected the diet during intervention, were related to the rate of weight loss across time. The scales for Healthy Lifestyle ($P < 0.0001$), Preoccupation with Food ($P < 0.0001$), Planning & Preparation ($P = 0.02$), as well as the score for Total Diet Satisfaction ($P < 0.0001$), were positively related to weight loss over the 12 months of the trial. Higher scores on these scales related to a greater amount of weight loss. The remaining scales did not show associations with weight loss in the DSat-45 (all $P > 0.40$).

When the seven scales of the DSat-45 were included in the same model, the scales for Healthy Lifestyle ($P < 0.001$), Preoccupation with Food ($P = 0.01$), and Planning & Preparation ($P = 0.07$) remained significantly related to weight change or trended toward significance.

DSat-28: Relationship with weight across time

The scales of the DSat-45 that were found to relate to weight loss across time were not altered, nor was the wording changed for any items in developing the revised DSat-28. Furthermore, the scales that were removed from the DSat-45 to create the DSat-28 did not show any relationship with weight change. Although the DSat-28 was not administered, parallel analyses were run to determine the associations with weight if only these 28 items were analyzed. In parallel with the findings reported above, the scales for Healthy Lifestyle ($P < 0.0001$), Preoccupation with Food ($P < 0.0001$), Planning & Preparation ($P = 0.02$), and Total Diet Satisfaction ($P < 0.0001$) were positively related to weight loss over the 12 months of the trial (fixed effects coefficients in Table 4.6 representing change in weight loss (kg) per unit

change in each scale score). As an example, participants in the highest tertile of Healthy Lifestyle score lost 6.1±5.3 kg after a year of intervention, compared to those in the lowest tertile who lost 2.4±3.0 kg. A similar pattern was found for the scales of Preoccupation with Food (highest tertile: 5.7±5.5 kg; lowest tertile: 3.4±4.1 kg) and Planning & Preparation (highest tertile: 5.3±5.2 kg; lowest tertile: 3.5±4.0 kg). A combined model using the five DSat-28 scales identified significant or marginally significant relationships with weight loss for the scales of Healthy Lifestyle ($P < 0.001$), eating out ($P = 0.04$), and Preoccupation with Food ($P = 0.05$). These findings offer further validity for the revised DSat-28 questionnaire and inform future research on diet satisfaction.

Discussion

The DSat-28 provides a new, valid instrument for assessing diet satisfaction in the context of weight loss. Furthermore, satisfaction ratings were found to be related to the trajectory of weight loss over time in a controlled trial. Acceptable internal consistency and reliability were shown in both samples for the 45-item, seven-scale structure (DSat-45) of the questionnaire, but further analysis indicated that a 28-item, five-scale structure (DSat-28) offered substantial improvements. The revisions made the questionnaire more concise and focused on the scales that showed strong reliability and validity, as well as relationships with weight loss across time. Results of the validation were found to be comparable in two large and varied samples using different study designs, thus supporting the use of the questionnaire in different contexts. The data reported here validate the 28-item, five-scale version of the questionnaire, which is recommended for future use in assessing ratings of satisfaction with different aspects of weight-management diets.

Weight loss outcomes vary substantially across individuals, and the constructs measured within the DSat-28 likely impact an individual's willingness to adhere to a diet that promotes energy restriction. Specifically, these findings reflect that satisfaction with how one's diet supports a Healthy Lifestyle was strongly related to weight change over time, which suggests that in developing weight-loss interventions, the perceived quality of the prescribed diet can have an impact on weight management. This scale represents satisfaction with overall physical health, particularly the diet's contribution, which appears to be important for weight loss. The Planning & Preparation scale also showed a relationship with these outcomes, and that construct suggests that reduced time, thought, and effort spent on the diet relates to a greater level of satisfaction, and more beneficial weight outcomes. The relationship with the Preoccupation with Food scale follows in parallel, demonstrating that a diet that enables less food-centered thoughts, partially through greater satiety, relates to weight loss.

The revised Diet Satisfaction Questionnaire (DSat-28) should have utility in weight-loss treatment, more general dietary interventions, and in non-treatment contexts. Its ability to assess diet satisfaction both within and outside the context of weight loss treatment, as well as to assess change in satisfaction during treatment make it useful in clinical settings. Reduced participant burden in the shortened DSat-28 facilitates use in such settings compared to the original DSat-45.

Although initial weight loss is achievable for many, it tends to plateau, followed by weight regain. Lack of adherence to the lifestyle changes that produced the weight loss, of which diet is often key, is a major contributor to this regain.[20] With the ability to assess changes in satisfaction with the current diet, interventionists could develop strategies to help individuals re-commit to a diet plan or introduce novelty in the diet in a way that promotes adherence. Using

the DSat-28 to assess satisfaction with and acceptance of a prescribed diet could contribute to our understanding of the variables that predict individual weight management. Low satisfaction would indicate the need to adjust intervention to better fit the individual, in order to improve long-term adherence by eliminating barriers to adoption. Repeated administration during treatment could also identify changes in diet satisfaction, which might predict changes in adherence, which in turn likely affect weight loss.

The participants assessed in this study were predominantly female, limiting conclusions about different aspects of diet satisfaction in men. However, this study does show consistent factor structure for the questionnaire in different age ranges, since one study primarily assessed women over the age of 40, while the other evaluated men and women primarily under age 35. Dietary data were not collected for Sample 2 participants; this lack of information precluded investigating the effect of current dieting status on the outcome of diet satisfaction. However, the validation findings were consistent in both samples despite the large difference in settings (a single-administration online survey in a free-living European sample compared to repeated assessment in a weight-loss trial in the US). Future studies should broaden these findings by administering the DSat-28 in additional populations and settings. The data from this study provide preliminary evidence for the validity of the revised version of the Diet Satisfaction Questionnaire, establishing the DSat-28 as a valid measure of different aspects of satisfaction with weight-management diets.

Table 4.1: Scale structure of the Diet Satisfaction Questionnaire

Scale	Scale description	Number of items
Healthy Lifestyle	Degree to which the diet supports a healthy lifestyle and promotes positive feelings about life	8
Convenience	Ease of finding foods that fit within the diet at restaurants and grocery stores	9
Cost	Financial cost of the diet	5
Family Dynamics	Family support of, and attitudes toward, the individual following the diet	6
Preoccupation with Food	Tendency to think about food and hunger between meals	6
Negative Aspects	Negative feelings of following the diet, such as deprivation, self-consciousness, or inconvenience	6
Preparation and Planning	Amount of time and effort spent in planning and preparing food on the diet	5

Scales are measured using a five-point Likert scale ranging from “Disagree Strongly” to “Agree Strongly”. Items are scored from 1 to 5, and reverse scored if necessary, so that higher scores indicate greater diet satisfaction. Item scores are averaged to provide scale scores and an overall satisfaction score.

Table 4.2: Original 45 items of the seven-scale Diet Satisfaction Questionnaire (DSat-45©), with revised items and scales of the five-scale version (DSat-28©) indicated in bold

Scale	Original Item #	Item Wording
Healthy Lifestyle	1	***I have a lot of energy.***
	2	***I feel good about myself.***
	3	***I think that I eat a healthy diet.***
	4	***I believe that I am reducing my risk for disease by the way that I eat.***
	5	***I believe that I am reducing my risk for disease by the way that I exercise.***
	6	***I think that I have a healthy lifestyle.***
	7	***I am satisfied with my current diet.***
	8*	***The way that I currently eat makes me feel guilty.***
Convenience **[Eating Out in DSat-28]**	9*	***The way I currently eat prevents me from eating in restaurants frequently.***
	10	***When dining out, I can easily choose foods from the menu that fit into my current diet.***
	11*	***Finding appropriate food choices at restaurants is difficult.***
	12*	*I have to prepare most of my foods "from scratch".*
	13	*I find eating satisfying*
	14*	***I have difficulty finding the foods I want when eating out.***
	15	*I find it easy to shop at my grocery store for the kinds of foods I eat.*
	16*	*I limit my choice of restaurants.*
	17	*I have plenty of different types of foods to choose from with my current diet.*
Cost	18*	***I feel that I spend a large amount of my budget on the foods that I eat.***
	19	***I think that preparing food and meals for the way I eat now is economical.***
	20*	***I think that preparing food and meals for the way I eat now costs a lot of money.***
	21*	***I spend a lot of money on food.***
	22*	***It is hard for me to afford the kind of foods that I eat.***
Family Dynamics	23*	*I feel that the way I eat now bothers my family.*
	24	*My family encourages me to keep eating the way I am eating now*
	25	*My family supports my efforts to eat a healthy diet.*
	26	*I enjoy getting together for holiday meals with family.*
	27*	*My family discourages me from eating the way I am eating now.*
	28*	*The way I currently eat causes stress within my family.*
Preoccupation with Food	29*	***Thoughts of food are always on my mind.***
	30*	***I think about food between almost every meal.***
	31*	***I have cravings for some of my favorite foods.***
	32*	***I always feel like I want to snack between meals.***
	33*	***I often feel hungry.***
	34*	***I feel that my diet controls my life.***
Negative Aspects	35*	*I feel deprived based on what I order when eating in a restaurant.*
	36*	*I feel self-conscious trying to eat my current diet at social events.*
	37*	*I feel embarrassed if I order specially prepared foods in a restaurant.*
	38	*My family eats the same foods that I currently eat.*
	39*	*I feel deprived when I choose to avoid some of my favorite foods.*
	40*	*I have to prepare separate meals for my family and myself.*
Planning & Preparation	41*	***I spend a lot of time planning my meals.***
	42*	***I spend a lot of time shopping for food.***
	43*	***I think preparing foods and meals for the way I eat now is time-consuming.***
	44*	***I think preparing food and meals for the way I eat now requires a lot of effort.***
	45*	***I spend a lot of time looking for new ideas for food and meals that fit into my current diet.***

Scales are measured using five responses ranging from "Disagree Strongly" to "Agree Strongly", which are scored from 1 to 5. Items are reverse-scored if necessary (indicated by an asterisk), so that higher scores indicate greater diet satisfaction. Item scores are averaged to provide scale scores.

Table 4.3: Mean scores[1] (±SD) on the 45-item version of the Diet Satisfaction Questionnaire (DSat-45) across five time points for Sample 1 and for the single administration in Sample 2

	Sample 1 (n = 186)					Sample 2 (n = 510)
Scale	Baseline (n = 186)	Month 1 (n = 186)	Month 3 (n = 175)	Month 6 (n = 154)	Month 12 (n = 142)	(n = 510)
Healthy Lifestyle	2.60±0.74[a]	3.86±0.65[b]	3.72±0.77[c]	3.81±0.70[b,c]	3.72±0.76[c]	3.52±0.88
Convenience[2]	3.76±0.57[a,d]	3.58±0.52[b]	3.66±0.56[a,b,c]	3.74±0.52[a,c,d]	3.80±0.53[d]	3.39±0.54
Eating Out (DSat-28)	3.70±0.78[a,c]	3.46±0.82[b]	3.62±0.84[a,b]	3.81±0.80[c]	3.87±0.76[c]	3.33±0.53
Cost	3.01±0.75[a]	3.28±0.72[b]	3.21±0.71[b]	3.21±0.73[a,b]	3.14±0.79[a,b]	3.21±0.74
Family Dynamics[2]	3.84±0.66[a]	4.30±0.66[b]	4.20±0.70[b]	4.28±0.67[b]	4.24±0.65[b]	3.84±0.67
Preoccupation with Food	2.78±0.77[a]	3.11±0.77[b]	3.07±0.80[b]	3.14±0.88[b]	3.16±0.87[b]	2.95±0.83
Negative Aspects[2]	3.69±0.62[a,c,d]	3.53±0.73[b]	3.62±0.69[a,b]	3.80±0.64[d]	3.88±0.69[c,d]	3.40±0.69
Planning & Preparation	3.43±0.80[a]	3.46±0.77[a]	3.37±0.77[a]	3.38±0.82[a]	3.41±0.82[a]	3.21±0.79
Total Diet Satisfaction (DSat-45)[2]	3.30±0.37[a]	3.61±0.41[b]	3.58±0.44[b]	3.65±0.44[b]	3.65±0.44[b]	3.38±0.52
Total Diet Satisfaction (DSat-28)	2.83±0.38[a]	3.05±0.33[b]	3.03±0.38[b,c]	3.04±0.37[b,c]	2.99±0.35[c]	3.05±0.48

[1]Scale scores range from 1 to 5

[2]This scale was omitted or revised in the DSat-28

[a,b,c,d] Means for the same scale with different letters are significantly different ($p < 0.05$)

Table 4.4: Confirmatory factor analysis of the revised Diet Satisfaction Questionnaire using data from a one-year weight-loss trial (Sample 1; n = 186)

Scale	Item #	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
Healthy Lifestyle	1	0.60				
	2	0.65				
	3	0.86				
	4	0.87				
	5	0.70				
	6	0.83				
	7	0.81				
	8	0.63				
Eating Out	9		0.48			
	10		0.59			
	11		0.82			
	12		0.76			
Cost	13			0.74		
	14			0.49		
	15			0.79		
	16			0.84		
	17			0.54		
Preoccupation with Food	18				0.85	
	19				0.87	
	20				0.43	
	21				0.54	
	22				0.61	
	23				0.64	
Planning & Preparation	24					0.51
	25					0.59
	26					0.90
	27					0.87
	28					0.44

All values are standardized regression weights representing factor loadings.

Table 4.5: Internal consistency within and correlations between scales for the revised, five-scale Diet Satisfaction Questionnaire (DSat-28)

Sample 1 (n = 186)	Cronbach's alpha	Pearson correlations				
		Healthy Lifestyle	Eating Out	Cost	Preoccupation with Food	Planning & Preparation
Healthy Lifestyle	$\alpha = 0.91$	1.00				
Eating Out	$\alpha = 0.75$	0.07	1.00			
Cost	$\alpha = 0.81$	0.21*	0.17*	1.00		
Preoccupation with Food	$\alpha = 0.83$	0.39*	0.23*	0.24*	1.00	
Planning & Preparation	$\alpha = 0.81$	0.07	0.19*	0.39*	0.34*	1.00

Sample 2 (n = 510)	Cronbach's alpha	Pearson correlations				
		Healthy Lifestyle	Eating Out	Cost	Preoccupation with Food	Planning & Preparation
Healthy Lifestyle	$\alpha = 0.89$	1.00				
Eating Out	$\alpha = 0.73$	0.05	1.00			
Cost	$\alpha = 0.82$	0.20*	0.19*	1.00		
Preoccupation with Food	$\alpha = 0.87$	0.33*	0.30*	0.33*	1.00	
Planning & Preparation	$\alpha = 0.85$	0.06	0.29*	0.43*	0.34*	1.00

* $p < 0.001$

Correlations were calculated across five time points for Sample 1 and for the single observation for Sample 2.

Table 4.6: Coefficients of random coefficients models examining the relationships between scales of the Diet Satisfaction Questionnaire (DSat-28) and the trajectory of weight loss (kg) during a one-year trial (Sample 1; n=186 women)

Variable	Base model coefficient (mean ± SEM)	Significance	Fixed effect coefficient (mean ± SEM)	Significance
Fixed effects included in all models				
Time, linear (week)	0.57 ± 0.05	P < 0.001		
Time, quadratic (week*week)	-0.01 ± 0.000	P < 0.001		
Baseline BMI (kg/m^2)	0.005 ± 0.006	P = 0.42		
Baseline Age (years)	0.000 ± 0.000	P = 0.15		
Fixed effects tested individually[1]				
Healthy Lifestyle scale			1.16 ± 0.11	P < 0.001
Eating Out scale			-0.09 ±0.10	P = 0.37
Cost scale			0.10 ± 0.12	P = 0.40
Preoccupation with Food scale			0.75 ± 0.11	P < 0.001
Planning & Preparation scale			0.25 ± 0.10	P = 0.02
Total Diet Satisfaction			1.23 ± 0.22	P < 0.001

BMI: body mass index
[1]Scales were included separately in the model to determine their individual relationship with weight loss. Results from models including all scales together are included in the text.

References

1. Ello-Martin JA. *Reducing dietary energy density for the treatment of obesity: the long-term effects on weight loss, hunger, and diet satisfaction* [dissertation]. University Park: The Pennsylvania State University; 2006.
2. MacLean PS, Wing RR, Davidson T, Epstein L, Goodpaster B, Hall KD, et al. NIH working group report: innovative research to improve maintenance of weight loss. *Obesity (Silver Spring)*. 2015;23:7-15.
3. Gupta S, Wang Z. Treatment satisfaction with different weight loss methods among respondents with obesity. *Clin Obes*. 2016;6:161-170.
4. Shapiro JR, Koro T, Doran N, Thompson S, Sallis JF, Calfas K, et al. Text4Diet: a randomized controlled study using text messaging for weight loss behaviors. *Prev Med*. 2012;55:412-417.
5. Finch EA, Linde JA, Jeffery RW, Rothman AJ, King CM, Levy RL. The effects of outcome expectations and satisfaction on weight loss and maintenance: correlational and experimental analyses—a randomized trial. *Health Psychol*. 2005;24:608-616.
6. Guyonnet D, Chassany O, Picard C, Guillemin I, Meunier J, Seignobos E. Perceived subject outcomes and impact on health-related quality of life associated with diet using the new Food Benefits Assessment (FBA) questionnaire: development and psychometric validation. *Public Health Nutr*. 2008;11:1163-1172.
7. Kolotkin RL, Crosby RD, Kosloski KD, Williams GR. Development of a brief measure to assess quality of life in obesity. *Obes Res*. 2001;9:102-111.
8. Kolotkin RL, Crosby RD, Williams GR, Hartley GG, Nicol S. The relationship between health-related quality of life and weight loss. *Obes Res*. 2001;9:564-571.
9. Kolotkin RL, Norquist JM, Crosby RD, Suryawanshi S, Teixeira PJ, Heymsfield SB, et al. One-year health-related quality of life outcomes in weight loss trial participants: comparison of three measures. *Health Qual Life Outcomes*. 2009;7:53.
10. Katcher HI, Legro RS, Kunselman AR, Gillies PJ, Demers LM, Bagshaw DM, et al. The effects of a whole grain-enriched hypocaloric diet on cardiovascular disease risk factors in men and women with metabolic syndrome. *Am J Clin Nutr*. 2008;87:79-90.
11. Wheeler B. *Dietary satisfaction and its association with weight loss: an exploratory analysis* [master's thesis]. University Park: The Pennsylvania State University; 2013.
12. Rolls BJ, Roe LS, James BL, Sanchez CE. Does the incorporation of portion-control strategies in a behavioral program improve weight loss in a one-year randomized controlled trial?. *Int J Obes*. 2017;41:434-442.
13. U.S. Department of Agriculture and U.S. Department of Health and Human Services. Dietary Guidelines for Americans, 2010. 7th ed. Washington, DC: U.S. Government Printing Office, 2010.
14. MacLean PS, Wing RR, Davidson T, Epstein L, Goodpaster B, Hall KD, et al. NIH working group report: innovative research to improve maintenance of weight loss. *Obesity (Silver Spring)*. 2015;23:7-15.

CHAPTER 5

CONCLUSIONS

Implications

The extensive literature showing an effect of portion size on energy intake and weight management led to the development of the first longitudinal trial to evaluate the effect of different portion control strategies. The Portion-Control Strategies Trial was designed to help further the knowledge about portion control and weight management by directly comparing two different strategies over one year. Results from this trial indicate that the two portion control strategies, as well as a usual care condition, produced comparable results. On average participants in all three groups achieved significant weight loss and maintained most of that weight loss through one year. Almost half of enrolled participants achieved clinically significant weight loss, and improvements in cardiometabolic risk factors were observed for all three groups. The hypothesized differences in weight loss outcomes between the usual care group and the groups incorporating portion size knowledge were not observed. All groups did well, and adding portion-specific education did not convey added benefit in the end. (1)

The Pre-portioned Foods group did initially experience a faster rate of weight loss, likely due to the easily-implementable behavior changes they were prescribed. Their target behavior change could be implemented from the first day. The Diet-Satisfaction Questionnaire data showed that although those participants reported greater initial satisfaction with the cost and convenience of their diet, they also felt burdened by having to prepare separate meals for their family. This may have contributed to the steep decline in reported use of pre-portioned foods that came after the first month of treatment. It may also be that willingness to purchase the pre-portioned meals themselves as the vouchers tapered off may not have been high, despite the early weight loss. This trial chose to gradually decrease the number of vouchers instead of continuing them throughout the trial as a means of assessing a real-world lifestyle choice. Once the education is there regarding a behavioral strategy and its effectiveness (initial phase of treatment), can individuals be encouraged to adopt and sustain it on their own? This trial indicated that the purchase of pre-portioned foods persists when there is provision, but that the behavior declines quickly beyond that.

This decline could be attributable to many factors. With pre-portioned foods, it is possible that these participants were experiencing monotony with the food selection or deprivation from the amounts given. The burden of having to prepare and eat different meals from their friends and family was also a negative effect this group reported. The potential time and financial burden associated with this type of preparation may also have contributed to the decline. It is hard to know exactly what drove the decline in treatment adherence, but it is clear that this decline was associated with a steep rate of weight regain in this group, so that by Month 6 and Month 12, their average weight loss was no different than the other two groups. Future work could consider transitioning to a meal plan or grocery list system to provide structure for these participants but with added flexibility. Previous research has shown this tactic can produce even greater weight loss than food provision (2), possibly because it promotes self-efficacy in the individual.

The Portion Selection group with its focus on energy density in conjunction with portion control education was hypothesized to show the best weight loss outcomes. Previous weight loss trials have shown that a focus on implementing energy density strategies resulted in greater weight loss compared to a standard care group, and that the amount of decrease in overall energy density of the diet is associated with weight loss success. It is possible that the energy density education combined with a focus on using portion control tools in this trial was too complex of a message. Other work has shown that treatment targeting a single behavior change is more effective than combination treatment. Studies evaluating energy density education have shown that a simple, single message is more beneficial for weight loss than combining it with fat reduction (3) or meal replacements for weight loss maintenance. (4) Easily-implementable strategies that provide structure without overburdening participants appear to have the most success. This was shown here with the Pre-Portioned Foods group, where a straightforward behavior change was quickly implemented and produced good results.

It should be noted that all groups did well at losing weight, including the Standard Advice group. However, with the amount of direct contact with interventionists and the accountability and structure provided by this type of treatment program, it is not surprising they saw significant weight loss, as well. It

has been shown that having a strong control group, such as this one, which received equal face time with interventionists and intensive lifestyle intervention, has a substantial effect on the treatment group differences observed across trials. (5) Although it is necessary to have equal face-time across groups to truly compare treatment differences, it substantially reduces the ability to see between-group differences.

Strengths, limitations, and future directions

Results from this trial indicate that multiple approaches to weight management can be effective in an intensive lifestyle intervention, such as this trial. Both portion control strategies were effective at promoting weight loss but not more so than usual care. While one portion control strategy showed favorable results early in treatment, the behavior change needed to sustain that difference was not maintained.

These findings were also affected by the fact that these participants were experienced dieters who had likely been exposed to portion control messages prior to enrolling in the trial. Therefore, maintaining treatment fidelity was difficult. The educational messages received by the Standard Advice group to eat less while making healthy choices from each food group also shares overlap with some of the energy density messages the Portion Selection group received. This overlap in messages combined with the strong effect of face-to-face accountability regardless of treatment, resulted in equivalent weight losses in the end.

Future research should focus on identifying specific lifestyle changes that are easier to maintain long-term or on methods to aid individuals in maintaining behavior change. Alternatively, it may be helpful for some individuals to introduce novelty into their weight management strategy (6), where they introduce a different set of behavioral strategies every few months to prevent monotony and still maintain the energy deficit that produces weight loss.

STUDY 1: EARLY PREDICTORS OF WEIGHT LOSS IN A ONE-YEAR BEHAVIORAL WEIGHT LOSS PROGRAM

Implications

Weight loss outcomes did not vary significantly by treatment group overall in the trial. However, differences in weight loss between participants based on certain eating behaviors and psychological factors were observed. Weight loss in response to treatment is widely variable among individuals, and findings from this trial support that trend. These analyses were able to identify differences between these individuals early in treatment that predicted how well they did longer-term, which bolsters our ability to develop increasingly effective treatments.

Three key eating behaviors and psychological factors were identified in these early predictor analyses. Early change in restraint, particularly flexible restraint, and the healthy lifestyle component of diet satisfaction were predictive of longer-term weight loss. These changes were quantifiable in the first month of treatment and showed large variability between individuals. This variability was then predictive of variability in weight loss.

The goal of any weight loss treatment is to produce a result that benefits the health of the participant long-term, and creating sustainable lifestyle change is key for attaining that goal. The eating behaviors and psychological factors that serve as early predictors may hold insight into which targets are most malleable and responsive to treatment. (7) Targeting these factors directly instead of simply having them as a side-effect of treatment could potentially enhance long-term outcomes even more.

Although it was outside the scope of this trial, weight loss maintenance is a key area of research due to the high weight regain rate in those who initially lose weight successfully. It may be that targeting factors such as restraint at the beginning of weight loss treatment is not the key time since they tend to improve in response to behavioral treatment and initial motivation alone. The weight loss maintenance period may instead be the key time for intervening on these factors. In fact, disinhibition, particularly internal disinhibition, has been shown to consistently predict long-term weight regain. (8,9) Diet

satisfaction is also presumably an area where change over time in levels of satisfaction could predispose an individual to weight regain. Developing strategies to help those people respond to declining satisfaction in a way that sustains their healthy lifestyle and weight management while still addressing the source of dissatisfaction could help sustain their weight loss success. For some individuals, diet consistency is the key to weight loss maintenance (10), while for others, introducing novelty could help sustain motivation and commitment to healthy eating patterns. Developing strategies to identify critical time periods for intervention and targeted approaches to improving these factors has to potential to substantially improve weight loss outcomes.

Strengths, limitations, and future directions

The next question is what to do with this information. Interventions are needed that target these factors directly and help answer the direction of causality question. Currently, the direction of influence can be assumed, but it is conceivable that initial weight loss success would make an individual perceive their current diet is supporting a healthy lifestyle, rather than the reverse. Nevertheless, assuming these factors are influencing weight loss, early, repeat evaluation could become a routine practice in weight loss treatment, with the potential of identifying those individuals who have not reported change in these factors and intervening to promote more favorable outcomes.

It is currently unknown how effective it is to intervene and increase support or change treatment for an individual who does not initially respond well to treatment. Preliminary, short-term work has revealed a beneficial impact of bolstering treatment for these individuals identified early as non-responders, but those individuals still did not reach the same level of success as those who initially responded well (11). It is critical that longer-term work follow up on these findings to determine what kind of intervention is most effective for those who initially struggle and how effective it can be long-term.

It is also important to consider the psychological ramifications of this type of intervention. Those individuals who do not initially respond to treatment may already be experiencing disappointment and frustration (12). Providing additional support or alternative treatment options must be done in a way that promotes motivation and re-commitment rather than defeat. An alternative is to discontinue treatment altogether for these individuals to prevent further frustration. However, the focus of future work should be on identifying effective means for changing but continuing treatment.

Overall, early predictors offer an opportunity for validation that treatment is having a beneficial impact and will likely continue to do so for those individuals who show initial improvements in these factors. They also offer the opportunity to intervene for individuals who are not initially responsive, not showing these changes. Further research should focus on identifying additional early predictors of long-term outcomes in an effort to create a comprehensive picture of the factors contributing to weight management both short and long term.

STUDY 2: THE WEIGHT-RELATED EATING QUESTIONNAIRE OFFERS A CONCISE ALTERNATIVE TO THE THREE-FACTOR EATING QUESTIONNAIRE FOR MEASURING EATING BEHAVIORS RELATED TO WEIGHT LOSS

Implications

Identification of the most helpful questionnaires for measuring key variables is important in the continued pursuit of more effective treatment options. The analyses in paper two added support for the validation of the concise, 16-item Weight-Related Eating Questionnaire (WREQ) as an alternative for the longer Three Factor Eating Questionnaire. Both questionnaires revealed consistent associations with weight loss over the year. This study extended previous findings by repeatedly administering both side-by-side. Previously, the available WREQ data were limited to single administrations or short-term repeat administrations.

The goal of these analyses was less about trying to replace the gold standard questionnaire and more about identifying an optional scale that could measure similar constructs in a much shorter form. The confirmation of the WREQ as a valid alternative has practical implications for clinical and research settings where eating behavior measurement is not a main outcome but is still a factor of interest.

Given the findings in the early predictor analyses, the eating behaviors measured by these two questionnaires are key facets of weight management, even from early in treatment. Having a measure to accurately assess these factors before, during, and after treatment is vital to understanding how they affect weight loss and weight regain. Increasing the number of restraint items in each of the two restraint scales on the WREQ could strengthen its utility in assessing change over time. Currently, the amount of change assessed was not sufficient to be included in the early predictors analysis. It is possible that individuals do not change considerably in these behaviors during weight loss treatment, but given the substantial increase in restraint quantified by the TFEQ, it is more likely that strengthening the restraint scales on the WREQ would reveal a similar pattern.

These findings contribute to a small but growing body of evidence for the validity and utility of the WREQ as a concise measure of eating behavior. Additional work should bolster the restraint scales and evaluate the WREQ in different contexts and populations to support the findings reported here.

Strengths, limitations, and future directions

The WREQ could be improved upon by adding items to the restraint scales, and its use in diverse populations across more than one administration has yet to be evaluated. However, these findings add to a growing body of evidence supporting its utility in identifying eating behaviors that are directly related to weight management. Future work should combine the targeted approach to these facets of eating behavior detailed above using these scales to evaluate the direct impact of this kind of intervention.

STUDY 3: VALIDATION OF THE DIET SATISFACTION QUESTIONNAIRE (DSAT-45)

Implications

In following with the TFEQ and WREQ findings that built evidence for effective measures, the development of the Diet Satisfaction Questionnaire (DSat-28) has the potential to greatly enhance understanding of a poorly studied facet of weight loss treatment. Diet satisfaction, as a completely subjective perception of the individual undergoing treatment, has the potential to substantially affect how well that individual does during and following treatment.

Research in weight loss and weight loss maintenance repeatedly shows a vital role of dietary self-monitoring and self-regulation in promoting successful weight outcomes (13,14). Although diet satisfaction could be low and these behaviors still persist, it is far more likely that an individual who is satisfied with key facets of their diet, such as its support of a healthy lifestyle, the amount of planning and preparation time required, and the amount of time they spend preoccupied by thoughts of food, would undoubtedly do better long-term at sustaining that diet.

Strengths, limitations, and future directions

These analyses resulted in a restructuring of the Diet-Satisfaction Questionnaire, removing two scales that did not perform adequately and shortening another. However, this revised structure was validated in a second, large sample, and the scales that showed significant associations with weight loss over time remain unchanged in the revised version of the questionnaire.

Future research should expand on the populations and settings in which in DSat-28 is tested. Although it has not yet been tested, the DSat-28 has potential utility outside of treatment for general assessment of an individual's diet satisfaction at any point. Further research could also add scales beyond those assessed to further broaden the facets of diet satisfaction evaluated. Diet satisfaction measurement has the potential to inform the development of dietary interventions that take the most impactful aspects into account, as well as strengthening modifications to treatment across time if satisfaction levels change.

FINAL CONCLUSIONS

Research in the area of weight loss treatment is increasingly focused on identifying effective components of treatment and developing new methods for increasing long-term success rates. Recent work has identified the components of treatment viewed as most helpful to the participants themselves and found that individual telephone coaching, online weight tracking, and the accountability of having a health coach review that tracking were the most beneficial aspects. (15) This type of information can be used to create new treatments that are tailored to fit the needs of the individual and also utilize repeat assessment and the insight behavioral and psychological measures can provide to improve outcomes during treatment, as well.

As the work progresses, researchers and clinicians will increasingly be able to determine which types of treatment are most effective for certain types of individuals. Pinpointing the factors that predict how well someone will do is on the horizon, and the potential for encouraging those who do respond well to treatment onward and designing methods for supporting and tailoring to fit the needs of those who do not respond could substantially reduce the wide variability currently seen in weight loss outcomes. These areas of work in combination have the potential for ushering in a new era of weight loss treatment, one in which individuals are matched with the type of treatment that gives them the best chance at long-term success and the tools and encouragement needed to make lifestyle change permanent.

References

1. Rolls BJ, Roe LS, James BL, Sanchez CE. Does the incorporation of portion-control strategies in a behavioral program improve weight loss in a one-year randomized controlled trial? *Int J Obes*. 2017;41:434-442.
2. Wing RR, Jeffery RW, Burton LR, Thorson C, Nissinoff KS, Baxter JE. Food provision vs structured meal plans in the behavioral treatment of obesity. *Int J Obes Relat Metab Disord*. 1996;20:56-62.
3. Looney SM, Raynor HA. Behavioral lifestyle intervention in the treatment of obesity. *Health Serv Insights*. 2013;6:15-31.
4. Lowe MR, Butryn ML, Thomas JG, Coletta M. Meal replacements, reduced energy density eating, and weight loss maintenance in primary care patients: a randomized controlled trial. *Obesity (Silver Spring)*. 2014;22:94-100.
5. Dawson JA, Kaiser KA, Affuso O, Cutter GR, Allison DB. Rigorous control conditions diminish treatment effects in weight loss-randomized controlled trials. *Int J Obes*. 2016;40:895-898.
6. Montesi L, El Ghoch M, Brodosi L, Calugi S, Marchesini G, Dalle Grave R. Long-term weight loss maintenance for obesity: a multidisciplinary approach. *Diabetes Metab Syndr Obes*. 2016;9:37-46.
7. Teixeira PJ, Going SB, Sardinha LB, & Lohman TG. A review of psychosocial pre-treatment predictors of weight control. Obes Rev. 2005;6:43-65.
8. Lillis J, Thomas JG, Niemeier H, Wing RR. Internal disinhibition predicts 5-year weight regain in the National Weight Control Registry (NWCR). *Obes Sci Pract*. 2016;2:83-87.
9. Niemeier HM, Phelan S, Fava JL, Wing RR. Internal disinhibition predicts weight regain following weight loss and weight loss maintenance. Obesity (Silver Spring). 2007;15:2485-2494.
10. Gorin AA, Phelan S, Wing RR, Hill JO. Promoting long-term weight control: does dieting consistency matter?
11. Unick JL, Dorfman L, Leahey TM, Wing RR. A preliminary investigation into whether early intervention can improve weight loss among those initially non-responsive to an internet-based behavioral program. J Behav Med. 2016;39:254-261.
12. Unick JL, Neiberg RH, Hogan PE, Cheskin LJ, Dutton GR, Jeffery R, et al. Weight change in the first 2 months of a lifestyle intervention predicts weight changes 8 years later. Obesity (Silver Spring). 2015;23:1353-1356.
13. Shieh C, Knisely MR, Clark D, Carpenter JS. Self-weighing in weight management interventions: A systematic review of literature. *Obes Res Clin Pract*. 2016;10:493-519.
14. Hartmann-Boyce J, Boylan AM, Jebb SA, Fletcher B, Aveyard P. Cognitive and behavioural strategies for self-directed weight loss: systematic review of qualitative studies. *Obes Rev*. 2017;ePub.
15. Dalcin AT, Jerome GJ, Fitzpatrick SL, Louis TA, Wang NY, Bennett WL. Perceived helpfulness of the individual components of a behavioural weight loss program: results from the Hopkins POWER Trial. Obes Sci Pract. 2015;1:23-32.

Appendix A: Three-Factor Eating Questionnaire

Read each of the following 36 statements carefully.
If you agree with the statement, or feel that it is true as applied to you, answer true by circling the "T".
If you disagree with the statement, or feel that it is false as applied to you, answer false by circling the "F".

1.	When I smell a freshly baked pizza, I find it very difficult to keep from eating, even if I have just finished a meal.	T	F		
2.	I usually eat too much at social occasions, like parties and picnics.	T	F		
3.	I am usually so hungry that I eat more than three times a day.	T	F		
4.	When I have eaten my quota of calories or fat, I am usually good about not eating any more.	T	F		
5.	Dieting is so hard for me because I just get too hungry.	T	F		
6.	I deliberately take small helpings as a means of controlling my weight.	T	F		
7.	Sometimes things just taste so good that I keep on eating even when I am no longer hungry.	T	F		
8.	Since I am often hungry, I sometimes wish that an expert would tell me that I have had enough to eat or that I can have some more.	T	F		
9.	When I feel anxious, I find myself eating.	T	F		
10.	Life is too short to worry about dieting.	T	F		
11.	Since my weight goes up and down, I have gone on reducing diets more than once.	T	F		
12.	I often feel so hungry that I just have to eat something.	T	F		
13.	When I am with someone who is overeating, I usually overeat too.	T	F		
14.	I have a pretty good idea of the number of calories or grams of fat in common foods.	T	F		
15.	Sometimes when I start eating, I just can't seem to stop.	T	F		
16.	It is not difficult for me to leave something on my plate.	T	F		
17.	At certain times of the day, I get hungry because I have gotten used to eating then.	T	F		
18.	While on a diet, if I eat food that is not allowed, I consciously eat less for a period of time to make up for it.	T	F		
19.	Being with someone who is eating often makes me hungry enough to eat also.	T	F		
20.	When I feel sad or blue, I often overeat.	T	F		
21.	I enjoy eating too much to spoil it by counting calories, counting grams of fat, or watching my weight.	T	F		
22.	When I see a real delicacy, I often get so hungry that I have to eat it right away.	T	F		
23.	I often stop eating when I am not really full as a conscious means of limiting the amount that I eat.	T	F		
24.	I get so hungry that my stomach often seems like a bottomless pit.	T	F		
25.	My weight has hardly changed at all in the last ten years.	T	F		
26.	I am always hungry, so it is hard for me to stop eating before I finish the food on my plate.	T	F		
27.	When I feel lonely, I console myself by eating.	T	F		
28.	I consciously hold back at meals in order not to gain weight.	T	F		
29.	I sometimes get very hungry late in the evening or at night.	T	F		
30.	I eat anything I want, any time I want.	T	F		
31.	Without even thinking about it, I take a long time to eat.	T	F		
32.	I count calories or grams of fat as a conscious means of controlling my weight.	T	F		
33.	I do not eat some foods because they make me fat.	T	F		
34.	I am always hungry enough to eat at any time.	T	F		
35.	I pay a great deal of attention to changes in my figure.	T	F		
36.	While on a diet, if I eat a food that is not allowed, I often then splurge and eat other high-calorie foods.	T	F		

Each question in this section is followed by a number of options. After reading each question carefully, choose <u>one</u> option which most applies to you, and circle the appropriate answer.

37. How often are you dieting in a conscious effort to control your weight?

1	2	3	4
rarely	sometimes	usually	always

38. Would a weight fluctuation of five pounds affect the way you live your life?

1	2	3	4
not at all	slightly	moderately	very much

39. How often do you feel hungry?

1	2	3	4
only at meal times	sometimes between meals	often between meals	almost always

40. Do your feelings of guilt about overeating help you to control your food intake?

1	2	3	4
never	rarely	often	always

41. How difficult would it be for you to stop eating halfway through dinner and not eat for the next four hours?

1	2	3	4
easy	slightly difficult	moderately difficult	very difficult

42. How conscious are you of what you are eating?

1	2	3	4
not at all	slightly	moderately	extremely

43. How frequently do you avoid buying a large amount of tempting foods?

1	2	3	4
almost never	seldom	usually	almost always

44. How likely are you to shop for low-calorie or low-fat foods?

1	2	3	4
unlikely	slightly likely	moderately likely	very likely

45. Do you eat sensibly in front of others and splurge alone?

1	2	3	4
never	rarely	often	always

46. How likely are you to consciously eat slowly in order to cut down on how much you eat?

1	2	3	4
unlikely	slightly likely	moderately likely	very likely

47. How frequently do you skip dessert because you are no longer hungry?

1	2	3	4
almost never	seldom	at least once a week	almost every day

48. How likely are you to consciously eat less than you want?

1	2	3	4
unlikely	slightly likely	moderately likely	very likely

49. Do you go on eating binges even though you are not hungry?

1	2	3	4
never	rarely	sometimes	at least once a week

50. To what extent does this statement describe your eating behavior?

"I start dieting in the morning, but because of any number of things that happen during the day, by evening I have given up and eat what I want, promising myself to start dieting again tomorrow."

1	2	3	4
not like me	a little like me	pretty good description of me	describes me perfectly

51. On the following scale of 1 to 6, where 1 means no restraint in eating (eat whatever you want, whenever you want it) and 6 means total restraint (constantly limiting food intake and never "giving in"), what number would you give yourself?

1 Eat whatever you want, whenever you want it

2 Usually eat whatever you want, whenever you want it

3 Often eat whatever you want, whenever you want it

4 Often limit food intake, but often "give in"

5 Usually limit food intake, rarely "give in"

6 Constantly limit food intake, never "give in"

Appendix B: Weight-Related Eating Questionnaire

Please choose a response that *best* expresses how well each statement *describes* you.

Items	Not at all	Slightly	More or Less	Pretty Well	Completely
1. I purposefully hold back at meals in order not to gain weight.					
2. I tend to eat more when I am anxious, worried, or tense.					
3. I count calories as a conscious means of controlling my weight.					
4. When I feel lonely I console myself by eating.					
5. I tend to eat more food than usual when I have more available places that serve or sell food.					
6. I tend to eat when I am disappointed or feel let down.					
7. I often refuse foods or drinks offered because I am concerned about my weight.					
8. If I see others eating, I have a strong desire to eat too.					
9. Some foods taste so good I eat more even when I am no longer hungry.					
10. When I have eaten too much during the day, I will often eat less than usual the following day.					
11. I often eat so quickly I don't notice I'm full until I've eaten too much.					
12. If I eat more than usual during a meal, I try to make up for it at another meal.					
13. When I'm offered delicious food, it's hard to resist eating it even if I've just eaten.					
14. I eat more when I'm having relationship problems.					
15. When I'm under a lot of stress, I eat more than I usually do.					
16. When I know I'll be eating a big meal during the day, I try to make up for it by eating less before or after that meal.					

Appendix C: Diet Satisfaction Questionnaire (DSat-45)

For each of the statements listed below, circle the number that best represents your response as it applies to the way you currently eat and your current level of physical activity. Please read each statement carefully before responding.

EXAMPLE	**Disagree strongly**	**Disagree somewhat**	**Neither disagree nor agree**	**Agree somewhat**	**Agree strongly**
I think that I exercise a lot.	**1**	**2**	**3**	**4**	**5**

Scoring instructions: Scores for each question are shown in the grid below. Note that positive statements are scored from 1 to 5, the same as the answer codes, and negative statements are scored 5 to 1, inversely from the answer codes. The average score for each of the seven factors (named in the heading of each section) is calculated by summing the scores and dividing by the number of questions for that factor. Higher scores represent higher satisfaction with the diet.

HEALTHY LIFESTYLE FACTOR (8 questions)	**Disagree strongly**	**Disagree somewhat**	**Neither disagree nor agree**	**Agree somewhat**	**Agree strongly**
1. I have a lot of energy.	*1*	*2*	*3*	*4*	*5*
2. I feel good about myself.	*1*	*2*	*3*	*4*	*5*
3. I think that I eat a healthy diet.	*1*	*2*	*3*	*4*	*5*
4. I believe that I am reducing my risk for disease by the way that I eat.	*1*	*2*	*3*	*4*	*5*
5. I believe that I am reducing my risk for disease by the way that I exercise.	*1*	*2*	*3*	*4*	*5*

6. I think that I have a healthy lifestyle.	*1*	*2*	*3*	*4*	*5*
7. I am satisfied with my current diet.	*1*	*2*	*3*	*4*	*5*
8. The way that I currently eat makes me feel guilty.	*5*	*4*	*3*	*2*	*1*
CONVENIENCE FACTOR ***(9 questions)***	**Disagree strongly**	**Disagree somewhat**	**Neither disagree nor agree**	**Agree somewhat**	**Agree strongly**
9. The way I currently eat prevents me from eating in restaurants frequently.	*5*	*4*	*3*	*2*	*1*
10. When dining out, I can easily choose foods from the menu that fit into my current diet.	*1*	*2*	*3*	*4*	*5*
11. Finding appropriate food choices at restaurants is difficult.	*5*	*4*	*3*	*2*	*1*
12. I have to prepare most of my foods “from scratch”.	*5*	*4*	*3*	*2*	*1*
13. I find eating satisfying.	*1*	*2*	*3*	*4*	*5*
14. I have difficulty finding the foods I want when eating out.	*5*	*4*	*3*	*2*	*1*
15. I find it easy to shop at my grocery store for the kinds of foods I eat.	*1*	*2*	*3*	*4*	*5*
16. I limit my choice of restaurants.	*5*	*4*	*3*	*2*	*1*
17. I have plenty of different types of foods to choose from with my current diet.	*1*	*2*	*3*	*4*	*5*

COST FACTOR ***(5 questions)***	**Disagree strongly**	**Disagree somewhat**	**Neither disagree nor agree**	**Agree somewhat**	**Agree strongly**
18. I feel that I spend a large amount of my budget on the foods that I eat.	*5*	*4*	*3*	*2*	*1*
19. I think that preparing food and meals for the way I eat now is economical.	*1*	*2*	*3*	*4*	*5*
20. I think that preparing food and meals for the way I eat now costs a lot of money.	*5*	*4*	*3*	*2*	*1*
21. I spend a lot of money on food.	*5*	*4*	*3*	*2*	*1*
22. It is hard for me to afford the kind of foods that I eat.	*5*	*4*	*3*	*2*	*1*
FAMILY DYNAMICS FACTOR ***(6 questions)***	**Disagree strongly**	**Disagree somewhat**	**Neither disagree nor agree**	**Agree somewhat**	**Agree strongly**
23. I feel that the way I eat now bothers my family.	*5*	*4*	*3*	*2*	*1*
24. My family encourages me to keep eating the way I am eating now.	*1*	*2*	*3*	*4*	*5*
25. My family supports my efforts to eat a healthy diet.	*1*	*2*	*3*	*4*	*5*
26. I enjoy getting together for holiday meals with family.	*1*	*2*	*3*	*4*	*5*
27. My family discourages me from eating the way I am eating now.	*5*	*4*	*3*	*2*	*1*
28. The way I currently eat causes stress within my family.	*5*	*4*	*3*	*2*	*1*

PREOCCUPATION WITH FOOD FACTOR ***(6 questions)***	**Disagree strongly**	**Disagree somewhat**	**Neither disagree nor agree**	**Agree somewhat**	**Agree strongly**
29. Thoughts of food are always on my mind.	*5*	*4*	*3*	*2*	*1*
30. I think about food between almost every meal.	*5*	*4*	*3*	*2*	*1*
31. I have cravings for some of my favorite foods.	*5*	*4*	*3*	*2*	*1*
32. I always feel like I want to snack between meals.	*5*	*4*	*3*	*2*	*1*
33. I often feel hungry.	*5*	*4*	*3*	*2*	*1*
34. I feel that my diet controls my life.	*5*	*4*	*3*	*2*	*1*

NEGATIVE ASPECTS FACTOR ***(6 questions)***	**Disagree strongly**	**Disagree somewhat**	**Neither disagree nor agree**	**Agree somewhat**	**Agree strongly**
35. I feel deprived based on what I order when eating in a restaurant.	*5*	*4*	*3*	*2*	*1*
36. I feel self-conscious trying to eat my current diet at social events.	*5*	*4*	*3*	*2*	*1*
37. I feel embarrassed if I order specially prepared foods in a restaurant.	*5*	*4*	*3*	*2*	*1*
38. My family eats the same foods that I currently eat.	*1*	*2*	*3*	*4*	*5*

39. I feel deprived when I choose to avoid some of my favorite foods.	*5*	*4*	*3*	*2*	*1*
40. I have to prepare separate meals for my family and myself.	*5*	*4*	*3*	*2*	*1*
MEAL PLANNING & PREPARATION FACTOR (5 questions)	**Disagree strongly**	**Disagree somewhat**	**Neither disagree nor agree**	**Agree somewhat**	**Agree strongly**
41. I spend a lot of time planning my meals.	*5*	*4*	*3*	*2*	*1*
42. I spend a lot of time shopping for food.	*5*	*4*	*3*	*2*	*1*
43. I think preparing food and meals for the way I eat now is time-consuming.	*5*	*4*	*3*	*2*	*1*
44. I think preparing food and meals for the way I eat now requires a lot of effort.	*5*	*4*	*3*	*2*	*1*
45. I spend a lot of time looking for new ideas for food and meals that fit into my current diet.	*5*	*4*	*3*	*2*	*1*

Thank you for completing this questionnaire.

Appendix D: Dieting Beliefs Scale

Indicate how well each statement describes your beliefs about weight loss and dieting. Place an X in one box under the scale from 1 (not at all descriptive of my beliefs) to 6 (very descriptive of my beliefs).

Statement	Not at all descriptive of my beliefs 1	2	3	4	5	Very descriptive of my beliefs 6
By restricting what one eats, one can lose weight.						
When people gain weight it is because of something they have done or not done.						
A thin body is largely a result of genetics.						
No matter how much effort one puts into dieting, one's weight tends to stay about the same.						
One's weight is, to a great extent, controlled by fate.						
There is so much fattening food around that losing weight is almost impossible.						
Most people can only diet successfully when other people push them to do it.						
Having a slim and fit body has very little to do with luck.						
People who are overweight lack the willpower necessary to control their weight.						
Each of us is directly responsible for our weight.						
Losing weight is simply a matter of wanting to do it and applying yourself.						
People who are more than a couple of pounds overweight need professional help to lose weight.						
By increasing the amount one exercises, one can lose weight.						
Most people are at their present weight because that is the weight level that is natural for them.						
Unsuccessful dieting is due to lack of effort.						
In order to lose weight people must get a lot of encouragement from others.						

Appendix E: Weight Efficacy Lifestyle Questionnaire

Listed below are some statements about difficult eating situations. For each statement, decide how confident (or certain) you are that you can resist eating in this situation. On the scale from 0 (not at all confident) to 9 (very confident), circle ONE number that reflects how confident you feel that you can resist eating.

1. I can resist eating when I am anxious (or nervous)

0	1	2	3	4	5	6	7	8	9
Not at all confident									Very confident

2. I can control my eating on the weekends

0	1	2	3	4	5	6	7	8	9
Not at all confident									Very confident

3. I can resist eating even when I have to say "no" to others

0	1	2	3	4	5	6	7	8	9
Not at all confident									Very confident

4. I can resist eating when I feel physically run down

0	1	2	3	4	5	6	7	8	9
Not at all confident									Very confident

5. I can resist eating when I am watching television

0	1	2	3	4	5	6	7	8	9
Not at all confident									Very confident

6. I can resist eating when I am depressed (or down)

0	1	2	3	4	5	6	7	8	9
Not at all confident									Very confident

7. I can resist eating when there are many different kinds of food available

0	1	2	3	4	5	6	7	8	9
Not at all confident									Very confident

8. I can resist eating even when I feel it's impolite to refuse a second helping

0	1	2	3	4	5	6	7	8	9
Not at all confident									Very confident

9. I can resist eating even when I have a headache

0	1	2	3	4	5	6	7	8	9
Not at all confident									Very confident

10. I can resist eating when I am reading

0	1	2	3	4	5	6	7	8	9
Not at all confident									Very confident

11. I can resist eating when I am angry (or irritable)

0	1	2	3	4	5	6	7	8	9
Not at all confident									Very confident

12. I can resist eating even when I am at a party

0	1	2	3	4	5	6	7	8	9
Not at all confident									Very confident

13. I can resist eating even when others are pressuring me to eat

0	1	2	3	4	5	6	7	8	9
Not at all confident									Very confident

14. I can resist eating when I am in pain

0	1	2	3	4	5	6	7	8	9
Not at all confident									Very confident

15. I can resist eating just before going to bed

0	1	2	3	4	5	6	7	8	9
Not at all confident									Very confident

16. I can resist eating when I have experienced failure

0	1	2	3	4	5	6	7	8	9
Not at all confident									Very confident

17. I can resist eating even when high-calorie foods are available

0	1	2	3	4	5	6	7	8	9
Not at all confident									Very confident

18. I can resist eating even when I think others will be upset if I don't eat

0	1	2	3	4	5	6	7	8	9
Not at all confident									Very confident

19. I can resist eating when I feel uncomfortable

0	1	2	3	4	5	6	7	8	9
Not at all confident									Very confident

20. I can resist eating when I am happy

0	1	2	3	4	5	6	7	8	9
Not at all confident									Very confident

Appendix F: Barratt Impulsiveness Scale

DIRECTIONS: People differ in the ways they act and think in different situations. This is a questionnaire to measure some of the ways in which you act and think. Read each statement and record your answer according to the following scale. Do not spend too much time on any statement. Answer quickly and honestly.

1	2	3	4
rarely/never	occasionally	often	almost always/always

1. I plan tasks carefully. _____
2. I do things without thinking. _____
3. I make-up my mind quickly. _____
4. I am happy-go-lucky. _____
5. I don't "pay attention." _____
6. I have "racing" thoughts. _____
7. I plan trips well ahead of time. _____
8. I am self-controlled. _____
9. I concentrate easily. _____
10. I save regularly. _____
11. I "squirm" at plays or lectures. _____
12. I am a careful thinker. _____
13. I plan for job security. _____
14. I say things without thinking. _____
15. I like to think about complex problems. _____
16. I change jobs. _____

1 rarely/never	2 occasionally	3 often	4 almost always/always

17. I act "on impulse." _____
18. I get easily bored when solving thought problems. _____
19. I act on the spur of the moment. _____
20. I am a steady thinker. _____
21. I change residences. _____
22. I buy things on impulse. _____
23. I can only think about one thing at a time. _____
24. I change hobbies. _____
25. I spend or charge more than I earn. _____
26. I often have extraneous thoughts when thinking. _____
27. I am more interested in the present than the future. _____
28. I am restless at the theater or lectures. _____
29. I like puzzles. _____
30. I am future oriented. _____

Appendix G: Variety-Seeking Questionnaire

1. When I eat out, I like to try the most unusual items, even if I am not sure I would like them.
2. When preparing foods or snacks, I like to try out new recipes.
3. I think it is fun to try out food items one is not familiar with.
4. I am eager to know what kind of foods people from other countries eat.
5. I like to eat exotic foods.
6. Items on the menu that I am unfamiliar with make me curious.
7. I prefer to eat food products I am used to.
8. I am curious about food products I am not familiar with.

Rating scale

- Strongly disagree
- Disagree
- Neither disagree nor agree
- Agree
- Strongly agree

Appendix H: Revised Diet Satisfaction Questionnaire (DSat-28)

For each of the statements listed below, circle the number that best represents your response as it applies to the way you currently eat and your current level of physical activity. Please read each statement carefully before responding.

For example: For the following question, "I think that I exercise a lot," you would base your answer on your current level of physical activity. If you feel that you currently exercise a lot, you would circle the number **5** to indicate that you strongly agree:

EXAMPLE	Disagree strongly	Disagree somewhat	Neither disagree nor agree	Agree somewhat	Agree strongly
I think that I exercise a lot.	1	2	3	4	(5)

Scoring instructions: Scores for each question are shown in the grid below. Note that positive statements are scored from 1 to 5, the same as the answer codes, and negative statements are scored 5 to 1, inversely from the answer codes. The average score for each of the seven factors (named in the heading of each section) is calculated by summing the scores and dividing by the number of questions for that factor. Higher scores represent higher satisfaction with the diet.

HEALTHY LIFESTYLE FACTOR (8 questions)	Disagree strongly	Disagree somewhat	Neither disagree nor agree	Agree somewhat	Agree strongly
1. I have a lot of energy.	*1*	*2*	*3*	*4*	*5*
2. I feel good about myself.	*1*	*2*	*3*	*4*	*5*
3. I think that I eat a healthy diet.	*1*	*2*	*3*	*4*	*5*
4. I believe that I am reducing my risk for disease by the way that I eat.	*1*	*2*	*3*	*4*	*5*
5. I believe that I am reducing my risk for disease by the way that I exercise.	*1*	*2*	*3*	*4*	*5*
6. I think that I have a healthy lifestyle.	*1*	*2*	*3*	*4*	*5*
7. I am satisfied with my current diet.	*1*	*2*	*3*	*4*	*5*
8. The way that I currently eat makes me feel guilty.	*5*	*4*	*3*	*2*	*1*

CONVENIENCE FACTOR (9 questions)	**Disagree strongly**	**Disagree somewhat**	**Neither disagree nor agree**	**Agree somewhat**	**Agree strongly**
9. The way I currently eat prevents me from eating in restaurants frequently.	*5*	*4*	*3*	*2*	*1*
10. When dining out, I can easily choose foods from the menu that fit into my current diet.	*1*	*2*	*3*	*4*	*5*
11. Finding appropriate food choices at restaurants is difficult.	*5*	*4*	*3*	*2*	*1*
12. I have difficulty finding the foods I want when eating out.	*5*	*4*	*3*	*2*	*1*

COST FACTOR (5 questions)	**Disagree strongly**	**Disagree somewhat**	**Neither disagree nor agree**	**Agree somewhat**	**Agree strongly**
13. I feel that I spend a large amount of my budget on the foods that I eat.	*5*	*4*	*3*	*2*	*1*
14. I think that preparing food and meals for the way I eat now is economical.	*1*	*2*	*3*	*4*	*5*
15. I think that preparing food and meals for the way I eat now costs a lot of money.	*5*	*4*	*3*	*2*	*1*
16. I spend a lot of money on food.	*5*	*4*	*3*	*2*	*1*
17. It is hard for me to afford the kind of foods that I eat.	*5*	*4*	*3*	*2*	*1*

PREOCCUPATION WITH FOOD FACTOR (6 questions)	**Disagree strongly**	**Disagree somewhat**	**Neither disagree nor agree**	**Agree somewhat**	**Agree strongly**
18. Thoughts of food are always on my mind.	*5*	*4*	*3*	*2*	*1*
19. I think about food between almost every meal.	*5*	*4*	*3*	*2*	*1*
20. I have cravings for some of my favorite foods.	*5*	*4*	*3*	*2*	*1*
21. I always feel like I want to snack between meals.	*5*	*4*	*3*	*2*	*1*
22. I often feel hungry.	*5*	*4*	*3*	*2*	*1*
23. I feel that my diet controls my life.	*5*	*4*	*3*	*2*	*1*

MEAL PLANNING & PREPARATION FACTOR (5 questions)	**Disagree strongly**	**Disagree somewhat**	**Neither disagree nor agree**	**Agree somewhat**	**Agree strongly**
24. I spend a lot of time planning my meals.	*5*	*4*	*3*	*2*	*1*
25. I spend a lot of time shopping for food.	*5*	*4*	*3*	*2*	*1*
26. I think preparing food and meals for the way I eat now is time-consuming.	*5*	*4*	*3*	*2*	*1*
27. I think preparing food and meals for the way I eat now requires a lot of effort.	*5*	*4*	*3*	*2*	*1*
28. I spend a lot of time looking for new ideas for food and meals that fit into my current diet.	*5*	*4*	*3*	*2*	*1*

Thank you for completing this questionnaire.

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RESEARCH EXPERIENCE

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- **Laboratory for the Study of Ingestive Behavior**, graduate assistant
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SELECT PUBLICATIONS & PRESENTATIONS

James BL, Roe LS, Rolls BJ (under review). Validation of the Diet Satisfaction Questionnaire: a new measure of satisfaction with diets for weight management. *Obes Sci Pract*

James BL, Roe LS, Loken E, Rolls BJ. Early predictors of weight loss in a 1-year behavioural weight-loss programme. *Obes Sci Pract*. 2018;4(1),20-28.

James BL, Loken E, Roe LS, Rolls BJ. The Weight-Related Eating Questionnaire offers a concise alternative to the Three-Factor Eating Questionnaire for measuring eating behaviors related to weight loss. *Appetite*. 2017;116,108-114.

Rolls BJ, Roe LS, James BL, Sanchez CE. Does the incorporation of portion-control strategies in a behavioral program improve weight loss in a one-year randomized controlled trial? *Int J Obes*. 2017;41:434-442

James BL, Loken E, Roe LS, Rolls BJ. A concise alternative to the TFEQ relates to weight change over 1 year. Presentation at The Obesity Society Annual Meeting; November, 2016; New Orleans, LA

James BL, Roe LS, Rolls BJ. Disinhibition is associated with the pattern of weight loss and regain in a 1-year trial of portion control strategies. Oral presentation at the Society for the Study of Ingestive Behavior Annual Meeting; July, 2015; Denver, CO.

James, BL, Savage, JS, & Birch, LL. Barriers to healthy eating in low-income WIC mothers are associated with unhealthy weight control strategies. Poster presented at The Obesity Society Annual Scientific Meeting; 2012, September; San Antonio, TX.