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Psychological and Behavioral Correlates of Baseline BMI in the Diabetes Prevention Program (DPP)

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Abstract

OBJECTIVE—To determine psychological and behavioral correlates of baseline BMI in the Diabetes Prevention Program (DPP).

RESEARCH DESIGN AND METHODS—Of 1,079 DPP lifestyle intervention participants, 274 completed validated questionnaires at baseline assessing weight loss history, stage of change, self-efficacy, dietary restraint, emotional eating, binge eating, perceived stress, depression, and anxiety.

RESULTS—The mean age of subjects was 52.5 years, 65% were women, and their mean BMI was 33.9 kg/m^2. Higher BMI correlated with more frequent weight cycling ($r = 0.50$, $P < 0.0001$) and efforts at weight loss ($r = 0.34$, $P < 0.0001$); younger age when first overweight ($r = -0.42$, $P < 0.0001$); lower exercise efficacy ($r = -0.15$, $P = 0.015$); lower weight loss efficacy ($r = -0.21$, $P < 0.001$); a less advanced stage of change for weight loss ($r = -0.12$, $P = 0.04$); more perceived stress ($r = 0.14$, $P = 0.02$); emotional eating ($r = 0.19$, $P = 0.001$); poor dietary restraint ($r = -0.14$, $P = 0.02$); binge eating frequency ($r = 0.18$, $P = 0.004$) and severity ($r = 0.30$, $P < 0.0001$); feeling deprived, angry, or upset while dieting ($r = 0.27$, $P \leq 0.0001$); and food cravings while dieting ($r = 0.31$, $P < 0.0001$). Correlations did not differ as a function of sex; however, correlations of BMI with anxiety and low-fat diet and weight loss self-efficacy differed as a function of ethnicity. In multivariate models, binge eating severity, poor dietary restraint, and food craving were independent correlates of baseline BMI.

CONCLUSIONS—Many psychological and behavioral factors are associated with higher BMI in this ethnically diverse group of men and women. Whether strategies that help patients increase levels of dietary restraint and reduce binge eating and food craving lead to long-term weight loss maintenance needs longitudinal study.

Abbreviations

BES, Binge Eating Scale; DPP, Diabetes Prevention Program

The Diabetes Prevention Program (DPP) was a randomized clinical trial comparing the efficacy of intensive lifestyle, metformin, and placebo in the prevention of type 2 diabetes in people with impaired glucose tolerance. Subjects randomly assigned to the lifestyle intervention had

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A table elsewhere in this issue shows conventional and Système International (SI) units and conversion factors for many substances.

goals of losing at least 7% of their body weight and maintaining activity levels at ≥150 min per week over 3–6 years (1). Psychological and behavioral determinants of eating and exercise behaviors may be strong predictors of body weight, and understanding these determinants is critical to the goals and outcomes of the DPP. Self-efficacy, perceived stress, depression, anxiety, dietary restraint, emotional eating, binge eating, and stage of change related to weight loss are potentially modifiable variables frequently cited in the literature as important correlates of body weight (2–14). However, it is unclear which of these psychological and behavioral measures are the most robust correlates of weight outcomes. Moreover, most of the research on these correlates of weight outcomes has been conducted primarily in young and middle-aged Caucasian women. Data for men, other races and ethnicities, and older age groups, each of which is well represented in the DPP, are very limited.

We hypothesized that greater readiness to lose weight, higher self-efficacy, and higher dietary restraint would be correlated with lower BMI and that perceived stress, depression, anxiety, binge eating, and frequency of emotional eating would be correlated with higher BMI. In this report, we examine two primary questions: What are the psychological and behavioral correlates of baseline BMI in subjects randomized to the lifestyle intervention of the DPP (1)? And, what is the relationship among self-efficacy, perceived stress, depression, anxiety, stage of change related to weight loss, and eating behavior (dietary restraint, emotional eating, and binge eating) and the relative importance of these factors for baseline BMI in the DPP? A secondary question was whether the psychological and behavioral correlates of baseline BMI differed as a function of sex and race-ethnicity.

RESEARCH DESIGN AND METHODS

Study participants and procedures

This substudy was conducted during the final year of recruitment for the DPP and enrolled 274 of the final 293 (94%) lifestyle participants from 18 of 27 DPP centers that agreed to participate. Of the nine centers that did not participate in this substudy, two were not invited because they had already randomized almost all of their center cohorts and the other seven declined to participate to minimize participant burden as they had elected to participate in other ancillary studies. Eligibility criteria and the baseline characteristics of the DPP cohort have been previously described (15). Participants had to have impaired glucose tolerance, BMI ≥24 kg/m^2 (≥22 kg/m^2 for Asian-Americans) and be at least 25 years of age (15). Other than slight differences in the racial distribution in the subcohort included in this study, the baseline characteristics were identical to those in the entire lifestyle group (Table 1).

We measured psychological and behavioral factors at baseline, 6 months, 1 year, and study end (2–3 years after randomization). This report describes the baseline results. After randomization to the lifestyle intervention of the DPP, participants were asked to complete self-administered questionnaires assessing weight loss history and psychological and behavioral variables.

Measures

Weight loss self-efficacy was assessed with the Weight Efficacy Lifestyle Questionnaire (WEL) (16). This previously validated and reliable instrument was designed to assess confidence in resisting overeating in 20 tempting situations, including food availability, negative emotions, physical discomfort, positive activities, and social pressure (16,17). Respondents were asked to rate their confidence using a 10-point Likert-type scale with higher numbers indicating greater confidence about resisting overeating. Low-fat diet self-efficacy was measured with a validated 16-item scale (18) that measures confidence about performing healthy diet behaviors. Respondents rate their confidence on a 5-point Likert scale (1 = “very

little" and 5 = "quite a lot"). The 5-item, validated exercise self-efficacy scale measured confidence in ability to exercise in various situations, representing negative affect, resisting relapse, and making time for exercise. A 7-point scale is used to rate each item (1 = "not at all confident" and 7 = "very confident") (19).

Perceived stress was measured with the Perceived Stress Questionnaire (21). In contrast to life event scales that list specific "worries," the validated 30-item Perceived Stress Questionnaire is a subjective measure intended to maximize sensitivity to ongoing stress by assessing feelings of being under pressure from current life events. Responses range from 1 = "almost never" to 4 = "usually," and scores are positively associated with stressful life events. The scale has been successful in demonstrating a relation between psychological factors and objective evidence of disease activity (20).

Emotional eating behavior was assessed with a validated 5-item instrument (9) that measures the desire to eat and eating frequency in response to five different categories of emotions ("disappointed," "depressed or discouraged," "anxious, worried or tense," "cross," and "emotionally upset"). Respondents are asked to score from 0 to 10 (0 = never and 10 = always) on how frequently they have something to eat when in that emotional state. This scale assesses actual eating in response to emotions and has proved to be more strongly associated with weight control than instruments that measure the desire to eat in response to emotions (9). The Binge Eating Scale (BES) (21) measures behaviors, feelings, and thoughts associated with binge eating episodes, giving a global score of eating disturbance. Although the original 16-item scale has been used in several clinical research trials (21–24), a shorter 5-item version of this scale, which has been proposed to identify binge eaters more accurately (24), was used in this study.

The 10-item Restraint Subscale of the Dutch Eating Behavior Questionnaire (DEBQ) (25–27) measured dietary restraint. It has been shown to have high test-retest reliability, high internal consistency, and stable factor structure across sexes, weight categories, and random samples (28). Respondents are asked to score from 1 to 5 (1 = never and 5 = very often) how often they use 10 different dietary restraint behaviors. The Stage of Change Algorithm for Weight Loss (14), consisting of a brief series of self-report questions assessing weight loss intentions and activities, was used. No reliability data for the stages of change algorithm for weight control are available; however, the stages of change construct has been found reliable across a wide range of other problem behaviors, including inadequate exercise and limiting high-fat foods (19,29).

In addition to completing the questionnaires, participants also reported their weight history including age of onset of obesity, frequency of weight cycling (change of 20 lbs or more), and number of previous attempts with self-imposed and formal weight loss programs. They also answered one question regarding the degree to which they felt deprived while dieting and one question regarding the degree to which they "fantasized a lot about favorite foods while dieting" (craving), with scores from 1 to 5 with 1 = "never" and 5 = "always" (30). In addition to the BES, which addressed binge eating severity, the frequency of binge eating versus episodic overeating was assessed using the first three questions from the Questionnaire on Eating and Weight Patterns (31). As part of the DPP, all participants also completed the Beck Depression and Anxiety Inventory (32,33). Specially trained outcomes staff measured body weight (after shoes and heavy clothing were removed and recorded to the nearest 0.1 kg) and height (with a wall-mounted stadiometer to the nearest 0.1 cm) according to a standardized protocol. Then, BMI was calculated.

Statistical analysis

To test the primary aims of this study, we used Pearson correlation coefficients to assess the relations between psychological and behavioral variables and the relations between age, weight history, these variables, and baseline BMI. To test the relative importance of the psychological and behavioral variables, we used stepwise multivariate regression to assess the independent association of these factors with baseline BMI. For each variable, a *P* value of 0.15 was required for entry into the model and a *P* value of 0.05 was required to stay in the model. To assess the robustness of the final model, we first added age, sex, and race-ethnicity to the model and then, in a separate analysis, we used generalized estimating equations (SAS GENMOD procedure) to test whether adding center as a cluster effect would change the final model. ANOVA was used to test for differences in baseline BMI by sex and race-ethnicity. To test the secondary aims of the study, multiple regression analysis was used to assess the interaction of sex and race-ethnicity with the psychological and behavioral correlates of BMI (Asians were not included due to the small number of subjects). With 150 patients, we estimated we had 90% probability of finding a correlation to be significant if its true value was ≥0.26 at a two-sided 0.05 significance level. This value is similar to the correlation found by Clark et al. (34) with respect to self-efficacy and weight outcomes. We anticipated a 10% drop-out rate in terms of returned questionnaire packets; therefore, we needed a minimum of 165 participants to enroll in this study. *P* values are two-sided and are not adjusted for multiple comparisons.

RESULTS

The 274 lifestyle participants enrolled in this study from 18 DPP centers represent approximately one-fourth of the lifestyle cohort in the DPP (*n* = 1,079) (Table 1). This subgroup appears to be representative of the total lifestyle group in terms of age, sex, initial BMI, and race, except that the American Indian centers did not participate in this substudy (Table 1). At baseline, the mean BMI for women (34.7 ± 7.2 kg/m^2) was significantly higher than that for men (32.3 ± 5.9 kg/m^2, $P = 0.005$), and higher BMI was correlated with younger age ($r = -0.32$, $P < 0.0001$). Average age when first overweight was 25 ± 14 years, and younger age when first overweight was correlated with higher BMI ($r = -0.42$, $P = <0.001$). We also found significant differences in mean BMI for each ethnic group with a mean BMI of 36.2 ± 8.2 kg/m^2 for African-Americans, 33.6 ± 6.4 for Caucasians, 32.9 ± 5.6 for Hispanics, and 30.8 ± 7.7 for Asians ($P = 0.02$).

Weight loss experience and motivation

The self-reported weight history (Table 2) revealed the following. Almost 90% had previously tried to lose weight on their own with 45% trying to lose weight on at least five occasions, and almost two-thirds had lost and regained ≥20 lbs (weight cycling) at least once in the past. Approximately half of the group had never tried a formal weight loss program. Baseline BMI in the DPP was positively associated with more frequent attempts at weight loss in the past; more frequent weight cycling; feeling deprived, angry, or upset; and fantasizing “a lot” about favorite foods while dieting (craving). Heavier subjects also seemed to have the least motivation to lose weight as measured by stage of change related to weight loss.

Psychological and behavioral variables

Of the participants, 22% reported episodic overeating and 9% reported binge eating ≥2 days per week (Table 3). Lower exercise efficacy, lower weight loss, low-fat diet self-efficacy, higher perceived stress, emotional eating, poor dietary restraint, and binge eating frequency and severity all correlated with higher baseline BMI. There was no significant relation between depression or anxiety scores and baseline BMI. In addition, there was no significant first-order interaction by sex on the association between psychological and behavioral variables and baseline BMI. However, there was significant interaction by ethnic group for the relation

between BMI and anxiety ($P = 0.017$), low-fat diet self-efficacy ($P = 0.007$), and weight loss self-efficacy ($P = 0.015$), indicating that the correlation between BMI and these variables differed by ethnic group. The correlation of anxiety with BMI was negative in African-Americans but was positive in Caucasians and Hispanics. For the self-efficacy measures, the correlations, although different in strength, had the same direction.

Stepwise regression testing the independent association of BMI with weight loss self-efficacy, exercise self-efficacy, restraint, binge eating frequency and severity, emotional eating, low-fat diet self-efficacy, perceived stress, depression, anxiety, craving, deprived, and weight stage of change revealed that the significant baseline correlates of BMI were binge eating severity ($\beta = 2.25 \pm 0.70$, $P = 0.0016$), dietary restraint ($\beta = -1.38 \pm 0.56$, $P = 0.0147$), and craving ($\beta = 1.42 \pm 0.41$, $P = 0.0007$). These three factors explained 15% of the variance in BMI. When the model was further adjusted for age, sex, and race-ethnicity and when center was added as a cluster effect, binge eating severity and craving remained significant and the effect of dietary restraint was reduced ($\beta = -1.03 \pm 0.62$, $P = 0.098$).

The relations between the modifiable psychological and behavioral variables are shown in Table 4 and provide insights about the three independent correlates of BMI. Those participants with more severe binge eating behavior had less self-confidence in the ability to lose weight but not necessarily less confidence about following a low-fat diet. Binge eating severity was correlated with emotional eating, perceived stress, craving, depression, and anxiety; however, none of these variables was related to dietary restraint. Those who reported more dietary restraint had more self-confidence in the ability to lose weight and to follow a low-fat diet and had greater readiness to lose weight as measured by stage of change related to weight loss. The participants who reported more food cravings while dieting reported less self-efficacy regarding weight loss, less confidence in following a low-fat diet, greater binge eating severity, more emotional eating, more perceived stress, and more depression.

CONCLUSIONS

In this representative sample of DPP lifestyle participants, age, sex, race-ethnicity, and weight control history were all significant factors associated with baseline BMI. In addition, many of the psychological and behavioral characteristics, including exercise self-efficacy, weight loss self-efficacy, low-fat diet self-efficacy, weight stage of change, perceived stress, emotional eating, dietary restraint, and binge eating frequency and severity were related to baseline BMI. Moreover, other factors, such as the frequency of feeling deprived, angry, or upset or fantasizing a lot about favorite foods while dieting, were also associated with higher initial BMI. As expected, some of the psychological and behavioral factors were interrelated and some were independent correlates of BMI. Those who had better dietary restraint skills had greater self-efficacy beliefs regarding ability to follow a diet and greater readiness to change regarding weight loss. However, the strongest intercorrelations were found among binge eating severity, perceived stress, emotional eating, weight loss self-efficacy, and food craving. Taking these intercorrelations into account, binge eating severity, dietary restraint, and the frequency of fantasizing a lot about favorite foods appeared to be particularly important independent correlates of obesity.

These results are consistent with previous findings that have shown that sex and race-ethnicity are important factors influencing body weight (35), and that higher BMI is correlated with early onset of obesity (36), repeated attempts at dieting (37), lower self-efficacy (3), low levels of dietary restraint (6–8), emotional eating (25,38,39), and binge eating (40,41). The current results also confirm the relations between higher BMI and levels of perceived stress (4,5) and demonstrate new associations between BMI and stage of change related to weight loss, feeling deprived while dieting, and fantasizing a lot about favorite foods while dieting.

The interrelationships between binge eating and lower self-efficacy (21,23,42,43), emotional eating (44), depression (43,45,46), and perceived stress (20,21) were confirmed; however, binge eating was also highly correlated with food craving. Even though depression, anxiety, and perceived stress were highly correlated with each other, only perceived stress correlated with baseline BMI in the DPP. Of our participants, 90% had a Beck Depression score ≤10 and an anxiety score ≤8, which may in part be due to study eligibility criteria, which excluded those on greater than the minimal therapeutic dose of selective serotonin uptake inhibitors and those with major psychiatric illness. The low levels of depression and anxiety in our group of DPP participants might explain why neither depression nor anxiety was correlated with baseline BMI, as seen in other studies (47).

This study expands on previous research by examining the relative importance of these psychological and behavioral variables on BMI after adjusting for the effects of age, sex, and race-ethnicity. We have identified the modifiable factors that are most important correlates of BMI in an ethnically diverse group of men and women with impaired glucose tolerance. The finding that the correlation of BMI with anxiety is different in African-Americans than in other ethnic groups is consistent with previous studies suggesting that African-Americans are less distressed by obesity and tend to lose less weight in lifestyle programs such as the DPP (48).

The findings of this study emphasize the important connections among psychological and emotional factors, eating behavior, and BMI and suggest the importance of helping patients learn dietary restraint behaviors and how to manage the stress, negative emotions, and self-talk that may trigger food cravings and binge eating. In most of the recent behavioral weight management interventions, these components are commonly included (1). Our preliminary results suggest that prioritizing strategies that improve dietary restraint skills and reduce binge eating and the frequency of fantasizing about favorite foods while dieting may be most effective in promoting weight loss.

It is critical to examine these baseline associations longitudinally during the DPP to determine the extent to which the identified psychological and behavioral factors affect the ability to lose weight and keep it off, particularly since the DPP results have conclusively demonstrated that lifestyle intervention reduces the risk of type 2 diabetes by 58% and that metformin reduces the risk of diabetes by 31% over 2.8 years (49). The longitudinal results will help identify new strategies for effective lifestyle modification and maintenance of long-term weight loss, which are key for delaying/preventing diabetes. Moreover, the long-term results may also help health care providers distinguish the psychological and behavioral profiles of patients who are likely to succeed with lifestyle intervention from those who might be more successful with medication to delay/prevent diabetes.

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Table 1

Baseline study sample characteristics

	DPP lifestyle cohort	Ancillary study subcohort
N	1079 (27 centers)	274 (18 centers)
Age (years)	50.6 ± 11.3	52.5 ± 12.1
Sex		
Male	345 (32)	97 (35)
Female	734 (68)	177 (65)
Race/Ethnicity		
Caucasian	580 (54)	171 (62)
African-American	204 (19)	54 (20)
Hispanic	178 (17)	38 (14)
American Indian	60 (6)	0 (0)
Asian	57 (5)	11 (4)
BMI (kg/m^2)	33.9 ± 6.8	33.9 ± 6.9
<25	38 (3)	8 (3)
25–29.9	320 (30)	80 (29)
≥30	721 (67)	186 (68)

Data are *n* (%) or means ± SD.

Table 2

Association of baseline BMI with weight loss experience and motivation

	N (%)	BMI (means ± SD)	Correlation coefficient (*r*)	*P*
Weight cycling (lost and regained ≥20 lbs)			0.50	<0.0001
Never	98 (36)	30.0 ± 4.7		
1–2 times	78 (28)	34.0 ± 4.6		
3–4 times	55 (20)	35.6 ± 6.3		
≥5 times	43 (16)	40.1 ± 9.2		
Self-imposed weight loss attempts			0.34	<0.0001
Never	31 (11)	28.9 ± 3.3		
1–2 times	58 (21)	31.6 ± 5.4		
3–4 times	63 (23)	34.6 ± 5.2		
≥5 times	122 (45)	35.8 ± 7.9		
Weight loss programs			0.34	<0.0001
Never	133 (49)	31.9 ± 6.0		
1–2 times	75 (27)	33.7 ± 5.7		
3–4 times	30 (11)	37.9 ± 6.0		
≥5 times	36 (13)	38.0 ± 9.4		
Food craving while dieting			0.31	<0.0001
Never	61 (22)	31.0 ± 5.0		
Rarely	78 (28)	33.3 ± 5.4		
Occasionally	95 (35)	34.7 ± 6.7		
Frequently	33 (12)	38.8 ± 9.6		
Always	7 (3)	34.8 ± 8.3		
Deprived, angry, or upset while dieting			0.27	<0.0001
Never	59 (22)	31.0 ± 4.9		
Rarely	86 (31)	33.3 ± 5.8		
Occasionally	96 (35)	35.3 ± 7.7		
Frequently	27 (10)	36.1 ± 8.3		
Always	6 (2)	38.4 ± 5.6		
Weight stage			−0.12	0.04
Precontemplation	13 (5)	40.1 ± 7.6		
Contemplation	44 (16)	33.3 ± 7.8		
Preparation	48 (18)	33.9 ± 5.7		
Action	67 (24)	34.4 ± 7.0		
Maintenance	102 (37)	33.0 ± 6.4		

Pearson correlation coefficients. *P* value for significance of correlation between weight loss experience and BMI.

Table 3

Correlation of baseline BMI and psychological and behavioral variables

	N (%)*	Score (means ± SD)	Correlation coefficient (*r*)	*P*
Exercise efficacy		5.0 ± 1.2	−0.15	0.015
Weight loss self-efficacy		139.6 ± 23.4	−0.21	<0.001
Low-fat diet efficacy		4.0 ± 0.6	−0.13	0.035
Perceived stress		0.3 ± 0.2	0.14	0.02
Emotional eating		2.9 ± 2.7	0.19	0.001
Dietary restraint		2.8 ± 0.7	−0.14	0.02
Depression†		4.1 ± 4.1	0.10	0.10
Anxiety†		3.4 ± 4.0	0.10	0.10
Binge eating severity		0.7 ± 0.6	0.30	<0.0001
		BMI (mean ± SD)		
Binge eating frequency			0.18	.004
No overeating	161 (59)	33.3 ± 6.5		
Episodic overeating	61 (22)	32.9 ± 5.2		
Binge eating	52 (19)	36.9 ± 8.7	0.27	.05
<1 day/week	15 (29)	33.4 ± 5.5		
1 day/week	13 (25)	37.9 ± 11.4		
2–3 days/week	21 (40)	37.8 ± 6.5		
4–5 days/week	3 (6)	44.2 ± 18.0		

Pearson correlation coefficients and *P* value for significance of correlations between psychological and behavioral variables and BMI.

*Of 274 patients;

†*n* = 268 for depression and anxiety due to missing data.

Table 4

Correlations of weight loss self-efficacy, restraint, binge severity, emotional eating, low-fat diet efficacy, perceived stress, craving, stage of change, depression, anxiety, and binge eating frequency

	Weight loss self-efficacy	Restraint	Binge severity	Emotional eating	Low-fat diet efficacy	Perceived stress	Craving	Weight stage	Depression	Anxiety
Restraint	0.15*									
Binge severity (BES)	−0.32†	−0.01								
Emotional eating	−0.48†	−0.10	0.53†							
Low-fat diet efficacy	0.55†	0.18‡	−0.10	−0.21§						
Perceived stress	−0.38†	−0.07	0.45†	0.44†	−0.28†					
Craving	−0.35†	−0.00	0.45†	0.33†	−0.24†	0.23†				
Weight stage	0.05	0.18‡	−0.06	−0.11	0.10	−0.07	−0.06			
Depression	−0.15*	−0.10	0.39†	0.25†	−0.12*	0.51†	0.19‡	0.07		
Anxiety	−0.14*	−0.02	0.21§	0.14*	−0.07	0.27†	0.02	0.04	0.48†	
Binge eating frequency	−0.27†	−0.10	0.42†	0.30†	−0.10	0.21§	0.23†	−0.13*	0.18‡	0.12

Pearson correlation coefficients for all interrelationships.

*$P \leq 0.05$;

‡$P \leq 0.01$;

§$P \leq 0.001$;

†$P < 0.0001$.

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