Predictors of dietary change among those who successfully lost weight in phase I of the Weight Loss Maintenance Trial

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Abstract

Aim—Dietary changes occurring during weight loss interventions can vary. The present study tested if pretreatment psychosocial, dietary and demographic factors were associated with changes in fat intake and fruit and vegetable intake during a weight loss intervention.

Methods—This analysis includes participants who lost at least four kilograms during the initial six month weight loss phase (phase I) of the Weight Loss Maintenance Trial, a group format behavioural intervention emphasising a low-fat diet and increased physical activity. Multiple linear regression was used to determine associations between pretreatment psychosocial, dietary, physical activity, and demographic variables and changes from pretreatment to six months in fat intake and fruit and vegetable intake.

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Results—Participants (n = 1032) were 63.4% female, 62.4% non-African American, and had a mean age of 55.6 and BMI of 34.1 kg/m². Being African American ($P < 0.0001$) and higher baseline kilojoule intake ($P < 0.01$) were associated with smaller reductions in fat intake. Being African American ($p < 0.001$) and older age ($P = 0.02$) were associated with smaller increases in fruit and vegetable intake, whereas a history of 10 or more past weight loss episodes of at least 10 lb (4.5 kg; $P < 0.01$) was associated with greater increases.

Conclusions—Few psychosocial factors examined contributed to variability in dietary change. Even when achieving meaningful weight losses during a behavioural weight loss intervention, African Americans may make fewer beneficial changes in fat and fruit and vegetable intake than non-African Americans.

Keywords

dietary fats; energy intake; weight loss

Introduction

Obesity is a global problem that affects approximately one-third of Americans,[1] a fifth of Australians,[2] and is increasing rapidly in countries around the world.[3] Obesity is often treated with lifestyle interventions that focus on making multiple behaviour changes, including increasing physical activity, reducing total energy, decreasing dietary fat, and increasing fruit and vegetable intake. High-quality weight loss interventions have been shown to result in clinically significant weight loss and improvements in cardiometabolic risk factors.[4,5]

During most weight loss programs, patients are advised to increase fruit and vegetable intake and decrease fat intake. These dietary behaviours appear to promote weight loss during dietary interventions and may contribute to maintenance of weight loss.[6,7] Additionally, fruit and vegetable intake also has beneficial effects on health independent of effects on body fat.[8] Thus, making changes in these variables during a weight loss intervention is important, regardless of weight loss achievement.

Despite the importance of making healthful dietary changes during weight loss interventions, little is known about factors that might be related to changes in important dietary variables such as fat and fruit and vegetable intake. Identifying patient characteristics that are associated with healthy diets may help interventionists to identify individuals who may need additional attention if they are to make optimal dietary change. Additionally, understanding the pre-treatment characteristics of those who are more successful in making important dietary changes may inform intervention development, particularly if these characteristics are modifiable. For example, if people with higher social support for healthy eating are more successful in increasing their fruit and vegetable intake, this might suggest that future interventions should focus on improving social support, even if social support is not directly related to weight loss outcomes.

While few studies have examined the relationship between pretreatment psychosocial characteristics and dietary change during a weight loss intervention, the extant data provide

interesting clues as to which psychosocial variables might be most relevant to dietary change. Tinker *et al.* found that social support for healthy eating predicted increases in fruit and vegetable consumption, but not dietary fat intake.[9] Tinker *et al.* also found that the mental health-related variable, optimism, emerged as a predictor of adherence to a low-fat diet.[9] Thus, fat intake and fruit and vegetable intake changes during a weight loss intervention may be influenced by social support and mental well-being characteristics such as stress, social support for healthy eating and health-related quality of life. In addition to these psychosocial variables, pretreatment dietary patterns may be associated with adherence to recommended dietary changes. However, no known study has examined how baseline dietary patterns relate to changes in other dietary patterns during a weight loss intervention.

In the current study, psychosocial and dietary variables assessed prior to treatment were evaluated for their association with six-month dietary change among individuals who had lost four kilograms or more during the initial weight loss phase (phase I) of the Weight Loss Maintenance Trial (WLM). Of those beginning phase I of WLM, 61% continued onto the next phase and are included in the current study. Pretreatment characteristics studied were chosen based on the above-described research examining predictors of dietary adherence, and additional variables were considered exploratory, including weight loss history and physical activity level. Based on past findings, we hypothesised the following: (i) lower stress and greater mental well-being prior to treatment would predict greater reduction in dietary fat intake; (ii) greater pretreatment social support would be associated with an increase in fruit and vegetable intake; (iii) tentatively, we hypothesised that baseline similarity to intervention dietary goals in one dietary domain would be associated with greater improvements in the other dietary domains examined; for example, lower baseline fat intake will be associated with a greater increase in fruit and vegetable intake; and (iv) finally, African American status, gender and age were examined as potential predictors of change in dietary patterns.

Methods

WLM was conducted in two phases. Phase I was a six-month intensive behavioural weight loss intervention. Participants who had lost four kilograms or more in phase I were randomised to one of three weight loss maintenance conditions at the start of phase II: self-directed/no-further-treatment control, personal contact intervention, or interactive technology intervention. The trial was conducted between August 2003 and June 2007 at four clinical sites (Baltimore, Baton Rouge, Durham and Portland). WLM received ethics approval for this research by all participating institutes' Institutional Review Board and conforms to the provisions of the Declaration of Helsinki. Further details regarding the design can be found at Brantley *et al.*[10] Primary outcomes of phase I[11] and phase II[12] have been published.

Participants

Multiple recruitment strategies were used, including mass mailings, print and radio advertisements, and printed fliers. Eligibility criteria included medication treatment of hypertension and/or dyslipidemia, body mass index (BMI) of 25–45 kg/m^2, and over 25

years of age. Exclusion criteria included contraindication to weight loss (e.g. malignancy or other serious illness), recent cardiac events, history of bariatric surgery and medication-treated diabetes. Participants were financially compensated for attending measurement visits. Further details about study participants can be found in Hollis *et al.*[11]

Measures

Demographic data were collected prior to the start of the phase I weight loss intervention. Participants completed a questionnaire concerning African American status, ethnicity, age, gender, education level, income, medication usage and smoking status.

The 100-item National Cancer Institute Block Food Frequency Questionnaire (FFQ) was administered before the start of phase I intervention and again at the end of phase I for those going on to phase II.[13] This scale has been well validated.[13–15] Food frequency questionnaires have shown sensitivity to change in dietary patterns in the course of a dietary intervention, and have been found by some researchers to produce estimates of dietary change similar to those obtained by dietary recall measures.[14,15] The NutritionQuest Data-on-Demand System was used to analyse the data. Study staff were trained on administration of the FFQ and participants were provided with verbal and written instructions and the serving size photo per questionnaire administration protocol. Participants were queried about their diet over the previous six months. Two variables derived from the FFQ were used in the current analysis: percentage of energy from fat and servings of fruits and vegetables per day. Fruit and vegetable serving sizes were determined by the FFQ creators by ranking the portion sizes reported in a large national survey and using the median portion size.[16] Change variables were created by calculating the difference between the pretreatment and post-treatment (end of WLM phase I/beginning of phase II) values.

Physical activity was measured using a calibrated, triaxial accelerometer (RT3, Stayhealthy Inc, Monrovia, CA, USA). The accelerometer was worn for a minimum of 10 hours/day for four days, including one weekend day. Results were used to estimate participants' weekly minutes of moderate-to-vigorous physical activity (MVPA). MVPA was defined as being above the previously published cut point of 1316.5 counts/minute.[17] Minutes of MVPA per week were computed taking a weighted average of daily weekday and weekend activity (weekly MVPA = (5 × average daily weekday MVPA) + (2 × average daily weekend MVPA). Further details about accelerometer measurements in the present study can be found in Chen *et al.*[18]

Perceptions of social support for healthy eating were measured using the Social Support and Eating Habits Survey.[19] Participants reported how often friends or family provided support for healthy eating over the previous three months on a 5-point Likert scale (1—none, 5—very often, or does not apply). Each item was answered twice, once with regard to support from friends and once with regard to support from family. Encouragement and discouragement for healthy eating were scored separately, creating four total subscales: (i) family encouragement; (ii) family discouragement; (iii) friend encouragement; and (iv) friend discouragement. These could each range in score from 4 to 35, depending on the subscale. These scales have demonstrated good internal consistency ($\alpha = 0.80$ to $\alpha = 0.87$) in their validation study, and have evidence of criterion and construct validity.[19]

The Perceived Stress Scale-4 item was used to measure perceived global stress.[20] Stressful thoughts and evaluations from the past month are rated on a 5-point Likert scale with response options of 0 (*never*) to 5 (*very often*), with total scores ranging from 0 to 20. This four-item scale has demonstrated adequate internal consistency ($\alpha = 0.72$) in validation studies, and has evidence of validity.[20]

The Medical Outcomes Study Short Form (SF-36) is a 36-item measure of health-related quality of life appropriate for the general population.[21] Eight subscales and two composite scale *t*-scores (physical and mental health) were computed. In the current study, only the physical and mental health composite scores were utilised. These scales have demonstrated excellent internal consistency ($\alpha = 0.90$) and their validity has been well supported.[21]

Participants also reported the number of times in their lifetime that they had previously lost 10 or more pounds (4.5 kg) during an intentional weight loss effort, utilising a single-item question developed for the present study. Response options available to participants were *never*, 1–2 times, 3–5 times, 6–10 times, or greater than 10 times.

Procedure

Study measures were completed by participants before beginning phase I intervention. At the end of phase I, measures were completed again only by those participants who had lost four kilograms of weight or more and who were randomised to participate in the weight loss maintenance phase (phase II) of the trial. The phase I intervention was composed of 20 weekly group sessions over approximately six months. Group sessions were led by nutrition and behavioural counsellors, trained in behavioural approaches and motivational interviewing. Sessions were participant centred and interactive. Sessions were approximately 1½ hours in duration with 18–25 participants per group. Sessions focused on enhancing motivation, identifying specific behaviour change goals and problem-solving. The weight loss program included proven and effective behavioural techniques and lifestyle goals to engage in 180 minutes/week of moderate physical activity and endorsed the DASH (Dietary Approaches to Stop Hypertension) eating pattern.[22] The DASH eating plan emphasises intake of fruits and vegetables, whole grains, and low-fat or non-fat dairy, and minimal intake of red meat, high sugar foods, high sodium foods and sugar-sweetened beverages.[22] Clinical trials have demonstrated the health benefits of the DASH diet.[22] Specific kilojoule goals were individually tailored but generally focused on moderate reduction in intake of 500 kcal/day. Additional details about the study protocol are available in Brantley *et al*.[10] and at the study website (http://www.kpchr.org/wlmpublic).[23]

Statistical analysis

Two multiple regression analyses were conducted with the dependent variable of change score from pretreatment to the end of phase I for fat intake and fruit and vegetable intake. Likelihood ratio methods were used to select the most parsimonious model for each outcome. Missing values were replaced using multiple imputation, and we report averaged results across the five imputations with *P*-values adjusted to account for between imputation variance.[24] Although the present study was limited to participants who completed both baseline and six-month assessment sessions, some items or questionnaires were missing due

to participant or research assistant error. Analyses were conducted using SAS (SAS Institute, Inc., Cary, NC, USA, 1999). Predictor variables were being African American, gender, age, pretreatment levels of physical activity, physical health quality of life, mental health quality of life, families' encouragement for healthy eating, families' discouragement for healthy eating, friends' encouragement for healthy eating, friends' discouragement for healthy eating, perceived stress, weight loss history, and pretreatment intake of total energy, dietary fat, and fruits and vegetables. The pretreatment dietary variable that is affiliated with the dependent variable being examined was included as a control in each analysis, that is, baseline fat intake was included in the analysis predicting change in fat intake.

Results

Descriptive data

Analyses reported here are for the 1032 participants who were randomised into phase II (61% of phase I baseline sample). The average age of participants was 55.6 (SD = 8.7), and more than 92% reported post-high school educational attainment. The average BMI was 34.1 kg/m^2 (SD = 4.8), and 77.7% of participants were obese. The majority of participants were women and non-African American. Compared with individuals who entered phase I of the study, the current sample was not significantly different in age or baseline BMI, but was more likely to be male (32.7% in initial sample *vs* 36.6% in current sample), $\chi^2 = 18.2$, $P < 0.0001$, and non-African American (56.3% in initial sample *vs* 62.4% in current sample), $\chi^2 = 9.8$, $P < 0.01$. Most participants' incomes were above $60 000 (57.4%). Blood pressure medication was used by 86.9% of participants and 39.8% were on lipid lowering medication. Additional information about the phase I sample can be found in Hollis *et al*.[11]

Participants' dietary intake, physical activity, and psychosocial measures at phase I entry and phase I completion are presented in Table 1. The sample displayed improvements in dietary intake and physical activity in the expected direction.

Change in total fat intake

On average, African American participants reduced their total fat intake significantly less than non-African Americans during the intervention (Table 2). Higher kilojoule intake at baseline was also associated with a smaller reduction in fat intake during the intervention. As expected, higher pretreatment per cent fat intake was associated with greater reduction in fat intake.

Change in fruit and vegetable intake

African Americans, on average, increased their fruit and vegetable intake less than non-African Americans (Table 3). Older age was also associated with lesser increase in fruit and vegetable intake. Having had past weight loss episodes occurring 10 times or more was associated with greater increases in fruit and vegetable intake. As anticipated, higher pretreatment fruit and vegetable intake was associated with smaller increases in fruit and vegetable intake.

Discussion

The current study sought to identify pretreatment demographic, psychosocial, dietary and physical activity variables that are associated with changes in dietary fat intake and fruit and vegetable intake during a six-month weight loss intervention among those who have achieved at least modest weight loss (4 kg). These dietary changes are worthy of consideration in addition to weight loss, because they are relevant for overall health and have implications for weight maintenance. Identifying factors associated with these dietary changes may contribute to the improvement of weight loss interventions.

Consistent with the goals of the intervention, participants in the present study increased their fruit and vegetable intake and reduced their fat intake. In the current analyses, few of the hypothesised variables were associations with these dietary changes. Nonetheless, a few noteworthy associations were found. We had hypothesised that baseline similarity to the DASH dietary recommendations in one aspect of individuals' diets would be associated with greater change in other dietary domains. We had partial support for this hypothesis, as lower total energy intake at baseline was associated with greater reduction in percentage fat intake over the course of the intervention. One possible explanation for this finding is that participants who, prior to treatment, are closer to targeted dietary recommendations in one area may have greater psychological resources to devote to making changes in other aspects of their diets. This is consistent with recent evidence that the ability to resist tempting stimuli is weakened after engaging in self-control in another domain.[25] However, although baseline dietary intake was associated with greater reductions in per cent fat intake, the association was weak and other associations between DASH diet variables and dietary change did not emerge, suggesting that this may not be a robust finding. It should be noted that the highly significant negative association between our initial dietary value and the dietary change value is to be expected and does not necessarily reflect an association between change and 'true' initial level.[26]

Individuals who reported a history of 10 or more past weight loss episodes of at least 10 lb (4.5 kg) had greater increases in fruit and vegetable intake over the course of the intervention. Individuals who have reported this high of a frequency of past weight loss episodes are likely adept at initial weight loss, but may struggle with maintaining these changes. In the current study, all participants lost at least four kilograms, yet individuals with an extensive diet history appeared to be particularly proficient at increasing their fruit and vegetable intake. This may be related to more frequent past participation in weight loss interventions, many of which focus on increasing fruit and vegetable intake. Although the increase in fruit and vegetable intake is likely health promoting, it is possible that individuals with an extensive dieting history are more likely to make dietary changes that are dramatic but ultimately unsustainable. Future research is needed to examine how initial dietary changes influence long-term weight loss among this group of seasoned dieters.

Contrary to our hypothesis, stress and mental well-being were not associated with the dietary change patterns examined. These results are somewhat inconsistent with a past study by Tinker *et al.*;[9] however, that study examined a different mental well-being construct (optimism), and did not restrict the sample to individuals with moderate weight loss.

Additionally, we found no relationship between dietary change and physical activity or social support. The lack of hypothesised relationships suggests that other variables, not measured in the current study, may be more relevant to understanding the sources of variability in dietary intake during a weight loss intervention.

Being African American was associated with lesser reductions in fat intake and lesser increases in fruit and vegetable intake. Previous weight loss trials have found that African Americans achieve less weight loss[27] and have poorer adherence to the DASH diet during weight loss trials.[28] The current results extend these past findings by showing that even when African Americans achieve meaningful weight loss during a dietary intervention, they may make dietary changes of lesser magnitude than for non-African Americans. Cultural influences on diet and environmental factors may play a role in this outcome.[27] It is notable that these differences were found despite the WLM intervention including culturally appropriate intervention strategies.[10] In addition, African American status and older age were also associated with smaller increases in fruit and vegetable servings. However, the effect was small; a 10-year difference in age was associated with only a 0.3% smaller change in servings of fruits and vegetables.

The present study should be interpreted in light of our focus on individuals who lost at least four kilograms during a six-month intervention. The focus on this restricted sample was imposed by study design; however, we believe that a focus on this group is warranted. In well-designed weight loss interventions such as that delivered in the current trial, the majority of participants are able to achieve clinically significant weight loss. Yet, there is variability in the types of dietary changes these participants make while losing weight, with implications for weight maintenance and participants' overall health. Identifying potential causes of this variability among successful weight losers may be important for designing interventions that promote overall health, in addition to weight loss.

The current study has several weaknesses. There are well-documented limitations to the validity of the FFQs.[29] FFQs were used in the present study instead of more precise dietary recall measures due to budget and time constraints related to an initial sample size of over 1600. Additionally, as with any dietary change study, reported dietary intake may have been biased as a result of social desirability motives.[30] Nonetheless, past research demonstrating sensitivity to change during dietary interventions[14,15] is suggestive of the utility of this measure for the purposes used in the present study. Furthermore, the use of accelerometers may over- or underestimate physical activity level. Another limitation that should be noted is that our pretreatment data were collected in 2003 and 2004, thus it is possible that different results would be obtained in current interventions. The study results should also be considered in light of the demographics of the present study participants, who were primarily Caucasian and African Americans, middle aged, and from the United States. Additionally, it should be appreciated that the results obtained may be specific to this intervention; weight loss interventions vary in their dietary recommendations, emphasis on behavioural skills and other components, all of which may affect the relationships examined in the current study.

In conclusion, the findings of the current study found little support for the role of psychosocial variables or pre-treatment physical activity in influencing dietary change among individuals losing at least a modest amount of weight (4 kg) during a behavioural weight loss intervention. However, African Americans achieved smaller decreases in fat intake and smaller increases in fruit and vegetable intake compared with non-African American. Older age was also associated with a lesser increase in fruit and vegetable intake, whereas a history of frequent weight loss episodes was associated with greater increases in fruit and vegetable intake. Future studies are needed to replicate these findings and identify factors that account for the associations observed.

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Table 1

Mean and standard deviations of dietary and psychosocial variables at phase I entry and phase I completion (*n* = 1032)

	Phase I entry		Phase I completion	
	Mean	**Standard deviation**	**Mean**	**Standard deviation**
Total energy intake per day, kcal/day	1929.2	758.7	1596.9	542.5
Total fat intake per day, %	38.7	7.5	30.2	7.6
Fruit and vegetable intake, servings per day	5.3	3.0	9.0	4.2
Moderate-to-vigorous physical activity (minutes/week)	117.0	115.6	163.3	153.8
SF-36 mental health composite	52.8	8.5	54.8	7.3
SF-36 physical health composite	50.5	7.9	53.4	6.7
Family encouragement of healthy eating	18.0	7.9	23.7	8.5
Family discouragement of healthy eating	14.6	4.7	14.8	4.6
Friends' encouragement of healthy eating	14.9	6.6	20.7	7.1
Friends' discouragement of healthy eating	13.6	4.1	14.5	4.3
Perceived stress	3.5	2.5	—	—
Past weight loss episodes (%)				
Never	9.9			
1–2 times	30.6			
3–5 times	34.6			
6–10 times	14.3			
>10 times	10.6			

Table 2

Parameter estimates and confidence interval for six-month change in percentage of energy from fat regressed on psychosocial and dietary variables (*n* = 1032)

				95% CI	
	B[a]	SE	P-value	LL	UL
African American status[b]	2.43	0.52	<0.0001	1.41	3.45
Female gender[c]	−0.15	0.51	0.77	−1.14	0.85
Age	0.02	0.03	0.47	−0.03	0.08
Moderate-to-vigorous physical activity (10 minutes/week)	0.02	0.02	0.40	−0.02	0.06
Total energy intake (100 kcal/day)	0.11	0.04	<0.01	0.04	0.18
Per cent energy from fat	−0.64	0.03	<0.0001	−0.70	−0.57
Fruit and vegetable servings	0.01	0.09	0.94	−0.16	0.17
Quality of life—physical health	−0.02	0.03	0.63	−0.08	0.05
Quality of life—mental health	0.02	0.03	0.51	−0.04	0.09
Family encouragement of healthy eating	−0.05	0.19	0.80	−0.43	0.33
Family discouragement of healthy eating	−0.17	0.19	0.36	−0.54	0.19
Friends' encouragement of healthy eating	−0.24	0.21	0.27	−0.66	0.19
Friends' discouragement of healthy eating	−0.17	0.20	0.38	−0.56	0.21
Perceived stress	0.16	0.10	0.11	−0.04	0.36
Past weight loss episodes[d]					
1–2 times	−1.04	0.80	0.19	−2.61	0.53
3–4 times	−1.28	0.83	0.12	−2.91	0.35
6–10 times	−1.74	0.93	0.06	−3.57	0.09
>10 times	−1.18	1.01	0.24	−3.16	0.79

Note: B = unstandardised parameter estimate; CI, confidence interval; LL, lower limit; SE, standard error; UL, upper limit.

[a] A positive parameter estimate indicates increasing values of the predictor are associated with a smaller reduction in fat intake. Predictors are coded such that a higher value indicates greater levels of that predictor.

[b] AA is coded 1 and non-AA is coded 0.

[c] Women are coded 1 and men are coded 0.

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(d)Zero past weight loss attempts is the reference category.

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Table 3

Parameter estimates and confidence interval for six-month change in total servings of fruit and vegetable intake regressed on psychosocial and dietary variables ($n = 1032$)

	B[a]	SE	P-value	95% CI LL	95% CI UL
African American status[b]	-1.22	0.29	<0.0001	-1.80	-0.64
Female gender[c]	0.20	0.29	0.49	-0.37	0.77
Age	-0.03	0.02	0.02	-0.06	0.00
Moderate-to-vigorous physical activity (10 minutes/week)	0.01	0.01	0.48	0.01	0.03
Total energy intake (100 kcal/day)	0.003	0.02	0.89	-0.04	0.04
Per cent energy from fat	-0.02	0.02	0.37	-0.05	0.02
Fruit and vegetable servings	-0.49	0.05	<0.0001	-0.59	-0.40
Quality of life—physical health	0.02	0.02	0.17	-0.01	0.05
Quality of life—mental health	0.02	0.02	0.21	-0.01	0.05
Family encouragement of healthy eating	-0.17	0.10	0.08	-0.37	0.02
Family discouragement of healthy eating	-0.07	0.10	0.48	-0.28	0.13
Friends' encouragement of healthy eating	0.03	0.10	0.75	-0.17	0.24
Friends' discouragement of healthy eating	0.12	0.10	0.25	-0.08	0.32
Perceived stress	0.02	0.06	0.68	-0.09	0.14
Past weight loss episodes[d]	.	.	.	.	.
1–2 times	0.42	0.49	0.39	-0.56	1.40
3–4 times	0.66	0.47	0.16	-0.27	1.59
6–10 times	0.39	0.52	0.46	-0.65	1.43
> 10 times	1.71	0.57	<0.01	0.58	2.84

Note: B = unstandardised parameter estimate; CI, confidence interval; LL, lower limit; SE, standard error; UL, upper limit.

[a] A positive parameter estimate indicates increasing values of the predictor are associated with greater increases in fruit and vegetable intake. Predictors are coded such that a higher value indicates greater levels of that predictor.

[b] African Americans are coded 1 and non-African Americans are coded 0.

[c] Women are coded 1 and men are coded 0.

(*d*)Zero past weight loss attempts is the reference category.