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Short- and long-term eating habit modification predict weight change in overweight, post-menopausal women: results from the WOMAN Study

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Abstract

Background—Standard behavioral obesity treatment produces poor long-term results. Focusing on healthy eating behaviors, rather than caloric intake, may be an alternative strategy. Furthermore, important behaviors might differ for short- vs. long-term weight control.

Objective—To describe and compare associations between changes in eating behaviors and weight after 6 and 48 months

Design—Secondary analysis of data collected during a randomized weight loss intervention trial with 48-month follow-up

Participants—465 overweight and obese postmenopausal women enrolled in the Women on the Move through Activity and Nutrition (WOMAN) Study

Main outcome measures—Changes in weight from baseline to 6 and 48 months.

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Statistical analyses performed—Linear regression models examined the associations between 6- and 48-month changes in eating habits assessed by the Conner Diet Habit Survey and changes in weight. Analyses were conducted in the combined study population and stratified by randomization group.

Results—At 6 months in the combined population, weight loss was independently associated with decreased desserts ($p<0.001$), restaurant eating ($p=0.042$), sugar-sweetened beverages ($p=0.009$), and fried foods ($p<0.001$), and increased fish consumption ($p=0.003$). Results were similar in intervention participants; only reduced desserts and fried foods associated with weight loss in controls. At 48 months in the combined population, weight loss was again associated with decreased desserts ($p=0.003$) and sugar-sweetened beverages ($p=0.011$), but also decreased meats/cheeses ($p=0.024$) and increased fruits/vegetables ($p<0.001$). Decreased meats/cheeses predicted weight loss in intervention participants; desserts, sugar-sweetened beverages, and fruits/vegetables were independently associated in controls.

Conclusions—Changes in eating behaviors were associated with weight change, though important behaviors differed for short- and long-term weight change and by randomization group. Future studies should determine whether interventions targeting these behaviors could improve long-term obesity treatment outcomes.

Keywords

diet; lifestyle intervention; weight maintenance; weight loss; obesity

INTRODUCTION

More than one third of Americans are obese,[1] a condition which increases the risk of cardiovascular disease, type 2 diabetes, and some cancers,[2] and has been associated with a yearly excess of 111,909 deaths in the U.S.[3] The prevalence of obesity has increased over the past 50 years,[1, 4] and public health initiatives for reducing the obesity epidemic have not yet substantially moved the needle on obesity rates.[5] Obesity treatment through behavioral lifestyle change has been widely researched in a clinical setting with limited long-term success. Intensive behavioral clinical weight loss trials usually result in about a 10% reduction of initial body after 6 months[6]; however, these changes are generally not sustained long-term – even when coupled with weight maintenance interventions.[7, 8]

Traditional behavioral treatment for obesity has emphasized rigorous self-monitoring of daily caloric intake to achieve negative energy balance and weight loss. Indeed, evidence from the National Weight Control Registry suggests that tracking daily food intake is a common habit among successful weight loss maintainers and other studies have found that increased self-monitoring was associated with weight loss success.[9–11] However, reported time and effort spent on weight control and dietary goal attainment as well as degree of satisfaction for a given effort have been reported to decrease even during the first 6 months of a weight loss program.[12] This observation, coupled with the discouraging long-term weight loss maintenance outcomes using standard treatment methods, has encouraged research in the area of changing dietary patterns or specific eating behaviors for weight loss or weight control.

The 2010 USDA Dietary Guidelines advocate movement toward a `more healthful eating pattern' with specific recommendations to decrease the intake of calorically dense foods (e.g. sweets, protein sources high in saturated fats) and increase the intake of fruits, vegetables, and whole grains.[13] Some studies have found long-term weight loss or maintenance to be inversely associated with eating behaviors (e.g. eating at restaurants or snacking between meals) and specific types of foods (e.g. fried foods, desserts, sweetened beverages, meats,

high fat dairy products).[14–20] Fruit and vegetable intake has been directly associated with long-term weight loss and maintenance.[14, 16] Moreover, emerging evidence suggests that eating strategies associated with short-term weight loss may be distinct from those associated with long-term weight loss.[14, 21] However, it is yet unclear which of these eating behavioral strategies are most important for weight loss in a clinical population seeking obesity treatment. Understanding which eating behaviors are important for short-term and/or long-term weight loss could be useful for designing interventions that target changes in eating behaviors as well as broader recommendations for obesity treatment and long-term weight loss at the population level.

The purpose of the current investigation was to determine if changes in eating behaviors and selected foods were associated with 6- and 48-month weight change in the WOMAN (Women on the Move through Activity and Nutrition) Study.[22, 23] We hypothesized that limiting eating at restaurants and reduced consumption of desserts, sugar-sweetened beverages, fried foods, meats and cheeses as well as increased consumption of fish, fruits and vegetables would be associated with 6-month weight loss outcomes, but that only some of these eating behaviors would be associated with long-term (48-month) weight changes. We further hypothesized that eating behavior changes that predict short- and long- term weight change may differ by randomized treatment group, where targeted eating behavior changes of the lifestyle intervention would predict weight change in intervention participants but not necessarily participants in the control group.

SUBJECTS and METHODS

Study Population and Design

The WOMAN Study was conducted at the University of Pittsburgh from April 2002 to June 2008 in post-menopausal women to investigate whether a diet and physical activity lifestyle intervention with a 10% weight loss goal could impact low-density lipoprotein particles, triglycerides, and subclinical cardiovascular disease.[22, 23] The study population has been previously described in detail.[23] In brief, the study recruited women via direct mailings from selected zip codes in Allegheny County, Pennsylvania starting in 2002. Key eligibility criteria included: aged 52–62 years and post-menopausal, body mass index from 25–39.9 kg/m^2, waist circumference >80 cm, blood pressure <140/95 mmHg, LDL cholesterol from 100–160 mg/dL, no use of lipid lowering drugs, no history of cardiovascular disease or diabetes, and no physical limitations that would preclude physical activity. A total of 508 women met eligibility criteria and were randomized to either a Lifestyle Change group (intervention) or a Health Education group (control) using block randomization. Participants were followed for 48 months. All study participants provided informed consent and the study was approved by the University of Pittsburgh institutional review board (#000356).

As previously described,[23] the Lifestyle Change intervention was group-based and facilitated by nutritionists, exercise physiologists, and psychologists. Intervention groups met weekly during the first six months, bi-weekly for the next six months, and monthly for the remainder of the study. The specific intervention targets for the dietary intervention included: 1) reducing total, saturated, and trans fat along with cholesterol from meat, dairy, fats, oils, baked goods, and snacks; 2) reducing caloric intake; 3) increasing foods high in soluble fiber; 4) promotion of fruits, vegetables, and whole grains; and 5) promotion of sources of stanols/sterols and n-3 fatty acids. The physical activity component was introduced slowly during the first 6 months of the study and utilized a stepped care approach with the minimum goal of 150 minutes per week of moderate- intensity physical activity (e.g. brisk walking), which is reflective of public health recommendations for physical activity.[24] If the participant was willing, the physical activity goal was increased to up to

240 minutes of moderate intensity physical activity per week. Strength training was included as an adjunct to aerobic training.

The Health Education (control) group was offered six seminars during the first year of participation and two to four yearly seminars during years two through four of the study. Seminars were lead by an experienced health professional and focused on general women's health (e.g. smoking cessation, health benefits of physical activity), but not specifically weight loss.

Study Assessments

The current investigation uses body weight assessed at baseline, 6 months, and 48 months as the primary outcomes. Eating behaviors were assessed the Connor Diet Habit Survey at the same follow-up intervals, which was slightly modified to include regional foods.[25] This questionnaire was developed for the Family Health Study and includes 32 items assessing regular eating behaviors in the past month, including frequency of desserts, fried foods, sugar-sweetened beverages, fruits, vegetables, meats and cheeses along with the frequency of eating meals (breakfast, lunch, and dinner separately) at restaurants. Questionnaire answers were converted into frequencies based on the question (e.g., times per month) and scores were averaged when more than one answer was selected by the participant. Associations were similar for fruits and vegetables taken separately as well as eating at restaurants for specific meals, and so these variables were combined into fruits + vegetables and all restaurant eating, respectively. Ten-day test-retest reliability as well as validity against 24 hour recall and with changes in plasma lipids over time for this instrument have been previously shown to be comparable with other dietary assessment instruments.[25, 26]

Leisure-time physical activity was assessed at baseline and 48 months using the Modifiable Activity Questionnaire (MAQ), an interviewer-administered questionnaire that assesses past-year leisure-time and occupational physical activity.[27] Due to the limited reported occupational activity in the WOMAN Study population,[28] only the leisure-time estimate is reported. Physical activity levels were calculated as the product of the duration and frequency of 39 common leisure activities ($hr \cdot wk^{-1}$), weighted by a standardized estimate of the metabolic equivalent (MET) of each activity,[29] and then summed for all activities performed. Leisure-time physical activity was expressed as metabolic equivalent hours per week ($MET \cdot hr \cdot wk^{-1}$). The MAQ is a reliable and valid estimate of self-reported physical activity.[30]

Statistical Analyses

This secondary data analysis included WOMAN Study subjects with complete body weight and eating habits data at baseline and at least one of the 6 or 48 month follow-up assessments. Baseline participant characteristics are summarized overall and by randomized group assignment. Continuous variables are reported as either mean ± standard deviation or median (interquartile rage). Categorical variables are presented as proportions.

Pearson's correlations were calculated between 6-month changes in weight and 6-month changes in eating behaviors overall and by randomized group, adjusted for baseline values of weight and eating behavior. This was repeated for 48-month changes. Participants were then categorized into one of four weight loss categories based on amount of weight lost from baseline to 6 and 48 months: weight gain defined as a weight increase ≥2.5 kg; weight stable defined as a weight change in either direction of < 2.5 kg[31]; moderate weight loss defined as a weight loss from 2.5 to 10 kg; and significant weight loss defined as a >10 kg weight loss. Eating behaviors at baseline and follow-up were plotted for each weight change category overall and by randomization group. Absolute changes in eating behaviors were compared

across increasing weight loss categories at 6 and 48 months using a parametric test for trend adjusted for randomized group (overall results only), baseline weight, and baseline eating behavior.

Linear regression models were used to examine associations between changes in weight (kgs) and changes in eating behaviors in separate models at 6 and 48 months. Change in weight was used as the dependent variable, controlling for baseline weight and group. All change variables were assessed for normality and models were evaluated for points of influence. Single behavior models used change in one eating behavior as the primary independent variable and adjusted for the baseline value of that behavior. Fully adjusted model included all covariates listed above and each change in behavior and baseline behavior value. Beta (β) coefficients were standardized so that the coefficient can be interpreted as the change in weight associated with a change of one standard deviation in each eating behavior and compared across behaviors. Models are reported in all participants and after stratification by randomized group assignment. Lastly, change in leisure-time physical activity from baseline to 48 months (not assessed at 6 months) was added to the 48 month models to determine the influence on associations between changes in eating habits and weight.

All analyses were conducted using Stata version 10 (StataCorp, College Station, TX).

RESULTS

Of the 508 women enrolled in the study, n=465 (92%) women had complete data for 6-months and n=419 (82%) women had complete data for 48 months. Table 1 presents baseline characteristics for women with complete data at either follow-up (n=481). Groups were balanced with the exception of greater dessert consumption among controls. Subsequent analyses adjust for baseline values and do not investigate the effect of the intervention.

Average weight change in intervention vs. control participants was −7.8 ± 4.5 kg vs. −1.3 ± 4.3 kg at 6 months ($p<0.001$) and −3.6 ± 7.3 kg vs. −0.2 ± 5.6 kg ($p<0.001$) at 48 months. When separated into categories of weight gain, weight stable, moderate and substantial weight loss, the distribution of participants across weight change categories differed by randomized group with intervention participants more frequently in the weight loss categories at 6 ($p<0.001$) and 48 months ($p<0.001$) (Figure 1).

At 6 months, changes in weight were significantly correlated with changes in each eating behavior in the expected direction in the combined study population (Table 2). Correlations were consistent across randomized groups for consuming desserts and fried foods, but significant correlations were only observed in the intervention group for eating at restaurants, consuming fish, and eating meats and cheeses. Weight change was significantly correlated with consuming sugar-sweetened beverages and fruits and vegetables in the control group only. At 48 months, again most changes in eating behaviors were correlated with changes in weight, with the exception of frequency of eating at restaurants ($r = 0.06$, $p=0.218$). Change in leisure-time physical activity was inversely correlated with weight change at 48 months ($r = −0.21$, $p<0.001$). When stratified by randomized group, consuming fish and meats and cheeses were only significantly correlated with weight change in intervention participants. Consumption of sugar-sweetened beverages was also significant in intervention participants and not controls, though the magnitude of association was quite comparable.

In the combined study population, progressive changes from baseline to 6 months in each behavior were observed across weight change categories in the expected direction (Figure

2), with the exception of a nonsignificant trend for change in frequency of eating at restaurants (p=0.051) and no association with change in consumption of meats and cheese (p=0.616). Analyses stratified by randomized group were similar with the exception of significant associations for eating at restaurants and fish among intervention participants only, while significant associations with sugar-sweetened beverages and fruits and vegetables were only observed in controls (Appendix Figures 1 and 2).

At 48 months in the combined study population, a progressive trend across weight change categories was observed for all behaviors except for frequency of eating at restaurants (p=0.573) (Figure 2). Within randomized groups, associations were heterogeneous across randomized groups. Among intervention participants, increasing weight loss category was associated with decreased consumption of meat and cheeses and sugar-sweetened beverages, and increased consumption of fruits and vegetables. Among controls, increasing weight loss category was associated with decreased consumption of desserts and fried foods, and with increased consumption of fruits and vegetables (Appendix Figures 1 and 2).

Using linear regression models including all eating behaviors, frequency of desserts, eating at restaurants, sugar-sweetened beverages, fried foods, and fish were independently associated with 6-month weight change in all WOMAN Study participants (bottom of Table 3). Similar relationships were observed when the analysis was repeated among only intervention participants. In controls, only changes in the frequency of eating desserts and fried foods were associated with changes in weight at 6 months.

At 48 months (bottom of Table 4), weight change was independently associated with frequency of consuming desserts, sugar-sweetened beverages, meats/cheeses, and fruits/vegetables when including all eating behaviors. Within the intervention group in the fully adjusted model, weight change was only significantly associated with frequency of meats and cheeses. Among controls, frequency of desserts, sugar-sweetened beverages, and fruits and vegetables were independent predictors of weight change in the fully adjusted model.

Change in leisure time physical activity was associated with 48 month weight change (standardized $\beta = -1.29$ kg per MET-hour/week, $p<0.001$), but the addition of physical activity to the model did not change associations observed between eating habits and weight change at 48 months (data not shown).

DISCUSSION

The WOMAN Study is one of the few long term weight reduction studies and, similar to other studies,[6] documents the difficulties of maintaining substantial weight loss over time for most of the participants. As hypothesized, most of the eating habits predicted weight change at 6 months when considered individually, and results in the intervention group mirrored the analysis including all WOMAN Study participants. Interestingly, most of these eating behaviors were independently associated with weight change in the fully adjusted model, suggesting a role for each eating behavior change in the context of short-term weight loss or control. Decreased consumption of fried foods and desserts had the largest standardized coefficients when including all WOMAN participants and within the intervention group, and these were the only significant predictors in fully adjusted analysis within the control group, highlighting these two specific targets for short-term weight change. At 48 months, frequency of eating at restaurants was consistently not associated with weight change, though the other eating behaviors continued to have associations when considered in isolation. In the fully adjusted model, only changes in meat and cheese intake were associated with weight change in the intervention group while desserts, sugar-sweetened beverages, and fruits and vegetables were independent predictors in the control

group. These behavior changes could represent changes in eating behaviors that both influence weight change and are sustainable long-term.

A surprising finding was that frequency of eating at restaurants was not related to weight change outcomes at 48 months. Reported restaurant eating decreased whether subjects decreased weight or not (see Figure 2), consistent with the lack of association observed even in the single behavior analyses. Specific measurement of the frequency of dining at fast food restaurants, which has been shown to predict weight change in other studies,[32, 33] was not available but may have been more strongly associated with weight change.

The associations observed at 6 months and 48 months were all consistent with a diet that decreases energy density. Lower energy density has been associated with greater weight loss or decreased weight gain in cohort studies,[34, 35] secondary analyses within clinical weight loss trials,[36–38] and in randomized trials.[39, 40] Further, successful weight loss maintainers report a diet with lower energy density compared to normal weight or obese controls,[16] indicating that decreasing energy density may be a particularly useful strategy for maintaining a weight-reduced state. At the same time, many of the behaviors that predicted weight change were specific targets of the intervention. Thus, results within the intervention group in particular may also reflect that weight loss or maintenance is more common among participants that follow dietary prescriptions more closely.

The differences in the magnitude of the associations between the intervention and control groups in this secondary analysis should be interpreted with caution. The intervention group received active treatment, especially during the first year, which resulted in a distribution of weight change in this group that was shifted toward weight loss with 85% of participants maintaining or losing weight at 48 months (Figure 1). In contrast among controls, the distribution of weight change was more centered around weight maintenance, with about a third of controls achieving weight loss (29%), maintenance (37%), and weight gain (34%) at 48 months (Figure 1). With this in mind, results from the intervention group may be more applicable to short- and long-term weight loss in a clinical setting; whereas, findings in the control group may be more applicable to women interested in weight loss who have not received an evidence-based intervention in a clinical setting.

Strengths of this study include a large sample size, long duration, and excellent retention in a lifestyle intervention study. Though the average weight loss at 48 months in the intervention group was <5%, a sizable subset of women had lost more than a 10 kgs at 48 months, providing variability in the outcome measure. With these strengths and the measurement of eating habits at relevant time points, this study was able to tease out which eating habits were independently related to short-term and long-term weight change in post-menopausal women.

On the other hand, several limitations deserve discussion. First, eating behaviors and physical activity were self-reported and thus vulnerable to the known biases involved with self-report, such as underreporting of undesirable habits (e.g. eating desserts). Further, seasonality may have affected certain eating habits between the baseline and 6 month assessments, e.g. fruits and vegetables, and this could explain why changes in fruits and vegetables were not independently associated with weight change at 6 months. Change in leisure-time physical activity over the first 6 months of the intervention was not included in regression models because the physical activity component of the intervention was slowly introduced during the first 6 months. However, the 48-month results reassuringly showed associations between eating behaviors and weight change to be independent of physical activity. Also, certain eating behaviors are collinear as evidenced by the attenuated associations when moving from single eating behavior models to all eating behaviors

models, for example eating of fried foods and eating at restaurants. However, these eating behaviors had independent associations with weight change at 6 months and each single behavior model is reported to inform this issue. Also, information on frequency of snacking between meals, which may be another eating behavior associated with weight change, was not collected. Lastly, this secondary analysis identifies associations between changes in eating behaviors and changes in weight, but the study was not specifically designed to evaluate whether targeting changes in these behaviors would result in greater weight loss.

In summary, these results suggest that decreased consumption of desserts and sugar-sweetened beverages consistently associate with short- and long-term weight loss or maintenance, but increased fruits/vegetables in controls as well as decreased meats/cheeses in an intervention are additional factors that may help for long-term, but not necessarily short-term, weight loss or control. If the goal is to decrease the burden of obesity, the focus must be on long-term strategies because changes in eating behaviors only associated with short-term weight loss are likely ineffective and/or not sustainable. Future studies should examine whether interventions focused on changing these specific eating behaviors associated with long-term weight change could improve obesity treatment outcomes.

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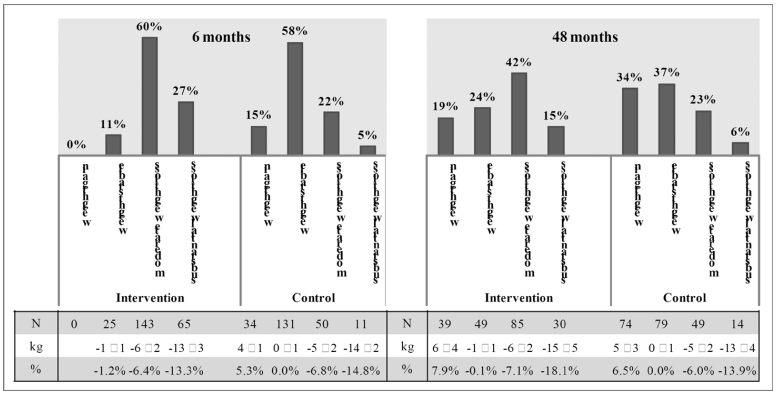

N	0	25	143	65	34	131	50	11	N	39	49	85	30	74	79	49	14
kg		-1 □1	-6 □2	-13 □3	4 □1	0 □1	-5 □2	-14 □2	kg	6 □4	-1 □1	-6 □2	-15 □5	5 □3	0 □1	-5 □2	-13 □4
%		-1.2%	-6.4%	-13.3%	5.3%	0.0%	-6.8%	-14.8%	%	7.9%	-0.1%	-7.1%	-18.1%	6.5%	0.0%	-6.0%	-13.9%

Figure 1. Weight Change Category at 6-months and 48-months by Intervention Group

Weight Gain (>2.5kg); Weight Stable (±2.5kg); Moderate Weight Loss (2.5–10kg); Substantial Weight Loss (>10kg)

Table displays number, mean weight loss ± standard deviation, and percent weight change by intervention group and weight loss category.

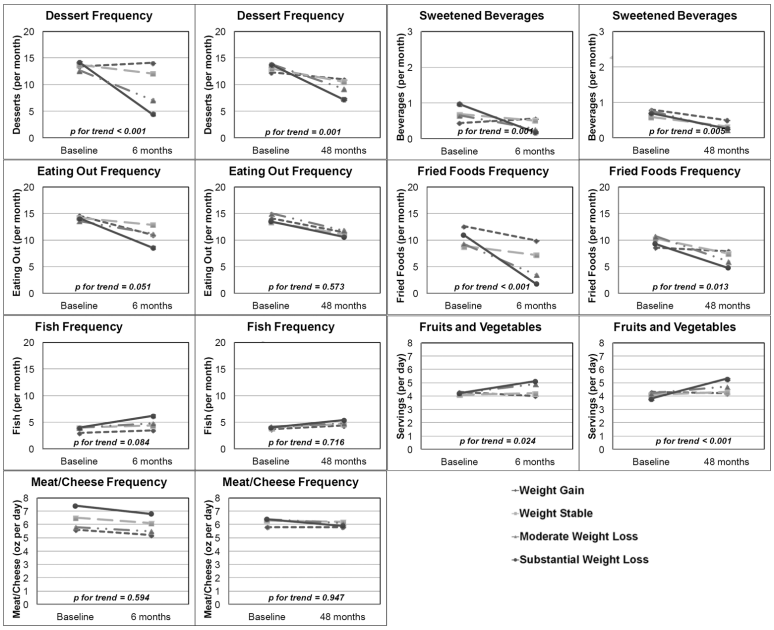

Figure 2. Change in Eating Behaviors by 6-month and 48-month Weight Loss Categories

Weight Gain (>2.5kg); Weight Stable (±2.5); Moderate Weight Loss (2.5–10kg); Substantial Weight Loss (>10kg) *p for trend* tests changes in each behavior across increasing weight loss categories adjusted for baseline weight, baseline eating behavior, and randomized group.

Table 1

Baseline Characteristics of WOMAN Study Participants

	Overall (n=481)	Intervention (n=241)	Control (n=240)	*p*-value[a]
Age, years	57.0 ± 2.9	56.8 ± 2.9	57.2 ± 2.9	0.237
% Caucasian	88	90	87	0.249
Body Mass Index, kg/m^2	30.8 ± 3.8	30.6 ± 3.8	30.9 ± 3.8	0.412
Weight, kg	81.7 ± 11.5	81.4 ± 11.3	82.0 ± 11.7	0.542
Desserts, servings per month	13.3 ± 9.5	12.3 ± 9.0	14.4 ± 9.9	0.019
Eating at Restaurants, times per month	13.9 ± 9.6	14.1 ± 9.8	13.7 ± 9.3	0.696
Sugar-sweetened Beverages, 12 ounce servings per day[b]	0 [0, 1]	0 [0, 1]	0 [0, 1]	0.714
Fried Foods, servings per month[b]	7 [2, 12]	7 [2, 12]	7 [2, 12]	0.792
Fish, servings per month	4.1 ± 3.3	4.2 ± 3.4	3.9 ± 3.1	0.292
Meat and Cheese, ounces per day	6.3 ± 2.4	6.3 ± 2.6	6.2 ± 2.3	0.568
Fruits and Vegetables, servings per day	4.1 ± 1.9	4.2 ± 1.8	4.2 ± 1.9	0.405
Leisure time physical activity, MET-hours/week[b]	11.1 [5.3, 20.3]	10.7 [5.9, 19.9]	11.5 [4.9, 21.5]	0.533

Data presented as mean ± standard deviation unless otherwise specified

[a] Comparison across intervention groups by *t* test, Wilcoxon rank-sum test, or the chi-square test as appropriate

[b] Median [interquartile range]

Table 2

Pearson's Correlations (r)[a] of Changes in Eating Behaviors[b] and Change in Weight at 6 and 48 Months in WOMAN Study Participants

Change in Eating Behavior	0–6 months			0–48 months		
	Overall (n=465)	Intervention (n=238)	Control (n=227)	Overall (n=419)	Intervention (n=203)	Control (n=216)
Desserts	0.43***	0.32***	0.29***	0.20***	0.17*	0.23**
Eating at Restaurants	0.19***	0.19**	0.12	0.06	0.10	0.04
Sugar-Sweetened Beverages	0.21***	0.12	0.21**	0.14**	0.13	0.15*
Fried Foods	0.39***	0.28***	0.25***	0.14**	0.13	0.10
Fish	−0.24***	−0.24***	−0.09	−0.12*	−0.18*	−0.02
Meat and Cheese	0.22***	0.14*	−0.04	0.18***	0.24**	−0.01
Fruits and Vegetables	−0.22***	−0.08	−0.17**	−0.24***	−0.20**	−0.29***
Physical Activity (MET-hr/week)[c]				−0.21***	−0.28***	−0.14*

[a] Adjusted for baseline weight and eating behavior

[b] Eating behaviors measured by the Connor Diet Habit Survey assessing usual behavior in the past month

[c] Physical activity assessed by the Modifiable Activity Questionnaire, not assessed at 6 months

* p<0.05,

** p<0.01

*** p<0.001

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Table 3

Association of Changes in Eating Behaviors[a] and Change in Weight at 6 Months

	All Subjects (n=465)		**Intervention (n=238)**		**Control (n=227)**	
Single Eating Behavior Model[b]	Std β	p-value	Std β	p-value	Std β	p-value
Change in Desserts	1.59	<0.001	2.11	<0.001	1.40	<0.001
Change in Eating at Restaurants	0.79	0.001	1.01	0.003	0.56	0.082
Change in Sugar-Sweetened Beverages	1.05	<0.001	0.86	0.071	1.05	0.001
Change in Fried Foods	1.93	<0.001	2.63	<0.001	1.77	<0.001
Change in Fish	−0.82	<0.001	−1.14	<0.001	−0.40	0.189
Change in Meat and Cheese	0.29	0.221	0.71	0.034	−0.18	0.578
Change in Fruits and Vegetables	−0.59	0.013	−0.36	0.267	−0.88	0.009
All Eating Behaviors Model[c]	std β	p-value	Std β	p-value	Std β	p-value
Change in Desserts	0.95	<0.001	1.41	0.001	0.83	0.020
Change in Eating at Restaurants	0.46	0.042	0.68	0.037	0.28	0.365
Change in Sugar-Sweetened Beverages	0.74	0.009	0.91	0.040	0.57	0.120
Change in Fried Foods	1.32	<0.001	1.48	0.031	1.49	<0.001
Change in Fish	−0.61	0.003	−0.87	0.003	−0.33	0.249
Change in Meat and Cheese	0.10	0.668	0.36	0.267	−0.24	0.424
Change in Fruits and Vegetables	−0.37	0.102	−0.15	0.627	−0.58	0.079

[a] Eating behaviors measured by the Connor Diet Habit Survey assessing usual behavior in the past month

[b] This model uses change in weight in kilograms as the dependent variable adjusted for group, baseline weight, and baseline eating behavior value but not the other eating behavioral variables listed in the table

[c] This model includes all eating behavior variables adjusted for group, baseline weight, and all baseline eating behavior values

Table 4

Association of Changes in Eating Behaviors[a] and Change in Weight (kg) at 48 Months

	All Subjects (n=419)		**Intervention (n=203)**		**Control (n=216)**	
Single Eating Behavior Model[b]	Std β	p-value	Std β	p-value	Std β	p-value
Change in Desserts	1.61	<0.001	1.60	0.015	1.61	0.001
Change in Eating at Restaurants	0.48	0.225	0.34	0.599	0.68	0.143
Change in Sugar-Sweetened Beverages	1.42	0.005	1.57	0.064	1.27	0.029
Change in Fried Foods	1.04	0.019	1.04	0.173	1.01	0.052
Change in Fish	−0.73	0.030	−1.40	0.012	−0.12	0.768
Change in Meat and Cheese	1.03	0.005	2.02	0.001	−0.09	0.834
Change in Fruits and Vegetables	−1.73	<0.001	−1.79	0.006	−1.76	<0.001
All Eating Behaviors Model[c]	Std β	p-value	Std β	p-value	Std β	p-value
Change in Desserts	1.20	0.003	0.74	0.282	1.59	0.001
Change in Eating at Restaurants	0.13	0.735	−0.10	0.871	0.27	0.546
Change in Sugar-Sweetened Beverages	1.25	0.011	1.53	0.072	1.28	0.023
Change in Fried Foods	0.46	0.304	0.72	0.358	0.34	0.505
Change in Fish	−0.30	0.372	−0.92	0.099	0.19	0.640
Change in Meat and Cheese	0.82	0.024	2.07	<0.001	−0.51	0.261
Change in Fruits and Vegetables	−1.48	<0.001	−1.13	0.090	−1.76	<0.001

[a] Eating behaviors measured by the Connor Diet Habit Survey assessing usual behavior in the past month

[b] This model uses change in weight in kilograms as the dependent variable adjusted for group, baseline weight, and baseline eating behavior value but not the other eating behavioral variables listed in the table

[c] This model includes all eating behavior variables adjusted for group, baseline weight, and all baseline eatins behavior values