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Behavioral, psychological, and environmental predictors of weight regain in a group of successful weight losers in a widely available weight-management program

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Abstract

Objective: The aim of this study was to identify predictors of weight regain and continued weight maintenance among individuals already successful at long-term weight loss in a widely available weight-management program.

Methods: Participants were 2843 weight-loss maintainers in WeightWatchers who had maintained weight loss ≥9.1 kg for ≥1 year (average 25.5 kg for 3.5 years; BMI = 26.7 kg/m^2). Validated behavioral, psychosocial, and home environmental questionnaires were administered at study entry and 1 year later. Discriminant analysis identified variables that discriminated gainers (≥2.3-kg gain) from maintainers (±2.3-kg change).

Results: Over the 1 year of follow-up, 43% were gainers (mean [SD], 7.2 [5.4] kg), and 57% were maintainers (0.4 [1.2] kg). Compared with maintainers, gainers were younger and had higher initial weight, more recent weight losses, and larger initial weight losses. Standardized canonical coefficients indicated that the 1-year changes that most discriminated gainers from maintainers were greater decreases in the ability to accept uncomfortable food cravings, urges, and desires to overeat (0.232); self-monitoring (0.166); body image (0.363); and body satisfaction (0.194) and greater increases in disinhibition (0.309) and bodily pain (0.147). The canonical correlation was 0.505 ($p < 0.001$).

Conclusions: Future interventions to prevent regain should consider targeting overeating in response to internal and external food cues and declines in self-monitoring and body image.

INTRODUCTION

Sociodemographic, behavioral, psychosocial, and environmental predictors and correlates of weight-loss maintenance have long been a topic of inquiry, but gaps in the literature persist [1–3]. In studies of predictors, consistent evidence has shown that age, gender, and socioeconomic status are not significant in predicting weight-loss maintenance [3]. More initial weight loss has been the most consistent predictor [2, 3]. However, few other baseline determinants of weight-loss maintenance have emerged.

Examining successful weight-loss maintenance over time, strong evidence has supported continued engagement in high levels of physical activity and self-monitoring and low levels of disinhibition [2]. However, other consistent correlates have been elusive [1–3], and a

2019 systematic review of 8222 studies of weight-loss maintenance concluded insufficient evidence for psychological (e.g., quality of life) and environmental (e.g., availability of food) determinants of weight-loss maintenance [3].

Several novel potential determinants have emerged from treatment and laboratory literatures but have lacked examination among weight-loss maintainers. These variables include eating and activity habit strength [4]; sedentary behavior [5, 6]; future orientation [7–12]; self-compassion; acceptance of uncomfortable thoughts, feelings, urges, and cravings [13]; and eating in the absence of hunger [14]. Large-scale, prospective, observational studies are needed to determine applicability of these variables to weight-loss maintainers outside of academic settings.

Moreover, few studies have examined predictors and correlates of weight-loss maintenance among individuals who lose weight in commercial weight-loss programs, which reach 10% to 15% of the US population and which are clinically recommended [15]. The 2019 review identified only one high-quality study that included use of a commercial weight-loss program in evaluating determinants of weight-loss maintenance [3]. Predictors and correlates of weight maintenance may differ in participants in commercial programs compared with academic settings because commercial programs are widely available; offer participant flexibility in adherence, mode, and treatment duration; require payment; and have a diversity of coaches and supports for ongoing weight management.

The purpose of this study was to identify the factors that best characterized long-term maintenance of weight loss in members of the WeightWatchers (WW) Success Registry (WWSR), an observational study of weight-loss maintainers in WW. WW is a widely available commercial weight-management program that has demonstrated clinically significant long-term average weight loss [16]. The study was designed to investigate whether sociodemographic, behavioral, psychological, and home environmental factors measured at entry predicted weight gain versus continued weight maintenance over a subsequent year and whether changes in factors would differ in weight gainers versus maintainers. We hypothesized that weight-loss maintainers who regained weight would have greater declines in behavioral (practice of weight-control strategies, eating in the absence of hunger, physical activity, habit strength, limiting sedentary behavior), psychological (restraint, acceptance, quality of life, limiting disinhibition), and environmental (availability of fruit and vegetables and exercise equipment in the home) variables compared with weight-loss maintainers who subsequently maintained their weight.

Study Importance

What is already known?

- The most consistent predictor of long-term weight loss is magnitude of initial weight loss.
- Common correlates of sustained weight-loss maintenance include maintaining high levels of physical activity and self-monitoring and low levels of disinhibition.

What does this study add?

- The variables that most strongly differentiated regainers from maintainers were greater decreases in willingness to accept uncomfortable food cravings, self-monitoring, and body image and greater increases in disinhibition and bodily pain over a 1-year period.

How might these results change the direction of research or the focus of clinical practice?

- Future weight-maintenance interventions should target overeating in response to both internal and external food cues and declines in self-monitoring and body image.

METHODS

The WWSR is an observational study of individuals who lost weight in the WW program and who were successful at long-term maintenance of weight loss. Previous studies of the WWSR have focused on cross-sectional analyses of participants' characteristics when they joined the registry [17]. This is the first analysis to examine longitudinal change from enrollment to 1 year in the WWSR. Weight-loss maintainers were recruited between January 2019 and June 2020 through an email sent by WW to members who had reported a loss in WW of ≥9.1 kg (20 lb) >1 year ago. Interested individuals were referred to the study website hosted by California Polytechnic State University, San Luis Obispo (Cal Poly) for online screening, consent, and enrollment [17]. To be eligible for enrollment, individuals were aged ≥18 years and had maintained weight loss ≥9.1 kg (20 lb) loss from WW entry for ≥1 year [17]. Eligibility was based on self-reported weight, height, weight change, and duration [17]. The consent form was sent to participants electronically via Research Electronic Data Capture (RedCap), and participants who consented were then directed to the online questionnaire. Procedures were approved by the Cal Poly Institutional Review Board, and all participants provided informed consent.

Measures

WWSR measures were selected a priori based on previous literature indicating a potential relationship with successful weight control. All measures were administered at study enrollment and 1 year later.

Demographics

Participants were asked standard demographic information (age, education level, marital status) and lifetime maximum weight, as well as current weight and height [17].

Behavioral factors

The Weight Control Strategies Scale (WCSS) [18] was used to measure weight-control strategies, including healthy dietary choices, self-monitoring, physical activity, and psychological coping. Eating in the absence of hunger (EAH) was measured using the EAH for Children [19] scale. This scale is composed of 14 items that assess dimensions related to stimuli that generate beginning or continuing to eat food in the absence of hunger. "Continuing EAH" is defined as continuing to eat immediately after being satiated at mealtime, and "beginning EAH" is defined as beginning to eat while not hungry several hours after being satiated [19]. The Multicontext Sitting Time Questionnaire (MSTQ) was used to measure the proportion of waking hours spent sitting during weekdays and weekends and doing activities including working/reading/studying, watching television/movies, playing video games, engaging in computer time, and sleeping and inactive transportation [20]. Physical activity was measured using the Paffenbarger Physical Activity Questionnaire. The Self-Report Habit Index was administered to assess the extent to which exercise and healthy eating were routine, frequent, and automatic [21].

Psychosocial factors

The Eating Inventory (EI) was used to assess restraint (conscious control over food intake), disinhibition (loss-of-control overeating in response to internal and external stimuli), and hunger [22]. The Food-Related Acceptance and Action Questionnaire (FAAQ) [23] was administered to assess acceptance (i.e., ability to experience, instead of controlling or avoiding, uncomfortable internal experiences, including thoughts, feelings, urges, and cravings) and willingness (i.e., choosing healthy diet even when associated with urges, cravings, and desires to overeat) [23]. The 12-item Consideration of Future Consequences Scale (CFC) [24] was used to measure the extent to which people consider potential distant outcomes of their current behaviors (e.g., "I am willing to sacrifice my immediate happiness or well-being in order to achieve future outcomes."). Self-kindness and compassion were measured using the validated Self-Compassion Scale [25], including subscales of self-kindness (i.e., being kind and understanding toward oneself in instances of pain or failure), self-judgment (being harshly self-critical), common humanity (perceiving one's experiences as part of the larger human experience), isolation (feeling alone), and mindfulness (holding painful thoughts and feelings in mindful awareness and overidentification, i.e., catastrophizing); note that items representing uncompassionate responses to suffering are reverse-coded so that higher scores represent a lower frequency of these responses. Body image was measured using the appearance evaluation subscale and the body areas satisfaction subscale of the Multidimensional Body-Self Relations Questionnaire (MBSRQ) [26]. Quality of life was measured using the 20-Item Short Form Health Survey (SF-20), which measures health perceptions (self-rated general health), mental health (negative and positive mental states), bodily pain (bodily pain and discomfort), physical functioning (ability to perform daily activities that require physical effort), role limitations (limitations in performing work and other usual activities), and social functioning (quantity and quality of social activities with others); subscales range from 0 (worst health) to 100 (perfect health).

Environmental factors

The Exercise Environment Questionnaire [27] was used to assess the presence of exercise equipment available in the home. The Household Food Inventory [28] was used to assess fruit and vegetables currently available in the home.

Statistical methods

The analysis in this study was focused on weight regain ≥ 2.3 kg (5 lb) based on other studies in the literature and data suggesting that it yielded findings in alignment with 5% and 10% weight regain criteria [29]. We excluded the relatively small group of individuals ($n = 148$; 4.9% of sample) who lost > 2.3 kg (average 6.5 [standard deviation (SD) 5.7] kg) over the 1-year study duration to be consistent with other studies in the literature [29] and owing to the potential for factors related to continued weight loss to differ from those related to weight maintenance or weight regain [30]. The study's approach to handling missing data was to evaluate whether completers and non-completers differed in baseline sociodemographic and weight-history factors and, in the event of differences, to consider the variables as covariates in analysis and interpretation of findings. The study's *a priori* plan did not include imputing missing values given the degree of uncertainty and assumptions for this approach. Group differences in sociodemographic variables and characteristics of those who completed versus did not complete the 1-year questionnaire were analyzed by independent *t* tests and χ^2 analyses. Logistic regression was used to determine characteristics measured at the initial assessment that would predict weight regain versus continued maintenance of weight at the 1-year follow-up. Repeated measures ANOVA was used to determine whether the groups experienced significantly different changes in behavioral, psychological, and environmental characteristics between the two assessments, adjusting for baseline age, weight, lifetime maximum weight, duration of weight-loss maintenance, and baseline value of dependent variables. Discriminant function analysis was used to determine the variables that most differentiated maintainers from gainers among the set of variables that were found to differ between the two groups in the initial univariate analyses. The resulting standardized canonical coefficients represent the measure of association between the discriminant function (based on the linear combination of variables) and each predictor variable and indicate the relative importance of each variable in distinguishing the two groups (similar to β weights in a multiple regression). Interpretation of statistical tests was done by examining the sizes of effect estimates and confidence limits, as well as precise *p* values. In an effort to guard against type I error due to multiple analyses [31] and limit type II error, which

TABLE 1 Sociodemographic and anthropometric characteristics at the initial assessment that predicted weight regain or maintenance at the 1-year follow-up among 2843 participants already successful at long-term weight loss in WW

	Overall ($N = 2843$)	Maintainers ($n = 1632$)	Gainers ($n = 1211$)	p value
Demographic and weight history				
Age (y), mean (SD)	55.6 (12.2)	58.1 (11.6)	52.2 (12.3)	**<0.001**
Gender (female), % (*n*)	91.6% (2603)	91.2% (1489)	92.0% (1114)	0.496
Race (non-Hispanic White), % (*n*)	95.3% (2709)	95.5% (1558)	95.0% (1151)	0.655
Annual household income (>$75,000), % (*n*)[a]	65.6% (1667)	66.9% (954)	63.9% (713)	0.182
Education (some college or higher), % (*n*) [a]	89.1% (2514)	90.1% (1457)	87.8% (1057)	0.049
Married, % (*n*)[a]	91.6% (2592)	93.0% (1508)	89.7% (1084)	0.002
Weight information				
Current weight (kg), mean (SD)	73.8 (14.8)	70.9 (11.9)	77.7 (17.2)	**<0.001**
Current BMI (kg/m^2), mean (SD)	26.7 (4.7)	25.8 (3.6)	27.9 (5.6)	**<0.001**
BMI category at study entry, % (*n*)				**<0.001**
Obesity	16.1% (457)	10.5% (171)	23.6% (286)	
Overweight	43.6% (1240)	43.1% (757)	44.3% (536)	
Normal weight	40.3% (1146)	46.4% (757)	32.1% (389)	
Lifetime maximum weight (kg), mean (SD)[a]	103.4 (21.8)	100.0 (19.8)	108.1 (23.4)	**<0.001**
Weight at start of WW (kg), mean (SD)	99.3 (20.2)	95.7 (17.8)	104.1 (22.2)	**<0.001**
BMI at start of WW (kg/m^2), mean (SD)	35.9 (6.6)	34.8 (5.8)	37.4 (7.3)	**<0.001**
Weight lost from maximum weight (kg), mean (SD)[a]	29.6 (15.1)	29.1 (14.7)	30.3 (15.5)	0.03
Weight loss since WW start (kg), mean (SD)	25.5 (12.7)	24.8 (12.5)	26.4 (13.0)	**<0.001**
Percentage weight loss since WW start (%), mean (SD)	25.0 (8.7)	25.1 (8.8)	24.8 (8.7)	**<0.001**
Duration of 9.1-kg loss criterion (y), mean (SD)[a]	3.5 (3.8)	3.8 (4.0)	3.0 (3.5)	**<0.001**
Weight at 1 year (kg)	77.1 (16.7)	71.3 (11.8)	84.9 (19.0)	**<0.001**
BMI at 1 year	27.9 (5.4)	25.9 (3.6)	30.5 (6.3)	**<0.001**
Weight gain (0 to 1 year)	3.3 (5.0)	0.4 (1.2)	7.2 (5.4)	**<0.001**

Note: Independent t tests for continuous variables and χ^2 tests for categorical variables were used to compare gainers and maintainers on baseline variables. To guard against type I error due to multiple analyses, statistical significance was set to $p < 0.001$ and differences are marked in bold.
Abbreviations: WW, WeightWatchers.
[a]Sample sizes were slightly reduced on some characteristics that participants self-selected not to report, as follows: income ($n = 2543$); education ($n = 2821$); marital status ($n = 2829$); lifetime maximum weight and weight lost from maximum weight ($n = 2835$); and duration of weight-loss maintenance ($n = 2833$).

can increase with increasing p value adjustments [31], statistical significance was set to $p < 0.001$, reflecting adjustment of the 5% error rate by 5 (0.05/5) to account for the five tests that make up the WWSR primary outcome (WCSS). Importantly, significance was interpreted only for group differences that resulted in partial eta squared (η_p^2) values > 0.01, representing at least a small effect size ($d \geq 0.20$) [32, 33]. The SPSS Statistics (25.0.0; IBM Corp.) statistical package was used for all analyses.

RESULTS

Of the 7025 WWSR participants who had reached their 1-year follow-up, 4004 (57%) did not complete the 1-year questionnaire, and 30 (0.4%) had implausible 1-year weight data, leaving a sample size of 2991. After removal of the individuals who lost > 2.3 kg over the 1-year study duration, this left a final analytic sample of 2843. Participants with complete versus incomplete data were older (55.6 [12.2] vs. 51.7 [12.7] years; $p < 0.001$), had lost more weight from their lifetime maximum weight (29.6 [15.1] vs. 27.0 [14.3] kg; $p < 0.001$), had a lower current weight (73.8 [14.8] vs. 78.1 [17.5] kg; $p < 0.001$), had a longer duration of weight-loss maintenance (3.5 [3.8] vs. 3.3 [3.7] years; $p < 0.001$), and were more likely to be non-Hispanic White (95.1% vs. 74.5%; $p < 0.001$). Analyses adjusted for these baseline variables.

Participants

Overall, most (92%) participants were women, 95% were White, 92% had an undergraduate or graduate college degree, and 92% were currently married. Although the minimum weight loss required for entry was 9.1 kg (20 lb), participants lost, on average, 25.5 kg. Similarly, although the minimum duration of weight maintenance was 1 year,

TABLE 2 Mean behavioral characteristics at the initial and 1-year follow-up assessments in maintainers and gainers

	Initial assessment			1-Year assessment		
	Maintainers, M (SD)	Gainers, M (SD)	OR (95% CI); *p* value	Maintainers, M (SD)	Gainers, M (SD)	Time: η_p^2; *p* value Group × time: η_p^2; *p* value
Weight-control strategies total score (0 = never; 4 = always)	2.9 (0.5)	2.7 (0.6)	0.8 (0.6–0.9); $p < 0.001$	2.8 (0.5)	2.4 (0.7)	**0.02; $p < 0.001$** **0.07; $p < 0.001$**
Psychological coping strategies subscale score	2.6 (0.7)	2.4 (0.7)	0.9 (0.8–1.0); $p = 0.034$	2.5 (0.7)	2.1 (0.8)	**0.02; $p < 0.001$** **0.06; $p < 0.001$**
Self-monitoring strategies subscale score	2.8 (0.8)	2.7 (0.8)	1.0 (0.9–1.1); $p = 0.56$	2.6 (0.9)	2.2 (1.0)	**0.01; $p < 0.001$** **0.04; $p < 0.001$**
Physical activity strategies subscale score	2.4 (1.1)	2.2 (1.1)	0.9 (0.8–0.9) $p \leq 0.001$	2.4 (1.0)	2.0 (1.1)	**0.02; $p < 0.001$** **0.03; $p < 0.001$**
Dietary choices subscale score	3.4 (0.4)	3.3 (0.5)	0.8 (0.6–0.9); $p = 0.003$	3.3 (0.5)	3.0 (0.6)	**0.03; $p < 0.001$** **0.04; $p < 0.001$**
Eating in the absence of hunger, EAH (possible range from 7 to 70)						
Continuing to EAH subscale	31.9 (8.6)	34.2 (8.7)	1.0 (1.0–1.0); $p = 0.002$	32.1 (9.0)	35.7 (9.0)	**0.06; $p < 0.001$** 0.01; $p < 0.001$
Beginning to EAH subscale	30.8 (8.7)	32.9 (8.8)	1.0 (1.0–1.0); $p < 0.001$	30.8 (9.0)	34.4 (9.1)	**0.06; $p < 0.001$** **0.011; $p < 0.001$**
Physical activity						
Total weekly energy expenditure, kcal/wk	2107.6 (2422.2)	2171.5 (8929.0)	1.0 (1.0–1.0); $p = 0.064$	1922.2 (1782.4)	1727.0 (1848.4)	**0.02; $p = 0.001$** 0.001; $p = 0.29$
Sedentary behavior						
Weekend proportion of waking hours spent sitting, %	58.6 (26.9)	57.3 (22.3)	OR = 0.9 (0.7–1.3); $p = 0.695$	57.4 (28.3)	60.2 (30.4)	0.007; $p < 0.001$ 0.0001; $p = 0.211$
Weekday proportion of waking hours spent sitting, %	62.6 (27.3)	64.3 (23.8)	1.0 (0.7–1.3); $p = 0.923$	61.8 (27.3)	65.8 (27.6)	**0.02; $p < 0.001$** 0.002; $p = 0.119$
Habit strength (1 = strongly disagree and 7 = strongly agree)						
Healthy eating habit strength	4.6 (1.7)	4.3 (1.7)	0.9 (0.8–0.9); $p < 0.001$	4.7 (1.7)	4.1 (1.8)	**0.03; $p < 0.001$** **0.02; $p < 0.001$**
Physical activity habit strength	5.5 (1.1)	5.3 (1.1)	0.9 (0.8–1.0); $p = 0.01$	5.6 (1.0)	4.9 (1.3)	**0.05; $p < 0.001$** **0.05; $p < 0.001$**

Note: Logistic regression examined differences at the initial assessment. General linear models with repeated measures examined 1-year changes. Analyses adjusted for baseline outcome variable, study entry weight, age, lifetime maximum weight, and duration of weight-loss maintenance; unadjusted means are displayed for interpretation purposes. η_p^2 refers to partial eta squared/effect size. Bold values indicate significant differences. To guard against type I error due to multiple analyses, statistical significance was set to $p < 0.001$, and significance furthermore was interpreted only for group differences that resulted in partial η square values ≥ 0.01, representing at least a small effect size ($d > 0.20$; OR converted to effect size using https://www.escal.site/) [33]. Participants could skip questions, resulting in slightly different sample sizes as follows: Restraint/Disinhibition/Hunger, $n = 1268$; Weight Control Strategies Scale, $n = 1531$; EAH, $n = 1126$; sitting time, $n = 1432$; habits, $n = 1226$; Paffenbarger Physical Activity Questionnaire, $n = 1356$.

Abbreviations: M, mean; OR, odds ratio.

participants had, on average, maintained the minimum weight loss for 3.5 years (Table 1).

Of 2843 individuals assessed at the 1-year follow-up, 1632 (57.4%) were classified as maintainers (i.e., maintained weight within 2.3 kg since initial assessment), and 1211 (42.6%) were classified as gainers (gained ≥2.3 kg since the initial assessment). The average 1-year weight gain among the maintainers was 0.4 (1.2) kg and among gainers was 7.2 (5.4) kg. Of note, at the 1-year follow-up, despite gaining more than maintainers, gainers remained, on average, 19.1 (13.5) kg (17.9% [9.7%]) below their WW starting weight, thereby still maintaining a substantial weight loss.

Baseline differences between gainers and maintainers

Weight-related and sociodemographic characteristics of gainers and maintainers at the initial assessment are shown in Table 1. Whereas gainers were younger than maintainers, the two groups appeared otherwise similar on sociodemographic variables. However, differences in weight-related variables were observed. Those classified as gainers reported a higher lifetime maximum weight and higher weight at enrollment into WW and into the WWSR. In addition, gainers had maintained their weight for fewer years than maintainers at enrollment into the WWSR. Gainers had lost more weight in kilograms but weight loss as a percentage of WW starting weight was lower than maintainers. Examining behavioral and psychological characteristics of the two groups at the initial assessment, maintainers and gainers did not appreciably differ (Table 2).

Longitudinal changes over 1 year

Behavioral changes

Examining changes between the initial assessment and 1-year follow-up, there were differences between maintainers and gainers on most behavioral variables (Table 2). Whereas maintainers' behaviors remained constant relative to study entry, gainers demonstrated declines in the practice of evidence-based weight-control behaviors measured by the WCSS, including self-monitoring, physical activity strategies, and dietary choices and coping. Gainers also reported increases in initiating EAH and declines in habit strength for healthy eating and activity. The group × time interactions were not significant for the Paffenbarger measure of total weekly energy expenditure and proportion of waking hours spent sitting (Table 2).

Psychological changes

Over the 1-year follow-up, maintainers also reported fewer changes in psychological characteristics than gainers (Table 3). Relative to maintainers, gainers reported greater increases in disinhibition (i.e., loss-of-control overeating in response to external and internal stimuli) and willingness to ignore food cravings. Gainers reported increases in self-judgment and isolation and worsening body image, perceptions of general health, mental health, and bodily pain.

Home environment changes

There were no significant group × time interactions in home environmental variables, including the number of pieces of exercise equipment in the home or number of fruit and vegetables in the home (Table 3).

Multiple discriminant analysis of behavioral and psychological factors

Multiple discriminant analysis was conducted to determine, among subscale variables that differed between gainers and maintainers in univariate analyses, which variables most strongly discriminated the groups. The overall model explained 25.5% of the variance (canonical correlation = 0.505; Wilks $\lambda = 0.745$; $\chi^2 = 322.1$; $p < 0.001$). Standardized canonical coefficients indicated variables with 1-year changes that contributed independently and most to discriminating gainers from maintainers were greater increases in disinhibition (0.309), declines in regulating eating in response to cravings (0.232), and decreases in self-monitoring (0.166). Gainers also reported worsening body image (0.363), body satisfaction (0.194), and bodily pain (0.147). These results are shown in Table 4.

DISCUSSION

Among individuals already successful at long-term weight-loss maintenance in a widely available commercial weight-management program, 57% maintained their weight over 1 year of follow-up, and 43% experienced weight regain ≥ 2.3 kg (5 lb). Despite regaining weight, gainers' weight remained 18% below their WW starting weight, exceeding weight-loss maintenance criteria for long-term successful weight loss and supporting other research in the field [34]. Nonetheless, compared with maintainers, gainers had greater declines in the regulation of eating in response to internal and external food cues, self-monitoring, and body image and increases in bodily pain over the 1-year follow-up.

Relative to maintainers, gainers' greater declines in disinhibition suggested greater challenges in sustaining eating regulation in the face of external (e.g., the sight of food, social situations) and internal (e.g., taste and smell of food, feelings) food cues. Similarly, gainers' greater declines in acceptance scores were indicative of less sustained tolerance of uncomfortable food cravings, urges, and desires to overeat. A more unhealthy food environment among gainers may have triggered uncomfortable cravings and intrinsic drives to consume unhealthy foods that conflicted with their weight-control goals [35], although gainers and maintainers did not significantly differ in the home food environment as measured in the current study. More

TABLE 3 Mean psychological characteristics and the home environment at the initial and 1-year follow-up assessments in maintainers and gainers

	Initial assessment			1-Year assessment		
	Maintainers, M (SD)	Gainers, M (SD)	OR (95% CI); *p* value	Maintainers, M (SD)	Gainers, M (SD)	Time: η_p^2; *p* value Group × time: η_p^2; *p* value
Eating Inventory						
Restraint	11.5 (1.8)	11.4 (1.8)	1.0 (0.94–1.0); $p = 0.392$	11.4 (1.8)	11.1 (2.0)	**0.144; $p = 0.001$** 0.002; $p = 0.10$
Disinhibition	9.6 (2.8)	10.6 (2.8)	1.1 (1.1–1.1); $p \leq 0.001$	9.4 (3.0)	11.4 (3.0)	**0.04; $p < 0.001$** **0.07; $p < 0.001$**
Hunger	5.2 (2.1)	5.8 (2.3)	1.0 (1.0–1.1); $p = 0.04$	5.1 (2.1)	6.0 (2.5)	0.02; $p < 0.001$ 0.006; $p < 0.001$
Food Craving Acceptance and Action Questionnaire (1 = very seldom; 3 = sometimes; 4 = frequently; and 6 = always)						
Willingness subscale (willingness to ignore cravings)	4.6 (0.6)	4.5 (0.6)	1.0 (0.8–1.1); $p = 0.51$	4.5 (0.6)	4.1 (0.8)	**0.08; $p < 0.001$** **0.06; $p < 0.001$**
Acceptance subscale (do not try to control urges)	3.3 (1.1)	3.1 (1.1)	0.9 (0.8–1.0); $p = 0.003$	3.5 (1.1)	3.1 (1.1)	**0.05; $p < 0.001$** **0.01; $p < 0.001$**
Future orientation (possible range from 12 to 60)	45.6 (6.8)	44.7 (7.2)	0.99 (0.98–1.0); $p = 0.32$	45.6 (6.8)	43.8 (7.5)	**0.09; $p < 0.001$** 0.007; $p = 0.006$
Self-compassion (2 = almost never; 10 = almost always)						
Self-kindness subscale	6.7 (1.6)	6.6 (1.5)	0.99 (0.9–1.0); $p = 0.60$	6.8 (1.6)	6.4 (1.7)	0.05; $p < 0.001$ 0.009; $p = 0.002$
Self-judgment subscale (higher scores represent a lower frequency of these responses)	6.3 (2.1)	6.1 (2.1)	1.0 (0.96–1.1); $p = 0.84$	6.5 (2.1)	5.9 (2.2)	**0.02; $p < 0.001$** **0.012; $p < 0.001$**
Common humanity subscale	6.9 [1.7]	6.6 [1.8]	0.99 (0.95–1.1); $p = 0.83$	6.9 (1.7)	6.5 (1.8)	**0.055; $p < 0.001$** 0.003; $p = 0.05$
Isolation subscale (higher scores represent a lower frequency of these responses)	6.6 (2.0)	6.1 (2.1)	0.96 (0.92–1.0); $p = 0.06$	6.8 (2.1)	6.1 (2.1)	**0.02; $p < 0.001$** 0.003; $p = 0.005$
Mindfulness subscale	7.4 (1.5)	7.2 (1.5)	0.97 (0.9–1.0); $p = 0.25$	7.3 (1.5)	6.9 (1.5)	**0.04; $p < 0.001$** **0.012; $p < 0.001$**
Overidentified subscale	6.3 (2.1)	6.1 (2.1)	0.99 (0.95–1.0); $p = 0.67$	6.6 (2.1)	5.8 (2.2)	**0.004; $p = 0.04$** **0.02; $p < 0.001$**
Body image (possible range from 9 to 45)						
MBSRQ 1-appearance evaluation (higher score indicates better body image)	23.7 (5.1)	22.5 (5.2)	1.0 (0.9–1.0); $p = 0.002$	23.1 (5.3)	19.7 (5.8)	**0.007; $p = 0.006$** **0.09; $p < 0.001$**
MBSRQ 2-body satisfaction (higher score indicates better body image)	31.0 (5.4)	29.6 (5.5)	1.0 (0.9–1.0); $p \leq 0.001$	30.6 (6.0)	27.1 (5.8)	**0.02; $p < 0.001$** **0.07; $p < 0.001$**

(Continues)

TABLE 3 (Continued)

	Initial assessment			1-Year assessment		
	Maintainers, M (SD)	Gainers, M (SD)	OR (95% CI); *p* value	Maintainers, M (SD)	Gainers, M (SD)	Time: η_p^2; *p* value Group × time: η_p^2; *p* value
Quality of life (possible range from 0 to 100)						
SF-36 total	80.1 (9.3)	78.6 (9.2)	0.99 (0.9–1.0); $p = 0.057$	79.1 (10.4)	75.2 (11.0)	0.040; **$p < 0.001$** **0.018; $p < 0.001$**
General health	81.3 (17.3)	78.4 (17.8)	0.99 (0.99–1.0); $p = 0.052$	79.9 (18.4)	72.0 (21.4)	**0.35; $p < 0.001$** **0.023; $p < 0.001$**
Mental health	78.5 (16.4)	76.0 (17.5)	0.99 (0.99–1.0); $p = 0.33$	77.8 (16.3)	72.1 (19.7)	**0.020; $p < 0.001$** **0.011; $p < 0.001$**
Bodily pain	70.7 (21.5)	70.3 (20.0)	0.99 (0.998–0.999); $p = 0.015$	70.6 (22.4)	65.1 (21.2)	**0.066; $p < 0.001$** **0.016; $p < 0.001$**
Physical functioning	88.4 (15.4)	86.7 (17.5)	0.99(0.98–0.99); $p \leq 0.001$	86.4 (17.4)	83.4 (20.3)	**0.083; $p < 0.001$** 0.002; $p = 0.163$
Role functioning	91.0 (21.6)	89.9 (24.2)	0.99 (0.99–1.0); $p = 0.35$	89.0 (23.8)	86.8 (26.4)	**0.099; $p < 0.001$** 0.001; $p = 0.357$
Social functioning	93.1 (14.3)	91.3 (16.2)	0.99 (0.99–1.0); $p = 0.057$	91.5 (15.8)	87.0 (20.1)	**0.128; $p < 0.001$** 0.006; $p = 0.008$
Environmental factors						
Total number of pieces of exercise equipment in the home	14.2 (6.0)	14.8 (5.9)	1.0 (0.99–1.03); $p = 0.22$	14.5 (6.0)	14.6 (5.9)	**0.029; $p < 0.001$** 0.005; $p = 0.019$
Total number of fruit and vegetables in the home	7.7 (1.9)	7.5 (1.9)	0.99 (0.94–1.03); $p = 0.59$	7.6 (1.9)	7.2 (2.0)	**0.039; $p < 0.001$** 0.003; $p = 0.084$

Note: Logistic regression examined differences at the initial assessment. General linear models with repeated measures examined 1-year changes. Analyses adjusted for baseline outcome variable, study entry weight, age, lifetime maximum weight, and duration of weight-loss maintenance; unadjusted means are displayed for interpretation purposes. η_p^2, partial eta squared/effect size. Bold values indicate significant differences. To guard against type I error due to multiple analyses, statistical significance was set to $p < 0.001$, and significance furthermore was interpreted only for group differences that resulted in partial η square values ≥ 0.01, representing at least a small effect size ($d > 0.20$; OR converted to effect size using https://www.escal.site/) [33]. Participants could skip questions, resulting in slightly different sample sizes as follows: Restraint/Disinhibition/Hunger, $n = 1268$; Weight Control Strategies Scale, $n = 1531$; eating in the absence of hunger, $n = 1126$; sitting time, $n = 1432$; habits, $n = 1226$; Paffenbarger Physical Activity Questionnaire, $n = 1356$; Food-Related Acceptance and Action Questionnaire, $N = 1193$; MBSRQ, $n = 1120$; self-compassion, $n = 1126$; SF-20, $n = 1123$; exercise equipment in the home, $n = 1147$; fruit and vegetables in the home, $n = 1096$.

Abbreviations: EAH, eating in the absence of hunger; M, mean; MBSRQ, Multidimensional Body-Self Relations Questionnaire; OR, odds ratio; SF, Short Form Health Survey.

TABLE 4 Factors that discriminate weight gain (vs. maintenance) at the 1-year follow-up

	Standardized canonical discriminant function coefficient
Current weight, mean (SD), kg (initial assessment)	−**0.382**
Current age, y	**0.378**
Lifetime maximum weight, kg	−**0.123**
Duration of 9.1-kg loss criterion, mean (SD), y	0.081
Disinhibition	−**0.309**
Psychological coping	−0.026
Self-monitoring	**0.166**
Physical activity strategies	0.009
Dietary choices	0.041
Habit formation: Healthy eating	0.041
Habit formation: Physical activity	0.028
Willingness subscale (willingness to ignore cravings)	**0.232**
Acceptance subscale (do not try to control urges)	0.088
Body image	**0.363**
Body satisfaction	**0.194**
Self-compassion: Self-judgment	0.051
Self-compassion: Mindfulness	0.058
Self-compassion: Overidentification	0.072
Eating in the absence of hunger, beginning to eat	0.098
General health	0.097
Mental health	−0.021
Bodily pain	**0.147**

Note: Multiple discriminant analysis was conducted to determine, among subscale variables that differed between gainers and maintainers in univariate analyses, which variables most strongly discriminated the groups. Bold values indicate significant differences. Results for the overall model (that included all the variables in the table) were as follows: 2 log likelihood 1098.9; Cox & Snell R^2 0.255; Nagelkerke R^2 0.353; classification % correct: 76.8% (overall); 89.6% maintainers, 52.4% gainers.

detailed measures of the home food environment and assessment of the environment outside the home are warranted [36]. Interventions that promote an ability to tolerate uncomfortable internal reactions to food triggers have shown promising results for long-term weight control [37]. In addition, weight-loss maintainers may vary in their responsiveness to cues that motivate overeating. Future research should investigate whether those higher in responsiveness to cues may benefit from specialized self-regulatory skills to prevent weight regain. To prevent weight regain, clinicians may work with patients to identify non-eating-related strategies to cope with uncomfortable feelings and external food cues.

Weight gainers also reported declines in practice of several behavioral strategies to support long-term weight maintenance, but the strongest behavioral discriminator between weight-loss maintainers and gainers was self-monitoring. Prior research has shown that the combination of high frequency (≥3 d/wk) plus high consistency of dietary self-monitoring is known to improve long-term success in weight management [38]. The accuracy and completeness of self-monitoring diaries are not as important as the frequency with which they are completed [38]. Most evidence-based treatment approaches, including the WW program, encourage digital tracking in an app. Reasons for declines in self-monitoring among long-term weight-loss maintainers are understudied and they may include stopping after reaching goal weight [4] or stopping while regaining weight to avoid negative experiences. Because weight changes and behavior changes were measured at the same time in this study, we cannot determine whether declines in monitoring caused the weight gain or vice versa. As this cohort continues to be followed beyond 1 year, prospective relationships between monitoring and weight regain can be studied. In addition, future studies with passive device monitoring or ecological momentary assessments could analyze prospective relationships between monitoring intensity and weight-loss maintenance. To prevent weight regain, clinicians may work with patients to identify strategies to sustain self-monitoring of weight, eating, and activity over time.

Gainers reported greater reductions in body image than maintainers. It is possible that gainers' body image was still improved relative to before weight loss. However, declines in body image have been linearly correlated with increases in depressive symptoms and lower self-esteem [39]. Such a relationship is unfortunate but not surprising in the context of a sociocultural climate where weight-based stigma and discrimination persist, particularly for women [40]. As a result, improvement in body image remains a strong source of motivation for weight-loss maintenance [41], and previous studies have found that even modest gains in weight can have a negative effect on body image [42]. Consistent with the body-image findings, gainers also reported greater increases than maintainers in negative self-judgment over time, but this did not emerge as an independent discriminator. Future weight-maintenance interventions should include empirically validated approaches for separating weight from body image [43, 44]. Social-change interventions are likely needed to combat the negative effects on body image and health of weight-based stigma and discrimination [45].

Bodily pain, which also was significant in discriminating gainers from maintainers, is a quality-of-life metric that may be important to consider in future interventions. Prior research has found that a reduction in pain is a key motivator of weight-loss maintainers [41]. Future weight-maintenance interventions may emphasize improvements in body function and pain rather than appearance as a motivator of long-term weight control and incorporate behavioral (e.g., physical activity) and psychological strategies to promote body function and minimize bodily pain. However, more frequent and detailed measures of bodily pain and weight regain are needed to understand directionality in the relationship between changes in bodily pain and weight.

The variables that did not discriminate weight-loss maintainers who regained or remained weight stable were also noteworthy. Weight-loss maintainers in the current study and prior literature are known to engage in high levels of physical activity [17], but calories expended in physical activity did not emerge as a discriminator. The

mean group changes over time were in the expected directions (i.e., smaller declines in activity among maintainers than regainers), but the ~300-kcal greater decline among gainers could have been compensated by eating or could be inaccurately measured via self-report. Sedentary behavior also did not change meaningfully in gainers and maintainers over the 1-year follow-up. Other research has found sedentary behavior to be lower among weight-loss maintainers than weight-stable individuals with obesity [5]. Longer-term studies with objective measures of movement are needed to confirm these findings.

The EI is a commonly administered measure in the behavioral weight-management literature, and it includes assessment of cognitive restraint and disinhibition. Cognitive restraint as measured by the EI has been a consistent predictor of weight-loss maintenance in treatment and observational studies. In the current study, cognitive restraint remained stable and at a level consistent with other studies of weight-loss maintainers, but it did not distinguish weight-loss maintainers from gainers. Disinhibition may more reliably identify weight regain.

Relatively few variables assessed at study entry distinguished maintainers versus gainers. In both the observational and clinical trial literature, few consistent predictors of weight regain have been identified [1, 2]. In the current study, gainers had a shorter duration of weight-loss maintenance than maintainers (average of 3 vs. 4 years), which is consistent with prior literature [29]. Gainers lost more total weight in kilograms than maintainers before enrolling in this study, but their percentage loss from WW starting weight, contrary to expectations, did not differ. Both groups lost 25% of their WW starting weight before joining the study. It is possible that weight change in the more immediate time after initial weight loss would discriminate maintainers from gainers, but that was not measured in the current study.

The study should be interpreted in the context of its limitations. Although the study was based on a large, nationally recruited sample of weight-loss maintainers in WW, participants were predominantly female and non-Hispanic White, and approximately two-thirds had annual household incomes > $75,000; therefore, it is unclear whether these findings generalize to more diverse samples. The follow-up rate in this study was lower than expected (43%). The lack of honorariums for participants and the large number of variables that were assessed could potentially explain the high attrition. Our analysis of baseline differences in the 1-year follow-up suggested that non-completers versus completers differed in some characteristics. Non-completers-reported a shorter duration of weight-loss maintenance, which could suggest higher risk of regain. On the other hand, non-completers also reported less weight loss from their lifetime maximum weight, which could suggest lower risk of regain. Thus, whether and how missing data affected weight-change classification in the study remains unclear, and future confirmatory research is needed. In addition, compared with completers, non-completers were younger and less likely to identify with a non-White racial or ethnic background. Although consistent evidence shows that age, gender, and socioeconomic status are not significant in predicting weight-loss maintenance [3], insufficient evidence exists for racial and ethnic differences in predicting weight maintenance versus regain [3]. Gainers and maintainers in the study did not differ significantly in race and ethnicity or gender and income. Thus, it is possible that sociodemographic factors may not usefully predict gainers versus maintainers, but cohorts with greater racial and ethnic diversity are needed. Weight measures were based on self-report, which have been validated in prior studies [29]. Nevertheless, the current study did not validate self-reported weight, lacked interim measures to capture weight trajectory, and did not collect measures of fat mass or other factors that could affect weight. Consistent with prior literature, the study classified regain using a 2.3-kg threshold, but it is possible that variables such as restraint and EAH would discriminate maintainers from people with greater weight regains.

In summary, this is the first known study to comprehensively and prospectively investigate determinants of weight-loss maintenance among individuals in a widely available commercial weight-management program. We found that that weight regain was common among long-term weight-loss maintainers. Despite this weight regain, the average weight loss among regainers was still 26 kg (25% of WW starting weight) after 3.5 years. The longitudinal study revealed that regainers had greater declines in the regulation of eating in response to internal and external food cues, self-monitoring, and body image and greater increases in bodily pain than did maintainers. Researchers, clinicians, and policy makers should consider these factors in the development of interventions to help prevent weight regain among those who have experienced clinically significant weight loss.

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CONFLICT OF INTEREST

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