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Predictors of Long-term Adherence to Multiple Health Behavior Recommendations for Weight Management

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Abstract

Background—Previously we demonstrated that patterns of behavioral adherence in the first six months of behavioral lifestyle interventions were associated with significant weight loss at 18 months. Here, we extend this work to examine patterns of behavioral adherence over 18 months and explore baseline demographic and psychosocial predictors.

Methods—Latent class analysis was applied separately to the Weight Loss Maintenance and PREMIER trial data to examine patterns of adherence to the following recommendations: a) consuming 9 servings of fruits and vegetables per day; b) 25% of energy from total fat; c) 7% energy from saturated fat; and d) 180 minutes of moderate-to-vigorous physical activity per week. Multinomial logistic regression was used to test demographic and psychosocial predictors of latent class membership.

Results—Four distinct subgroups with common patterns of behavioral adherence were identified in each trial including, “Behavioral Maintainers” who maintained adherence to all behavioral recommendations for one year, “Non-Responders” who did not adhere to the recommendations at any time point, and latent classes that reflected patterns of adherence to one or two behaviors or behavioral relapse. A significantly higher proportion of Behavioral Maintainers sustained 5% weight loss for one year compared to Non-Responders. Participants with higher vitality scores at baseline were more likely to belong to a latent class with long-term adherence to one or more recommendations than the Non-Responders class.

Conclusions—Regular assessment of health behaviors and psychosocial measures such as vitality may help identify non-responders and inform treatment tailoring to improve long-term behavioral and weight outcomes.

Keywords

Weight loss maintenance; Behavior change; Treatment response; Adherence; Latent class analysis; Psychosocial predictors

Obesity prevalence in the U.S. has doubled since the 1960s, with more than one-third of adults in the U.S. now having a body mass index (BMI) greater than 30 kg/m² (Ogden, Carroll, Kit, & Flegal, 2014). Obesity is associated with increased risks for cardiovascular disease, diabetes, certain types of cancer, mobility limitations, and increased health care costs (Finkelstein, Trogdon, Cohen, & Dietz, 2009; Must & McKeown, 2000; Thorpe, Yang, Long, & Garvey, 2013; Wang et al., 2015). While behavioral lifestyle interventions typically yield clinically significant weight loss (5% or more of initial weight) in the short term, (Butryn, Webb, & Wadden, 2011) maintaining weight lost long-term remains a challenge for many individuals. Past research has shown that fast, early weight loss during treatment is predictive of greater weight reduction and long-term weight maintenance (Nackers, Ross, & Perri, 2010; Volger et al., 2013; Yank et al., 2014). However, examining early weight loss alone does not provide information about engagement in health behaviors that may impact participants' long-term success. To create effective interventions, it is necessary to determine if participants are adhering to behaviors associated with weight maintenance and to identify the characteristics that predict long-term engagement in those behaviors.

Several studies have demonstrated that participants who are successful in long-term weight-loss maintenance eat a healthier diet, engage in more minutes of moderate-to-vigorous physical activity, and self-monitor weight and/or dietary intake more frequently than non-maintainers (Elfhag & Rossner, 2005; Look, 2014; Volger et al., 2013). In the Weight Loss Maintenance Trial (WLM), having a healthy dietary pattern at baseline or an improvement in dietary pattern over the course of the trial was associated with significant weight loss over 36 months (Svetkey et al., 2012). Also in WLM, increases in consumption of fruits and vegetables, physical activity, and frequent self-weighing mediated the relationship between treatment randomization and less weight regain (Coughlin et al., 2013). These studies demonstrate that long-term adherence to healthy behavior recommendations is associated with long-term weight loss maintenance.

Previous research has identified demographic, clinical, behavioral, and psychosocial factors that predict short- and long-term adherence to dietary interventions (Aggarwal, Liao, Allegrante, & Mosca, 2010; Downer et al., 2016; Epstein et al., 2012). While these studies provide some insight into the predictors of dietary adherence, there may be additional, unexplored factors that predict adherence in lifestyle interventions targeting multiple behavioral changes. Establishing common predictors of long-term adherence to dietary and physical activity guidelines across multiple behavioral lifestyle trials can inform development of tailored interventions that will maximize behavioral adherence and promote sustained weight loss.

The purpose of this study was to apply latent class analysis to data from the Weight Loss Maintenance (WLM) and PREMIER trials in order to: 1) identify patterns of adherence to behavioral recommendations over 1 year; and 2) establish common baseline predictors of patterns of sustained behavioral adherence. This work builds off of our previous application of latent class analysis to these datasets to establish patterns of early behavior change over 6 months, and their association with weight outcomes (Fitzpatrick et al., 2015). The current study extends this work by examining patterns of dietary and physical activity adherence over 18 months, and exploring baseline demographic and psychosocial measures as potential predictors of these patterns.

Methods

Data Sources

Detailed descriptions of the WLM and PREMIER trials have been published elsewhere. In brief, WLM was a multi-center randomized clinical trial comparing two active weight loss maintenance interventions with a self-directed approach among adults with overweight/obesity who were taking medications for hypertension, dyslipidemia, or both (Brantley et al., 2008). In Phase 1 of WLM, all 1,685 participants were enrolled in an intensive behavioral lifestyle intervention that consisted of 20 weekly group sessions over 6 months. Participants who lost > 4 kg at the end of Phase 1 (n = 1,032) were randomized to one of three maintenance strategies in Phase 2, which lasted for 30 months: 1) Self-Directed; 2) Interactive Technology; or 3) Personal Contact. Although there was weight regain across all three maintenance strategies, the Personal Contact arm, consisting of brief, monthly contacts with an interventionist, provided some benefit for sustaining weight loss long-term (Svetkey et al., 2008).

PREMIER was a multi-center trial that tested the effects of multi-component lifestyle interventions among 810 adults with prehypertension or Stage 1 hypertension who were not taking antihypertensive medication (Appel et al., 2003). Participants were randomly assigned to one of three conditions: 1) an “Advice only” condition; 2) an “Established” lifestyle intervention that recommended increasing physical activity, reducing sodium consumption, and weight loss for participants with a body mass index (BMI) ≥ 25; or 3) an “Established plus DASH,” intervention that consisted of the Established intervention plus behavioral counseling on the DASH diet (Appel et al., 1997; Karanja et al., 1999). The two active interventions occurred over 18 months with weekly group meetings in the first three months, bi-weekly meetings in the next three months, and monthly meetings thereafter. Participants who were randomized to the Established or Established plus DASH conditions had significantly greater weight loss and blood pressure reduction compared to participants in the Advice only condition at 6- and 18-month follow-ups (Appel et al., 2003; Elmer et al., 2006). There were no significant differences in weight loss between the Established and Established plus DASH conditions.

Participants Included in this Analysis

Participants in the WLM and PREMIER trials who received a behavioral lifestyle intervention and had a baseline BMI ≥ 25 were included in this secondary analysis. For

WLM, only participants in Phase 2 (n= 1,032) had behavioral data collected at multiple time points, so only these participants were included. In PREMIER, 506 participants (255 in the Established intervention and 251 in the Established + DASH intervention) with BMI ≥ 25 were included.

Measures

We used measurements of weight (using a calibrated scale), dietary intake, and physical activity collected at baseline, 6 months, and 18 months in both trials (Appel et al., 2003; Elmer et al., 2006; Svetkey et al., 2008). Weight data was also collected at other time points, and dietary intake and physical activity data were collected at the 30-month follow-up in WLM, but these data were not included in this study.

The two trials assessed dietary intake and physical activity differently. In WLM, dietary intake was assessed using the 100-item Block Food Frequency Questionnaire, and physical activity was assessed using accelerometry (Svetkey et al., 2008). In PREMIER, two unannounced 24-hour dietary recalls were conducted by telephone using the multiple pass method, and physical activity was assessed using the 7-day Physical Activity Recall (Appel et al., 2003). Similar self-report psychosocial measures were administered in both trials at baseline and were included in this analysis: SF-36TM (Ware & Sherbourne, 1992); Social Support and Eating Habits Survey and Social Support and Exercise Survey (Sallis, Grossman, Pinski, Patterson, & Nader, 1987); Perceived Stress Scale (PSS) (Cohen, Kamarck, & Mermelstein, 1983); self-reported previous weight loss attempts; and the Patient Health Questionnaire (PHQ-8) (only administered in WLM) (Kroenke, Spitzer, & Williams, 2001).

Statistical Analysis

Repeated measures latent class analysis (RMLCA) (Collins & Lanza, 2010) was applied separately to WLM and PREMIER data to identify distinct patterns of behavioral adherence over 18 months and to examine predictors of these patterns. Long-term behavioral adherence was defined as meeting specific behavioral recommendation(s) at the 6- and 18-month follow-ups. The four behaviors of interest were fruit and vegetable intake, percent of energy from fat, percent of energy from saturated fat, and minutes of moderate-to-vigorous physical activity per week. There were specific intervention recommendations for each of these behaviors in each trial (Appel et al., 2003; Hollis et al., 2008). Participants in WLM and those randomized to the Established + DASH intervention in PREMIER were encouraged to consume 9–12 servings of fruits and vegetables per day, less than 25% of energy from fat, and less than 7% energy from saturated fat based on the DASH diet guidelines. Participants in the Established intervention in PREMIER did not have a specific recommendation for fruit and vegetable intake, and the recommendations for fat intake (30% of energy) and saturated fat intake (10% of energy) were based on national guidelines. Since the Established and Established + DASH conditions were combined for the RMLCA of PREMIER, we set the dietary recommendations for fat and saturated fat intake to be less than 25% and less than 7%, respectively. Fewer than 20% of participants in the PREMIER active interventions consumed nine or more servings of fruits and vegetables at each time point (see table 2). Therefore, we set the fruit and vegetable intake recommendation for

PREMIER to five or more servings of fruits and vegetables per day, which is consistent with national guidelines (Agriculture, 1992). We retained the fruit and vegetable intake recommendation of nine or more servings for the WLM analysis. All conditions in both trials recommended 180 minutes of moderate-to-vigorous physical activity per week.

Twelve binary variables (yes or no) were created in each dataset to indicate whether a participant met each of the four behavioral recommendations at baseline, 6-month, and 18-month follow-up. Latent classes (patterns of behavioral adherence) were based on the pattern of responses (yes or no) across the four behaviors and across time (baseline, 6 months, and 18 months). Latent class prevalences (proportions of individuals who share a similar response pattern across the four behaviors and across time) and item-response probabilities (probabilities of meeting a behavioral recommendation given latent class membership) were estimated (Collins & Lanza, 2010). Item-response probabilities higher than the marginal (overall) probabilities (Table 2) and/or 0.5 indicated that participants within that class had a high probability of meeting the recommendation.

RMLCA with 1–7 classes were estimated for each dataset. Several fit indices and criteria were examined to aid in selection of the optimal model for each dataset. Better relative model fit was defined as: a) a lower Akaike information criterion (AIC) (Akaike, 1987); b) a lower Bayesian information criterion (BIC) (Schwarz, 1978); c) a lower sample-size adjusted BIC; d) a significant bootstrap likelihood ratio test (BLRT), suggesting the more complex model fits the data better than the model with one fewer patterns; e) higher entropy, an estimate of certainty of classification (ranging from 0 to 1); and f) meaningfulness or interpretability of the classes. Mplus version 7.4 was used to estimate all RMLCAs with 1000 random starts and 1000 bootstrap draws for each likelihood ratio test.

After the optimal latent class solution was identified, we validated the classes by comparing them on the proportion of participants with maintenance of clinically significant weight loss for one year. Participants were classified as successful weight maintainers if they maintained a weight loss of 5% or more of their initial weight at the 6- and 18-month follow-ups. The BCH command within Mplus was used to conduct this analysis (Asparouhov & Muthén, 2014). Finally, we used the R3STEP command in Mplus to conduct multinomial logistic regressions testing predictors of class membership. Sex, race/ethnicity, age, previous weight loss attempts, and BMI at initial screening visit, and baseline scores on the PSS, PHQ-8, SF-36, and social support scales were examined.

Results

Table 1 presents the baseline characteristics for WLM and PREMIER participants included in this analysis. Although we did not test for significant differences, participants in WLM were older and had lower mental health composite and vitality scores on average than participants in PREMIER. Across both trials, the proportion of participants meeting each behavioral recommendation increased between baseline and 6-month follow-up, but decreased between 6-month and 18-month follow-ups.

WLM Behavioral Adherence RMLCA

The model fit indices of the WLM class solutions are presented in Table 3. The BIC, AIC, and sample-size adjusted BIC were not minimized and the BLRT always suggested the model with one additional class. However, the six- and seven-class solutions appeared underidentified and had a low number of replications of the best log-likelihood despite 1000 random starts. Based on these model fit indices, we examined the four- and five-class solutions. Similar classes emerged in these two models, but the fifth class could not be clearly interpreted given several borderline item-response probabilities. Thus, we selected the four-class model for interpretation and additional analysis.

Parameter estimates (latent class prevalences and item-response probabilities) for the four-class WLM model are presented in Table 4. Class 1, “Behavioral Maintainers”, ($n = 44$, 14% of the sample) was characterized by low probabilities of meeting any of the behavioral recommendations at baseline, but moderate to high probabilities of meeting all recommendations at the 6- and 18-month follow-ups. Class 2, “Nutrition Responders / Non-Maintainers”, ($n = 176$, 17%) was characterized by low probabilities of meeting any recommendations at baseline, high probabilities of meeting nutrition-related recommendations at 6 months, and low probabilities of meeting any of the recommendations at 18 months. Class 3, “Physical Activity Maintainers”, ($n = 199$, 19%) maintained a high probability of meeting only the physical activity recommendation from baseline through the 18-month follow-up. The largest class, “Non-Responders”, ($n = 513$, 50%) had very low probabilities of meeting any of the recommendations at any time point. See Supplemental Table 1 for baseline characteristics of participants in WLM by latent class membership.

Approximately, 46% of participants in WLM met our criteria for long-term clinically significant weight loss maintenance. Rates of maintenance differed significantly across the four latent classes ($\chi^2 = 66.57$, $p < .001$). A significantly higher proportion of Behavioral Maintainers (72%) maintained clinically significant weight loss compared to Nutrition Responders/ Non-Maintainers (53%), Physical Activity Maintainers (52%), and Non-Responders (34%) (Figure 1). Nutrition Responders/ Non-Maintainers and Physical Activity Maintainers also had significantly higher rates of weight loss maintenance than Non-Responders.

PREMIER Behavioral Adherence RMLCA

PREMIER RMLCA model fit information and selection criteria are presented in Table 3. While the AIC and sample-size adjusted BIC were not minimized and the BLRT always suggested the model with one additional class, the BIC was minimized for the four-class model. Also, the five- and six- class solutions were considered underidentified due to poor replication of the maximum log-likelihood. Therefore, we selected the four-class model for interpretation and additional analysis.

Parameter estimates for the PREMIER four-class model are shown in Table 5. Two classes were common to both the WLM and PREMIER trials (Class 1: Behavioral Maintainers and Class 4: Non-Responders) with some small differences; the other classes differed. Class 1, “Behavioral Maintainers”, ($n = 80$, 16% of the sample) had moderate to high probabilities of

meeting all of the recommendations at each time point, including at baseline. Class 2, “Responders / Fruit and Vegetable Maintainers Only”, ($n = 106$, 21%) had low probabilities of meeting any recommendation at baseline, moderate to high probabilities of meeting all recommendations at 6 months, but high probabilities only for meeting the fruit and vegetable recommendation at 18 months. Class 3, “Fruit & Vegetable / Physical Activity Maintainers”, ($n = 111$, 22%), was characterized by high probabilities of meeting only the fruit and vegetable and physical activity recommendations at every time point. Class 4, “Non-Responders”, was the largest class ($n = 209$, 41%) and was characterized by low probabilities of meeting any of the recommendations at any time point. See Supplemental Table 2 for baseline characteristics of participants in PREMIER by latent class membership.

Twenty-eight percent of participants in PREMIER maintained clinically significant weight loss for one year following the intensive phase of the intervention; maintenance differed significantly across the four latent classes ($\chi^2 = 43.67$, $p < .001$). As presented in Figure 2, 51% of Behavioral Maintainers maintained clinically significant weight loss, a significantly higher proportion than Fruit & Vegetable/ Physical Activity Maintainers (30%) and Non-Responders (11%). Responders/ Fruit & Vegetable Maintainers Only (40%) and Fruit & Vegetable/ Physical Activity Maintainers also had significantly higher rates of maintaining clinically significant weight loss than Non-Responders.

Predictors of Behavioral Adherence Patterns

The following variables significantly predicted class membership in WLM based on multivariate likelihood ratio tests ($-2LL$): sex, race/ethnicity, age, BMI at screening, vitality, family exercise encouragement, and friend exercise encouragement (see Table 6). Black non-Hispanics compared to non-Blacks were less likely to be in the Nutrition Responders/Non-Maintainers class and marginally less likely to be in the Physical Activity Maintainers class than the Non-Responders class. Participants with lower BMI at the screening visit were more likely to be in the Behavioral Maintainers and Physical Activity Maintainers classes, whereas participants with higher BMI were marginally more likely to be in the Nutrition Responders/Non-Maintainers class than the Non-Responders class. Participants with higher vitality scores at baseline were marginally more likely to be in the Physical Activity Maintainers class than the Non-Responders class. Participants with high encouragement from friends to exercise were more likely to be in the Nutrition Responders/ Non-Maintainers and Physical Activity Maintainers classes than the Non-Responders class.

In PREMIER, sex, age, vitality, and treatment randomization (Established vs. Established + DASH) were significant predictors of class membership (see Table 7). Compared to men, women were less likely to be in the Behavioral Maintainers and the Fruit & Vegetable/ Physical Activity Maintainers classes than the Non-Responders class (Table 7). Participants with high baseline vitality were more likely to be in the Behavioral Maintainers class than the Non-Responders class.

Discussion

In two large-scale behavioral lifestyle intervention trials, we identified four distinct patterns of behavioral adherence to dietary and physical activity recommendations over 18 months.

In both WLM and PREMIER, we identified latent classes of Behavioral Maintainers (participants who maintained high probabilities of meeting all recommendations at both 6 months and at 18 months) and Non-Responders (participants who had low probabilities of meeting any recommendations at any time point). In each trial, Behavioral Maintainers had the highest proportion of participants who maintained clinically significant weight loss over one year, while Non-Responders had the lowest proportion. These findings are consistent with previous studies that have demonstrated that maintaining adherence to multiple behavioral recommendations is associated with weight loss maintenance (Thomas, Bond, Phelan, Hill, & Wing, 2014), reducing risk for diabetes (Lindstrom et al., 2006), and cardiovascular disease events (Stampfer, Hu, Manson, Rimm, & Willett, 2000). Interestingly, more than half of the participants in the Physical Activity Maintainers class in WLM and the Responders/ Fruit & Vegetable Maintainers Only class in PREMIER also maintained clinically significant weight loss for one year. This suggests that maintaining adherence to a single behavior may be sufficient for maintaining clinically significant weight loss for some individuals. We also found that vitality was a significant predictor of latent class membership in both trials, indicating that participants with higher vitality scores at baseline are more likely to adhere to one or more behavioral recommendations long-term.

Vitality is a psychological component of wellbeing consisting of the subjective feeling of enthusiasm, vigor, energy, and alertness (Swencionis et al., 2013). Several behavioral lifestyle studies have demonstrated a significant relationship between an increase in vitality and weight loss (Hope, Kumanyika, Shults, & Holmes, 2010; Swencionis et al., 2013). Our study suggests that vitality scores prior to the start of treatment may help to determine who will adhere to multiple behavioral recommendations and could therefore inform treatment tailoring. Among participants with below average vitality scores at baseline, a behavioral intervention grounded in self-determination theory could be ideal for increasing vitality and improving weight outcomes (Ryan & Deci, 2008), but further research is needed.

Perhaps because of the larger sample size, we identified several additional significant predictors of latent class membership in WLM, including race/ethnicity, BMI at screening, and family and friend encouragement to exercise. Compared to non-Blacks, Black non-Hispanics were more likely to be in the Non-Responders class than in the other three classes, indicating a lower probability of adhering to one or more recommended behaviors. Further research is needed to examine barriers to adherence and determine if there are certain behaviors associated with weight loss and weight maintenance that Black non-Hispanics are more likely to adhere to long-term. Consistent with past literature, we found that participants with higher family and friend encouragement to exercise at baseline were more likely to maintain adherence to physical activity recommendations (Floegel et al., 2015). Future behavioral intervention studies may consider using level of social support for exercise to inform treatment tailoring.

A surprisingly high proportion of participants in the Nutrition Responders/ Non-Maintainers class (53%) in WLM maintained clinically significant weight loss. The existence of this class is consistent with the common weight regain trajectory seen in most behavioral lifestyle trials as frequency of intervention contacts are reduced (Knowler et al., 2009; Look & Wing, 2010). The Nutrition Responders/ Non-Maintainers class reflects the need for

regular assessment of behaviors during treatment to identify relapse early and to modify the treatment (e.g., continuing weekly or bi-weekly intervention contacts) to increase success of participants.

Conducting behavioral assessments throughout an intervention would also help to identify Non-Responders earlier. Non-responders, who had very low probabilities of adhering to any of the behavioral recommendations throughout the study, made up approximately half of the participants in each trial. Given that so many participants were unable to meet any of the behavioral recommendations, even during the intensive intervention phase, suggests that the recommendations may have been inappropriately ambitious and did not account for possible disparities in access to healthy foods or safe environments to engage in physical activity. Although minimal, it should be noted that Non-Responders did make some behavioral changes that contributed to 30% in WLM and 15% in PREMIER achieving and maintaining clinically significant weight loss. A major objective for future research will be to determine whether different behavioral treatment approaches and patient-centered recommendations can improve long-term behavioral and weight outcomes amongst members of this class (Ma et al., 2015; Sherwood et al., 2016).

Limitations

Differences in participant eligibility and data collection tools between WLM and PREMIER may have limited the similarity of latent classes and the predictors of class membership across trials. Participants in WLM were older and sicker than those in PREMIER. This may explain why there was a higher probability of meeting the behavioral recommendations even at baseline in PREMIER, particularly in the Behavioral Maintainers class. In addition, only participants from Phase 2 of WLM were included in these analyses. Participants had to lose at least 4 kg of their initial weight during Phase 1 to be randomized in Phase 2. For PREMIER, participants were included regardless of weight loss in the intensive intervention phase.

Use of different cutoffs for the fruit and vegetable intake recommendation may have contributed to different fruit and vegetable focused classes emerging in PREMIER (Responders/Fruit & Vegetable Maintainers Only and Fruit & Vegetable/ Physical Activity Maintainers) that were not seen in WLM. However, when the fruit and vegetable cutoff of nine or more was used in PREMIER, the classes that emerged were uninterpretable. Of course, there are obvious limitations in the use of self-report measures for dietary intake in both trials (Dhurandhar et al., 2015). However, 24-hour dietary recall and the Block Food Frequency Questionnaire were the most common measures of dietary intake in the field during the time these trials were conducted, which was more than a decade ago.

Another limitation of this study was that we did not examine weight change post-intervention. However, the 6- and 18-month follow-ups occurred when the intervention contacts had been reduced from weekly to monthly or not at all (Self-Directed arm in WLM), which is when behavioral relapse and weight regain are more likely to happen. Thus, we were able to use RMLCA to identify subgroups of participants who maintained adherence to all or some recommendations during this difficult transition in treatment and relate it to their success in maintaining clinically significant weight loss.

Conclusions

Using RMLCA, we identified distinct patterns of long-term behavioral adherence in two large-scale randomized behavioral clinical trials. Adherence to single or multiple behavioral recommendations was significantly associated with maintenance of clinically significant weight loss. Patterns of long-term behavioral adherence were predicted by age, sex, and vitality score in both trials and by race/ethnicity, BMI at screening, and social support for exercise in WLM. Our study demonstrates the potential of using behavior change instead of weight change as an indicator of treatment response. Focusing on behavior change provides the opportunity to compare and examine participants who adhere to a single behavior versus those who adhere to multiple behaviors, which has implications for future treatment development and tailoring. Additionally, treatment tailoring based on baseline scores on psychosocial measures could increase the number of people who benefit from behavioral lifestyle interventions and lead to more cost-effective interventions. Further research is needed to replicate our findings, identify additional psychosocial predictors of long-term behavioral adherence, and explore how patterns and predictors of adherence vary across cultural and health contexts.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Figure 1.
Proportion of Participants who Maintained 5% Loss of Initial Weight for One-year in the Weight Loss Maintenance Trial by Latent Class

Figure 2.
Proportion of Participants who Maintained 5% Loss of Initial Weight for One-year in
PREMIER by Latent Class

Table 1.

Baseline Sample Characteristics for Weight Loss Maintenance Trial and PREMIER

	Weight Loss Maintenance (N = 1032)	PREMIER (N = 506)
Sex, n (%) female	654 (63)	306 (60)
Age, M(SD), years	55.64 (8.69)	49.91 (8.74)
Race/ethnicity, n (%) Black non-Hispanic	388 (38)	174 (34)
Body Mass Index, M(SD), kg/m ²	34.03 (4.76)	33.56 (5.49)
Education, n (%)		
High School or Less	81 (8)	48 (9)
Some college or higher	951 (92)	458 (91)
Annual household income, n (%)		
<\$60,000	457(44)	229 (45)
>\$60,000	575 (56)	277 (55)
SF-36 Vitality subscale, M(SD)	51.08 (9.52)	60.21 (18.38)
SF-36 Mental Health composite, M(SD)	53.52 (7.15)	79.55 (13.27)
Perceived Stress Scale, M(SD)	4.07 (2.70)	3.83 (2.76)
PHQ-8, M(SD)	3.58 (3.55)	---
Family Encouragement, eating habits, M(SD)	12.53 (7.46)	12.66 (7.69)
Friend Encouragement, eating habits, M(SD)	9.99 (6.22)	9.39 (6.53)
Family Discouragement, eating habits, M(SD)	11.28 (5.81)	11.06 (5.65)
Friend Discouragement, eating habits, M(SD)	9.98 (4.95)	9.26 (5.34)
Family Encouragement, exercise habits, M(SD)	28.30 (10.44)	28.07 (13.15)
Friend Encouragement, exercise habits, M(SD)	17.07 (8.39)	24.86 (12.54)

Table 2.

Proportion Meeting Intervention Behavioral Goals at Each Time Point

	Weight Loss Maintenance (n = 1032)			PREMIER (n = 506)		
	B	6M	18M	B	6M	18M
Fruit & Vegetable 9 ^a	0.10	0.48	0.30	0.05	0.17	0.15
Fruit & Vegetable 5 ^b	0.46	0.84	0.73	0.37	0.63	0.56
% Fat 25%	0.03	0.24	0.16	0.14	0.43	0.36
% Saturated Fat 7%	0.05	0.27	0.19	0.10	0.36	0.30
Physical Activity 180 mins/ week	0.21	0.38	0.31	0.39	0.61	0.54

^aThe recommendation to consume 9 or more servings of fruits and vegetables per day is based on the DASH diet. This cutoff was applied only to the Weight Loss Maintenance trial repeated measures latent class analysis.

^bThe recommendation to consume 5 or more servings of fruits and vegetables per day is based on national recommendations. This cutoff was applied only to the PREMIER trial repeated measures latent class analysis due to the low number of participants meeting the recommendation for 9 or more servings each time point.

Table 3.
Model Fit Indices for Repeated Measures Latent Class Solutions for Weight Loss Maintenance and PREMIER

Classes	Loglikelihood	# of Parameters Estimated	AIC	BIC	Sample-size Adjusted BIC	Entropy	BLRT
Weight Loss Maintenance Trial							
1	-5777.82	12	11579.64	11638.91	11600.79	1.00	---
2	-5331.26	25	10712.51	10835.99	10756.59	0.79	<.001
3	-5229.42	38	10534.84	10722.53	10601.83	0.73	<.001
4	-5156.80	51	10415.60	10667.50	10505.52	0.75	<.001
5	-5093.62	64	10315.24	10631.35	10428.08	0.78	<.001
6 ^a	-5039.40	77	10232.80	10613.13	10368.57	0.80	<.001
7 ^a	-4991.39	90	10162.79	10607.32	10321.47	0.82	<.001
PREMIER							
1	-3370.93	12	6765.86	6816.58	6778.49	1.00	---
2	-3106.40	25	6262.81	6368.47	6289.12	0.72	<.001
3	-3048.29	38	6172.59	6333.20	6212.58	0.77	<.001
4	-2995.32	51	6092.65	6308.20	6146.32	0.70	<.001
5 ^a	-2961.74	64	6051.48	6321.98	6118.84	0.77	<.001
6 ^a	-2934.23	77	6022.46	6347.91	6103.50	0.77	<.001

Note. The class solution shaded in gray indicates the selected model. Dashes indicate criterion was not applicable for the model. AIC = Akaike Information Criteria; BIC = Bayesian Information Criteria; BLRT = bootstrap likelihood ratio test.

^aModel appeared to be unidentified and had poor replication of the best log-likelihood despite 1000 random starts.

Table 4.

Model Selection: Parameter Estimates for 4 Class Solution for Weight Loss Maintenance

	Class 1: Behavioral Maintainers (n = 144, 14%)			Class 2: Nutrition Responders/Non-Maintainers (n = 176, 17%)			Class 3: Physical Activity Maintainers (n = 199, 19%)			Class 4: Non-Responders (n = 513, 50%)		
	B	6M	18M	B	6M	18M	B	6M	18M	B	6M	18M
Fruit & Vegetable ⁹	0.14	0.64	0.56	0.14	0.75	0.39	0.10	0.45	0.29	0.08	0.35	0.20
% Fat 25%	0.12	0.60	0.82	0.07	0.64	0.12	0.01	0.11	0.03	0.00	0.03	0.02
% Saturated Fat ^{7%}	0.16	0.64	0.93	0.12	0.83	0.15	0.02	0.11	0.05	0.00	0.02	0.03
Physical Activity ^{180 mins/wk}	0.33	0.48	0.45	0.05	0.24	0.19	0.58	0.88	0.78	0.09	0.20	0.10

Note. Item-response probabilities with the darker gray shading indicate high probability of meeting behavioral recommendation, lighter gray shading indicates moderate probability, and no shading is low probability. B = baseline; 6M = 6-months; 18M = 18-months.

Table 5.

Model Selection: Parameter Estimates for 4 Class Solution for PREMIER

	Class 1: Behavioral Maintainers (n = 80, 16%)			Class 2: Responders/Fruit & Vegetable Maintainers Only (n = 106, 21%)			Class 3: Fruit & Vegetable/ Physical Activity Maintainers (n = 111, 22%)			Class 4: Non-Responders (n = 209, 41%)			
	B	6M	18M	B	6M	18M	B	6M	18M	B	6M	18M	
Fruit & Vegetable ₅	0.61	0.84	0.82	0.26	0.72	0.63	0.53	0.89	0.78	0.24	0.28	0.25	
% Fat _{25%}	0.50	0.94	0.94	0.10	1.00	0.42	0.11	0.16	0.36	0.05	0.05	0.07	
% Saturated Fat _{7%}	0.41	0.88	0.89	0.03	0.83	0.32	0.06	0.09	0.28	0.03	0.03	0.06	
Physical Activity _{180 mins/wk}	0.63	0.86	0.77	0.24	0.54	0.47	0.57	0.80	0.68	0.26	0.41	0.37	

Note. Item-response probabilities with the darker gray shading indicate high probability of meeting behavioral recommendation, lighter gray shading indicates moderate probability, and no shading is low probability. B = baseline; 6M = 6-months; 18M = 18-months.

Table 6.

Predictors of Class Membership for Weight Loss Maintenance – Adjusted Covariate Analysis

Odds Ratio (95% CI)										
Classes	Sex (Male as reference)	Age	Race/ethnicity (non-Black as reference)	BMI at screening	SF-36 Vitality	PHQ-8	Family Encouragement ent., exercise	Friend Encouragement ent., exercise	# of times lost 100% or more	# of times seek assistance for weight loss
Behavioral Maintainers	0.62 (0.36, 1.05)	1.00 (0.98, 1.02)	0.66 (0.39, 1.09)	0.92 (0.87, 0.98)	1.03 (0.99, 1.07)	1.07 (0.99, 1.16)	1.02 (1.00, 1.04)	1.02 (0.98, 1.06)	1.08 (0.87, 1.34)	0.97 (0.74, 1.28)
Nutrition Responders, Non-Maintainers	1.31 (0.72, 2.41)	1.01 (0.97, 1.05)	0.39 (0.22, 0.69)	1.06 (1.00, 1.13)	0.98 (0.94, 1.02)	0.89 (0.80, 0.98)	1.01 (0.99, 1.03)	1.04 (1.02, 1.06)	1.19 (0.96, 1.47)	0.94 (0.72, 1.24)
Physical Activity Maintainers	0.23 (0.13, 0.41)	0.95 (0.91, 0.99)	0.57 (0.32, 1.00)	0.91 (0.86, 0.97)	1.04 (1.00, 1.08)	0.98 (0.89, 1.08)	1.00 (0.98, 1.02)	1.06 (1.02, 1.10)	1.13 (0.84, 1.51)	0.78 (0.52, 1.18)
Non-Responders (reference)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Table 7.

Predictors of Class Membership for PREMIER – Adjusted Covariate Analysis

Classes	Odds Ratio (95% CI)				
	Sex (Male as reference)	Age	BMI at screening	SF-36 Vitality	Treatment (Established as reference)
Behavioral Maintainers	0.40 (0.18, 0.92)	1.05 (0.99, 1.11)	0.93 (0.86, 1.01)	1.03 (1.01, 1.05)	5.05 (2.35, 10.85)
Responders/ Fruit & Vegetable Maintainers Only	0.86 (0.38, 1.96)	1.03 (0.99, 1.07)	1.01 (0.95, 1.07)	1.00 (0.98, 1.02)	5.42 (2.73, 10.76)
Fruit & Vegetable/ Physical Activity Maintainers	0.20 (0.08, 0.49)	1.08 (1.02, 1.15)	1.00 (0.98, 1.02)	1.01 (0.99, 1.03)	2.80 (1.33, 5.90)
Non-Responders (reference)	1.00	1.00	1.00	1.00	1.00