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Psychological Status and Weight Variability Over Eight Years: Results from Look AHEAD

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Abstract

Objective—Cross-sectional studies suggest an association between weight cycling and psychological status. Although this is often interpreted as suggesting that weight cycles “cause” psychological distress, the relationship could be bi-directional. This study provides a prospective analysis of the bi-directional association between weight variability and psychological status over an eight-year period in overweight/obese adults with type 2 diabetes.

Methods—Data were from the first eight years of Look AHEAD, a randomized controlled trial comparing health outcomes in individuals with type 2 diabetes assigned to an intensive lifestyle

intervention designed to produce weight loss or a diabetes education and support control group. Psychological status (mental health, depressive symptoms, binge eating) was assessed via surveys and were examined in relation to weight variability at both baseline and year eight. Weight variability was derived from eight possible annual measurements from participants who had a minimum of three consecutive body weight measurements ($n = 4,774$) and operationalized as the number of year-to-year cycles and the coefficient of variation across all available weight measurements.

Results—Controlling for study group, higher baseline scores on mental health (SF-36 Mental Component Summary) and lower levels of depressive symptomatology (Beck Depression Inventory) and binge eating (Questionnaire on Eating and Weight Patterns) were associated with significantly less subsequent weight variability. The prospective association between weight variability and psychological status at year eight was less robust.

Conclusions—These results suggest that the cross-sectional relationship between weight variability and psychological status is due primarily to poorer psychological function preceding greater weight instability.

Keywords

body weight; mental health; depressive symptoms; binge eating; body weight change

In a recent Gallup poll, more than half of American adults reported wanting to lose weight. Over a quarter reported seriously trying to do so at the time of survey (Gallup, 2014). Regrettably, the majority of individuals who successfully lose weight, regain most, if not all, of weight lost within five years of completing a weight-loss program (Anderson, Konz, Frederich, & Wood, 2001). Weight loss and regain associated with unsuccessful weight control attempts have led to speculation about the potential negative physical and psychological health consequences of weight cycling (Brownell & Rodin, 1994; French & Jeffery, 1994). Most of the literature on correlates of weight cycling has been devoted to physiological consequences (e.g. heart disease, metabolic syndrome, morbidity, mortality) (Casazza et al., 2013; Montani, Schutz, & Dulloo, 2015; Vergnaud et al., 2007). Psychological factors have been less studied, with mixed results. Some studies have found a significant relationship between weight cycling and mental health (Foreyt et al., 1995), depressive symptoms (de Zwaan, Engeli, & Müller, 2015), and binge eating (Bartlett, Wadden, & Vogt, 1996; Dalle Grave, Todisco, Oliosi, & Marchi, 1996; de Zwaan et al., 2015; Marchesini et al., 2004; Spitzer et al., 1992; Venditti, Wing, Jakicic, Butler, & Marcus, 1996). Others have failed to find a relationship between weight cycling and mental quality of life (Strychar et al., 2009), depressive symptoms (Bartlett et al., 1996; Clark & King, 2000; Dalle Grave et al., 1996; Foreyt et al., 1995; Foster, Wadden, Kendall, Stunkard, & Vogt, 1996; Kuehnel & Wadden, 1994; Messier et al., 2014; Osborn, Forsy, Psota, & Sbrocco, 2011; Simkin-Silverman, Wing, Plantinga, Matthews, & Kuller, 1998), or binge eating (Foster et al., 1996; Kuehnel & Wadden, 1994; Osborn et al., 2011). As an example of these inconsistent findings, Bartlett, Wadden & Vogt (1996) studied cross-sectional relationships in 130 obese women with an average age of $41.1 \pm$ years. Weight cycling was assessed using the Weight and Lifestyle Inventory (Wadden & Foster, 2006), totaling the number of times the individual had dieted, and dividing this into quartiles. Depressive symptoms were

assessed using the Profile of Mood States (McNair, Lorr, Droppleman, & others, 1981), and binge eating was assessed with both the Questionnaire on Eating and Weight Patterns (QEWP) (Spitzer et al., 1993) and the Binge Eating Scale (BES) (Gormally, Black, Daston, & Rardin, 1982). Though they did not find a relationship between weight cycling and depressive symptoms or binge eating using the QEWP, a positive relationship between weight cycling and binge eating was found using the BES ($r = 0.24$, $p = 0.003$) (Bartlett et al., 1996). More recently, DeZwaan, Engeli, and Muller (2015) investigated the relationship between weight cycling, binge eating and depression in 923 overweight and obese adults. Average age was in the mid-forties and did not differ between severe-cyclers, defined by losing at least 10 kg on three or more occasions, and non-cyclers (all other participants). Depression was assessed with the Patient Health Questionnaire-9 (Kroenke, Spitzer, & Williams, 2001) and binge eating was assessed using the Eating Disorder Examination-Questionnaire (Fairburn, Beglin, & Fairburn, 2008). Severe cyclers (as compared to non-cyclers) reported a significantly higher depression rating (6.2 ± 4.7 versus 4.0 ± 3.6 , $p = 0.02$) and were more significantly more likely to report binge eating in the past 28 days (29.5% versus 9.9%, $p < 0.001$).

In addition to divergent findings due to defining weight cycling or other issues of assessment, another possible reason for discrepant findings could be study design. Most published data on weight cycling and psychological outcomes have been cross sectional, which confounds causal interpretations (Bartlett et al., 1996; Dalle Grave et al., 1996; de Zwaan et al., 2015; Foreyt et al., 1995; Friedman, Schwartz, & Brownell, 1998; Kensinger, Murtaugh, Reichmann, & Tangney, 1998; Kuehnel & Wadden, 1994; Marchesini et al., 2004; Osborn et al., 2011; Simkin-Silverman et al., 1998; Spitzer et al., 1992; Strychar et al., 2009; Venditti et al., 1996). Only three studies prospectively evaluated this relationship and none found evidence of weight variability predicting poorer psychological outcomes, conceptualized as mood/depressive symptoms, depression, or binge eating (Clark & King, 2000; Foster et al., 1996; Messier et al., 2014). Two of these studies were limited in sample size, and the remaining study had a short follow-up interval. Furthermore, these three prospective studies posited weight cycling as a predictor of psychological outcomes; however, it is possible that the relationship is bidirectional: psychological factors could predict weight cycling. Poorer psychological status predicts greater attrition from weight loss programs (e.g. Sherwood, Jeffery, & Wing, 1999), less weight loss and greater chance of regain (Elfhag & Rössner, 2005). In addition, mechanistically, poorer psychological status (e.g. negative emotion) is associated with greater food intake (Chua, Touyz, & Hill, 2004; Geliebter & Aversa, 2003), which, over time, could lead to weight gain, desire to lose weight, weight loss, and regain (Stein et al., 2007; Stojek et al., 2016). Thus, additional prospective data on the antecedents, correlates and consequences of weight variability would be helpful in resolving concerns about the potential adverse psychological consequences of repeated weight loss and regain (Foster, Sarwer, & Wadden, 1997).

The Look AHEAD (Action for Health in Diabetes) trial provides a unique opportunity to study weight variability and psychological factors including mental health, depressive symptomology, and binge eating behaviors, in overweight and obese individuals with Type 2 Diabetes. A large cohort of overweight and obese individuals has been followed for more than eight years, half of whom received an intensive behavioral intervention to help them

lose weight and sustain weight loss. Measured weights are available for eight years, as are repeated measurements of self-reported mental health, depressive symptomatology and binge eating. The purpose of this study is twofold. First, to examine baseline psychological predictors (quality of life, depressive symptomatology, and binge eating) of weight variability in this cohort of overweight and obese adults with type 2 diabetes over a period of eight years. Second, because the relationship between weight variability and psychological status may be bidirectional, to examine weight variability over eight years as a predictor of psychological outcomes at year eight. It was hypothesized that less favorable psychological status at baseline predicts more weight variability over eight years, and that greater weight variability predicts poorer psychological outcomes at study end (year eight); hence, the relationship between psychological status and weight variability is bidirectional.

Method

Design & Sample

The design of the Look AHEAD trial has been described in detail (Ryan et al., 2003). In summary, Look AHEAD was a multicenter, randomized, clinical trial designed to determine whether an intensive lifestyle intervention to achieve weight loss through caloric restriction and increased physical activity would decrease cardiovascular morbidity and mortality among overweight or obese adults with type 2 diabetes. Inclusion criteria included being between the ages of 45 and 74, having a Body Mass Index (BMI) of $\geq 25.0 \text{ kg/m}^2$, and type 2 Diabetes Mellitus. Excluded were those who were pregnant or nursing, or had severe psychiatric (e.g. psychosis, bipolar disorder) or physical illnesses known to shorten the lifespan (e.g. HIV, renal disease) (Ryan et al., 2003). Look AHEAD also aimed to recruit and establish a sample consisting of more than 1/3 racial and ethnic minority populations, thus studying a diverse sample. Each center obtained approval from its respective institutional review board (IRB) regarding procedures and consenting of individuals prior to study participation. A total of 5,145 participants were randomized to either an intensive lifestyle intervention group (ILI) or to a control group that received Diabetes Support and Education (DSE). The ILI treatment was developed based on the Diabetes Prevention Program (Diabetes Prevention Program Research Group, 2002b, 2002a) and consisted of both individual and group sessions delivered by a multidisciplinary care team. Participants were encouraged to self-monitor their dietary intake and physical activity and to strive to achieve individually calculated energy intake goals to achieve weight management and increase physical activity to at least 175 minutes per week. Adherence was supported by evidence-based behavior modification strategies specific to phase of weight loss versus maintenance as previously described (Wadden & Look AHEAD Research, 2006). Sessions and contact with care providers were scheduled more frequently in the first year (i.e. three group sessions and one individual session per month for the first six months and two group sessions and one individual session for months 7-12), and less frequently after the initial year of intervention (i.e. one in-person and one phone/electronic contact per month for months 13-48; one in-person contact per year during and after month 49) (Ryan et al., 2003). Refresher and maintenance meetings were in place to help manage weight regain. The comparison group, DSE, was provided with three optional sessions per year which focused

on education about nutrition, physical activity, and social support (Wesche-Thobaben & The Look AHEAD Research Group, 2011).

Psychological Status—This study focuses on the following psychological status measures obtained at baseline and year 8.

Mental Health: Mental Health was assessed with the Short Form -36 (SF-36) Mental Component Summary (MCS). This 36-item questionnaire has been widely used to assess physical and mental functioning as related to overall quality of life, and its adequate psychometric properties have been documented (McHorney, Ware Jr, & Raczek, 1993; Ware Jr & Sherbourne, 1992). In this study, the MCS score was used to operationalize mental health/well-being and as a predictor and consequence of weight cycling. Scores for the MCS range from 0 (poorest mental health/well-being) to 100 (exceptional mental health/well-being). Cronbach's alpha for the MCS at baseline in this sample was 0.93.

Depressive symptoms: Depressive symptoms were measured using the original Beck Depression Inventory (BDI-I) (A. T. Beck, Ward, Mendelson, Mock, & Erbaugh, 1961), a well-studied instrument with satisfactory psychometric properties in nonpsychiatric populations (Aaron T. Beck, Steer, & Carbin, 1988). The BDI has 21 items; however, since one of the items asks about weight loss, this item was removed from our analyses. The resulting BDI is a 20-question assessment depressive symptoms with scores ranging from 0 (no reported depressive symptoms) to 60 (clinically significant number and severity of reported depressive symptoms). Cronbach's alpha for the BDI at baseline in this sample was 0.82.

Binge eating: Binge eating was assessed using the Questionnaire on Eating and Weight Patterns (QEWP) (Spitzer et al., 1993). To be considered to have self-reported binge eating, an individual was required to have answered "yes" to both of the following items:

1. During the past 6 months, did you ever eat what most people, like your friends, would think was a *really big* amount of food? *If response was 'yes', follow up question was:* Did you ever eat a *really big* amount of food within a short time (2 hours or less)?
2. When you ate a *really big* amount of food, did you ever feel that you could not stop eating? Did you feel that you could not control what or how much you were eating?

Weight Variability—Weights were measured annually by staff members who were blind to the intervention condition. Drawing upon previous researchers' recommendations for operationalizing weight variability and weight maintenance (Cutter et al., 1996; Stevens, Truesdale, McClain, & Cai, 2006), weight variability was operationalized using annual body weight follow-up data in the following two ways: (1) individual weight coefficient of variation, which is the unit-less numerical representation of an individual's deviance relative to their mean weight; and (2) the number of times in which change in weight from the previous year was at least 3% of weight the current year, and in the succeeding year the change was at least $\pm 3\%$, but the sign was reversed. Three percent was used as a cut-off

based on the definition of weight maintenance being $\pm 3\%$ of original weight (Stevens et al., 2006). Thus, if an individual had 8 years of follow-up measurements, they would have a maximum amount of 6 possible ‘weight variable’ cycles. If a person gained 1.5% of their weight from year 5 to year 6 and continued with another 1.5% gain from year 6 to year 7, they would not be considered to have had any weight variable cycles over this period.

Statistical Analyses

Baseline characteristics were compared across the number of weight variable cycles. Analysis of Variance models were used for continuous variables and chi-square tests were used for categorical variables. The association between weight coefficient of variation and baseline psychological measures was analyzed using general linear models (GLM). Since the distribution of weight coefficient of variation was highly skewed, log-transformation was used in GLMs. The estimated regression coefficients and corresponding confidence intervals were back-transformed (**exponentiated**) to the natural scale for ease of interpretation (Manikandan, 2010). Ordinal logistic regression models were used to assess the association between baseline psychological measures and the number of weight cycles. Proportional odds assumption was examined using score test for each model. Odds ratios (OR) and associated 95% confidence intervals (CI) were reported. All models were adjusted for group assignment by including group as a covariate.

For weight variability predicting year eight psychological outcomes, one model was run including weight variability (either number of weight cycles or weight coefficient of variation), baseline values of the psychological outcome measures, and baseline characteristics including age, gender, race, BMI, history of cardiovascular disease (CVD), and randomization assignment. Since the interventions were designed to be most intensive during the first year in Look AHEAD, percent weight change from baseline to year 1 was adjusted for in all analyses (by including this value as a covariate in the models), in addition to weight change over the course of the eight-year period. Another “unadjusted” model was run using only baseline value of the outcome variable and randomization assignment. The regression coefficients represent the mean change in a continuous outcome for every unit increase in weight variability. Binge eating was analyzed as a binary outcome using logistic regression models. Model predictors were similar to those used in the GLMs. Odds ratios (OR) and associated 95% confidence intervals (CI) were reported. All analyses were performed using SAS 9.4. A two-sided p-value of less than 0.05 was considered statistically significant.

Results

Of the 5,145 participants randomized to the ILE or DSE group, 4,774 had at least three consecutive annual weight measurements allowing us to assess number of weight cycles. Continuous characteristics are displayed in Table 1. The mean age of the sample at baseline was 58.7 ± 6.9 years and mean BMI was 35.9 ± 5.9 kg/m². Mean scores for MCS was 54.9 ± 8.0 . Mean BDI score was low, indicating few reported depressive symptoms (Beck, Steer, & Carbin, 1988). About 93% of the sample met the criteria for minimal depression, and 5% for mild depression.

Table 2 displays the number of weight cycles experienced according to categorical baseline characteristics. In females, about half (52.5%) experienced no weight cycles, 30% experienced one weight cycle, 11.9% experienced two weight cycles, and 5.6% experienced three or more weight cycles. The proportion of females experiencing weight cycles was significantly greater than the proportion of males (47.5% versus 39%, respectively; $p < 0.0001$). The proportion who experienced none, one, two, or three or more weight cycles did not differ by race/ethnicity. Although the effect of study group on weight cycles was not significant, 57.5% in ILI and 54.3% in DSE experienced no weight cycles ($p = 0.056$). Though the percentage of participants having no, one, two, or three or more weight cycles was not significantly different by study group, the mean weight CV in the ILI group was significantly higher than that of the DSE group (4.1%, CI: 4.0, 4.2 versus 3.8%, CI: 3.7, 3.8, $p < 0.0001$). To address the potential role of study group on the relationship between psychological variables and weight cycling, data were used from year 1 onward (baseline to year 1 was the intensive portion of the treatment), and adjusted for study group in all analyses.

Binge eating was reported by 12.7% of the sample at baseline; weight cycles were significantly more likely in those reporting binge eating symptoms ($p = 0.035$). Of the participants reporting binge eating, just over half (50.7%) did not experience any weight cycles, about a third (30.5%) experienced one weight cycle, 12.6% experienced two weight cycles, and 6.1% experienced three or more weight cycles. Of the participants not reporting binge eating at baseline, 56.6% did not experience any weight cycles, 28.2% experienced one weight cycle, 10.2% experienced two weight cycles, and 5.0% experienced three or more weight cycles.

Table 3 displays predictors of number of weight cycles (none, one, two, three or more) over eight years controlling for study group. Components of quality of life, depressive symptomology, and binge eating at baseline all significantly predicted the chance of having more weight cycles. For every 1-unit increase in MCS, there was a 1% decrease in the odds of having more weight cycles (OR = 0.99; CI: 0.98, 1.00; $p = 0.008$). For every 1-unit increase in baseline BDI, the odds of having more weight cycles increased by 2% (OR = 1.02; CI: 1.01, 1.03; $p = 0.001$). Finally, those who reported binge eating at baseline had 1.28 times greater odds of more weight cycles compared with those who did not report binge eating at baseline (OR = 1.28; CI: 1.09, 1.50; $p = 0.003$).

Since the literature on weight cycling has advised using both number of cycles and weight coefficient of variation (CV) (Cutter et al., 1996), Table 4 presents results using weight CV. Values in this table are back-transformed values from the log scale controlling for study arm. The results seen in Table 4 with CV are similar to Table 3, except for the relationship between MCS and weight CV not being significant. For every 1-unit increase in BDI, there was a 1% increase in weight CV (Beta = 1.01; CI: 1.00, 1.01; $p = 0.0002$). Individuals who reported binge eating at baseline experienced a mean weight CV of 4.3% (CI for Beta: 4.14, 4.52), while those who did not report binge eating at baseline experienced an average weight CV of 3.8% (CI for Beta: 3.79, 4.92), ($p < 0.0001$). Thus, the weight of individuals who reported binge eating varied more from their mean weight over eight years than those who did not report binge eating.

Tables 5a, 5b, 6a, and 6b display results from fully and minimally adjusted models looking at weight variability over eight years as a predictor of year-eight psychological outcomes. In the fully adjusted models, number of weight cycles did not significantly predict year eight psychological outcomes, but weight CV significantly predicted poorer psychological outcomes for MCS and depressive symptoms. Every 1% increase in weight CV was associated with a 0.13-point decrease in MCS (Beta $\pm$ SE = -0.13 ± 0.05 ; $p = 0.0114$) and a 0.07-point increase in depressive symptoms (Beta $\pm$ SE = 0.07 ± 0.03 ; $p = 0.0118$). In the minimally adjusted models, weight variability, both as a 1% increase in weight CV and a 1-unit increase in number of weight cycles, significantly predicted decreases in MCS at year eight (Beta $\pm$ SE = -0.13 ± 0.05 ; $p = 0.0054$; Beta $\pm$ SE = -0.32 ± 0.15 ; $p = 0.0312$, respectively). Weight variability did not predict binge eating at year eight in any models.

Discussion

In this sample of over 4,700 adults with overweight/obesity and type 2 diabetes, poorer psychological status at baseline (indicated by lower scores on mental well-being and higher scores on depression and presence of binge eating) was associated prospectively with more weight variability over the following eight years. Women and individuals reporting binge-eating symptoms at baseline were significantly more likely to experience a greater number of weight cycles over this eight-year period than men or individuals not reporting binge-eating symptoms at baseline. In contrast, there was limited support for weight variability over eight years predicting poorer psychological functioning at year eight; although in the hypothesized direction, the associations were inconsistently significant and overall less robust. When considering these findings, it must be noted; however, that statistical significance does not necessarily translate to clinical meaningfulness. The odds ratios presented translate to effects that are very small, or small (Chen, Cohen, & Chen, 2010). At the same time, there has been hesitancy to determine minimal clinically meaningful cutoffs for outcomes such as health-related quality of life, noting that small differences can still be clinically meaningful (Hays & Woolley, 2006; Jaeschke, Singer, & Guyatt, 1989). Overall, the findings reported here should be interpreted in the context of the sample size and sample population.

The present study is unique and adds to the literature by providing a large sample of repeated weight measures with long-term follow up of both psychological factors and objective measures of weight, thus allowing for examination of the bi-directional prospective relationship. These findings suggest that the cross-sectional association most often observed between weight variability and psychological status may be due primarily to poorer psychological status predicting greater weight cycling rather than unstable weight management leading to greater psychological distress. These findings are in agreement with another fairly large study of adults with diabetes ($n = 1,100$), which used self-report to operationalize weight cycling. Women were significantly more likely to experience weight cycles than men, and those who had major depression were significantly more likely to report having experienced weight cycles than those who did not have major depression (Messier et al., 2014).

The findings reported in this manuscript also concur with evidence from other studies showing that weight variability does not predict poorer psychological outcomes (Clark & King, 2000; Foster et al., 1996; Messier et al., 2014). In addition, limited evidence was found to support the notion that psychological distress is negative sequela of weight cycling. In this study, only weight CV (and not number of cycles) significantly predicted poorer psychological outcomes, and the effect was very small. It is likely that the larger sample size and long-term follow up allowed for the identification of weak associations between weight cycling and psychological outcomes that other studies were not able to detect due to power limitations.

This study also provides important data suggesting that weight cycles occur less frequently than has been previously assumed. Over half of the participants had no weight cycles over the eight years, and less than 15% had 2 or more cycles. Women experienced more weight cycles than men, but no differences were observed across ethnic/racial groups. Further studies are needed to determine whether this low frequency of weight cycles is a widespread phenomenon, or occurred particularly in this sample (individuals with type 2 diabetes who were enrolled in a clinical trial of lifestyle intervention for weight loss). A unique aspect of this study was the ability to analyze the frequency of weight cycles in both participants randomized to an intensive weight loss intervention and a self-education control group. Because intensive lifestyle interventions typically produce a pattern of significant weight loss, followed by limited weight regain (as occurred in Look AHEAD), they are often criticized for creating weight cycles. Thus, it is very important to note that 57.5% of participants in the lifestyle intervention group in Look AHEAD had no weight cycles over eight years, compared to 54.3% in the control group ($p=.056$).

Strengths of the study include the prospective design, objective weight measures, and the large sample size, with a balance of male and female volunteer participants and racial and ethnic diversity (more than 1/3 from racial and ethnic minority populations), which make findings generalizable to the population of older adults with Type 2 diabetes. The findings are limited however, by the low rates of depressive symptomatology and binge eating in this sample. Relatedly, this group of older adults with Type 2 diabetes did not have a great deal of weight variability despite participating in a weight loss intervention and exhibited generally good psychological functioning. Thus, exploring weight variability and psychological status in samples with greater variability and poorer psychological status is an important step for future research. The criterion used to assess binge eating (any episodes in past 6 months) did not assess frequency of binge episodes. Finally, though many factors confounding the relationship between weight variability and psychological status were controlled for statistically (e.g. weight loss during intense portion of the intervention), measures of other potential confounds including individual factors such as personality and broader cultural or environmental factors (e.g. accessibility to health-promoting behaviors) were not available.

The findings generated in this paper suggest several potential avenues for further exploration. It is possible that individuals with poorer psychological function are less able to exert consistent levels of behavioral self-control (Hagger, Wood, Stiff, & D, 2010). These individuals may also be more prone to emotional overeating and may have less stable

behavioral lifestyle patterns. This lack of stability could result in alternating cycles between strict dieting followed by excessive overeating (i.e. and “all-or-nothing” approach to weight control), and thus greater weight instability. Future studies could explore whether there are novel approaches to weight loss efforts that might be advantageous for these weight unstable individuals. Efforts to address binge eating or depression before starting weight loss have had limited success and possibly have not been studied adequately. However, recent studies suggest that weight loss programs based on Acceptance and Commitment Treatment (ACT) may be particularly well suited to individuals who report emotional overeating and may improve their weight management efforts (Forman et al., 2016). Additionally, future studies could benefit from objectively measuring weight at more frequent intervals and using approaches such as Ecological Momentary Assessment (EMA) to determine the type of psychological factors that immediately precede weight regain and/or weight loss and lead to the increases in weight variability. It would also be useful to compare perceptions of weight cycling with measured weight over time, to see if perceptions of weight control are more psychologically meaningful than actual weight change as one study has suggested (Friedman et al., 1998).

To conclude, the Look AHEAD trial assessed weight variability and psychological status over eight years and found that better psychological status at baseline (i.e. higher mental well-being, lower levels of depressive symptoms, absence of binge eating), was predictive of improved long-term weight management. In contrast, there was limited evidence to suggest that weight cycling was predictive of poorer psychological outcomes (i.e. lower mental well-being, more depressive symptoms, and more frequent binge eating). Women were found to be more susceptible to these effects. Research targeting interventions to assist vulnerable populations such as women with risk factors for poor psychological status and weight cycling are indicated.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1

Baseline Continuous Demographic Characteristics of Analytic Sample (N=4,774)

Variables	Mean ± Standard Deviation
Age (Years)	58.7 ± 6.9
Body Mass Index (kg/m ²)	35.9 ± 5.9
SF-36 Mental Component Summary Score	54.1 ± 8.0
Beck Depression Inventory Score	5.4 ± 4.8

Beck Depression Inventory Score (% of sample)

· 0–13: minimal depression 4565 (93.13%) 4438 (93.3)

· 14–19: mild depression 260 (5.30%) 249 (5.2)

· 20–28: moderate depression 70 (1.43%) 66 (1.4)

· 29–63: severe depression 7 (0.14%) 6 (0.1)

Table 2

Baseline Categorical Demographic Characteristics and Number of Weight Cycles (n=4,774)

Sex			P-value
Female	59.8% (n=2,855)	Females experiencing...	<0.001
		No weight cycles	52.5%
		One weight cycle	30.0%
		Two weight cycles	11.9%
		Three or more weight cycles	5.6%
Male	40.2% (n=1,919)	Males experiencing...	
		No weight cycles	61.0%
		One weight cycle	26.2%
		Two weight cycles	8.4%
		Three or more weight cycles	4.4%
Race/Ethnicity			
White	63.6% (n=3,037)	Whites experiencing...	0.43
		No weight cycles	55.7%
		One weight cycle	28.7%
		Two weight cycles	9.9%
		Three or more weight cycles	5.5%
African American	15.7% (n=750)	African Americans experiencing...	
		No weight cycles	55.3%
		One weight cycle	29.6%
		Two weight cycles	10.9%
		Three or more weight cycles	4.1%
Hispanic	12.3% (n=589)		
		No weight cycles	55.0%
		One weight cycle	27.7%
		Two weight cycles	11.9%
		Three or more weight cycles	5.4%
American Indian	5.3% (n=254)		
		No weight cycles	61.0%
		One weight cycle	24.4%
		Two weight cycles	11.8%
		Three or more weight cycles	2.8%
Other	3.0% (n=143)		
		No weight cycles	54.5%
		One weight cycle	28.7%
		Two weight cycles	12.6%
		Three or more weight cycles	4.2%
Study Group			

Sex		P-value		
Intensive Lifestyle Intervention	50.5% (n=2,410)		0.056	
		No weight cycles		57.5%
		One weight cycle		26.8%
		Two weight cycles		10.3%
		Three or more weight cycles		5.4%
Diabetes Self-Education (DSE)	49.5% (n=2,364)			
		No weight cycles	54.3%	
		One weight cycle	30.3%	
		Two weight cycles	10.7%	
		Three or more weight cycles	4.9%	
History of Cardiovascular Disease				
Present	13.6% (n=360)		0.10	
		No weight cycles		57.7%
		One weight cycle		29.2%
		Two weight cycles		7.7%
		Three or more weight cycles		5.4%
Absent	86.4% (n=4,124)			
		No weight cycles	55.6%	
		One weight cycle	28.3%	
		Two weight cycles	10.9%	
		Three or more weight cycles	5.1%	
Baseline Binge Eating				
Present	12.7% (n=603)		0.035	
		No weight cycles		50.7%
		One weight cycle		30.5%
		Two weight cycles		12.6%
		Three or more weight cycles		6.1%
Absent	87.3% (n=4144)			
		No weight cycles	56.6%	
		One weight cycle	28.2%	
		Two weight cycles	10.2%	
		Three or more weight cycles	5.0%	

Table 3

Baseline Psychological Variables Predicting Number of Cycles (none, one, two, three or more) Controlling for Study Arm

Variable (baseline)	Odds Ratio (OR)	Lower 95% Confidence interval for OR	Upper 95% Confidence Interval for OR	P-value
Mental Component Score	0.99	0.98	1.00	0.008
Beck Depression Inventory	1.02	1.01	1.03	0.001
Binge Eating (yes)	1.28	1.09	1.50	0.003

Table 4

Baseline Psychological Variables Predicting Weight Coefficient of Variation Controlling for Study Arm

Variable (baseline)	Beta	Lower 95% Confidence Interval for Beta	Upper 95% Confidence Interval for Beta	P-Value
Mental Component Score	1.00	1.00	1.00	0.3326
Beck Depression Inventory	1.01	1.00	1.01	0.0005
Binge Eating (yes)	4.33	4.14	4.52	<0.0001
Binge Eating (no)	3.85	3.79	3.92	

Table 5a

Weight Variability Over Eight Years Predicting Continuous Outcomes

Weight Variability—Coefficient of Variation				Weight Variability—Number of Cycles			
Outcome	Beta	SE	P-value	Outcome	Beta	SE	P-value
Mental Health	−0.13	0.05	0.0114	Mental Health	−0.24	0.15	0.1007
Depressive Symptoms	0.07	0.03	0.0118	Depressive Symptoms	0.11	0.08	0.1454

Note: Beta = average change in outcome per unit change in weight variability; SE = Standard Error. Models include baseline outcome measure, baseline BMI, age, gender, race, history of CVD, randomization assignment, % weight change during year 1 of the intervention, and % weight change over 8 years.

Table 5b
Weight Variability Over Eight Years Predicting Continuous Outcomes—Unadjusted

Weight Variability—Coefficient of Variation				Weight Variability—Number of Cycles			
Outcome	Beta	SE	P-value	Outcome	Beta	SE	P-value
Mental Health	−0.13	0.05	0.0054	Mental Health	−0.32	0.15	0.0312
Depressive Symptoms	0.04	0.03	0.0903	Depressive Symptoms	0.11	0.08	0.1451

Note: Beta = average change in outcome per unit change in weight variability; SE = Standard Error. Models include baseline outcome measure and randomization assignment.

Table 6a

Weight Variability Over Eight Years Predicting Binge Eating

Weight Variability—Coefficient of Variation				Weight Variability—Number of Cycles			
Outcome	OR	95% CI	P-value	Outcome	OR	95% CI	P-value
Binge Eating	0.99	0.94, 1.05	0.8266	Binge Eating	1.03	0.88, 1.22	0.7071

Note: OR = Odds Ratio; SE = Standard Error; CI = Confidence Interval. Models include baseline outcome measure, baseline BMI, age, gender, race, history of CVD, randomization assignment, change during year 1 of the intervention, and % weight change over 8 years.

Table 6b

Weight Variability Over Eight Years Predicting Binge Eating—Unadjusted

Weight Variability—Coefficient of Variation				Weight Variability—Number of Cycles			
Outcome	OR	95% CI	P-value	Outcome	OR	95% CI	P-value
Binge Eating	1.00	0.96, 1.05	0.8968	Binge Eating	1.02	0.87, 1.20	0.7715

Note: OR = Odds Ratio; SE = Standard Error; CI = Confidence Interval. Models include baseline outcome measure and randomization assignment.