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Frequency of consuming foods predicts changes in cravings for those foods during weight loss: The POUNDS Lost Study

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Abstract

Objective—Food cravings are thought to be the result of conditioning or pairing hunger with consumption of certain foods.

Methods—In a two-year weight loss trial, subjects were randomized to one of four diets that varied in macronutrient content. The Food Craving Inventory (FCI) was used to measure cravings at baseline, 6, and 24 months. Also, food intake was measured at those time points. To measure free-living consumption of food items measured in the FCI, items on the FCI were matched to the foods consumed from the food intake assessments. Secondarily, we analyzed the amount of food consumed on food intake assessments from foods on the FCI.

Results—367 subjects who were overweight and obese were included. There was an association between change from baseline FCI item consumption and change in cravings at months 6 ($p<0.001$) and 24 ($p<0.05$). There was no association between change from baseline amount of energy consumed per FCI item and change in cravings.

Conclusions—Altering frequency of consuming craved foods is positively associated with cravings; however, changing the amount of foods consumed does not appear to alter cravings. These results support the conditioning model of food cravings and provide guidance on how to reduce food cravings.

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Disclosure: Intellectual property of the Food Craving Inventory (FCI) is owned by LSU and PBRC. Donald Williamson also has an interest. The other authors declared no conflict of interest.

The authors have no conflicts of interest.

Keywords

Food Craving Inventory; Diet; Energy Restriction; Conditioning; Extinction

Introduction

Food cravings are defined as "an intense desire to consume a particular food (or type of food) that is difficult to resist"(1). Food cravings occur in the majority of the population (2, 3) and occur frequently (i.e. multiple times per week) (4, 5) with 80–85% of craving episodes resulting in persons consuming the craved food item or a similar item (2, 4). Food cravings are positively associated with BMI in persons with impaired glucose tolerance (6) and cravings for high fat foods have also been positively associated with BMI (1). A recent meta-analysis found that cravings attributed 11% of the variance in eating behavior and weight gain (7).

Food cravings fluctuate and one etiological theory posits that food cravings are the result of conditioning (8, 9, 10, 11), where consumption of certain foods is paired with internal (e.g., hunger, anxiety) or external (e.g., time of day, driving, watching television) stimuli and, after a few pairings, the stimuli subsequently elicit cravings for the foods that were previously consumed when the stimuli were present. This theory is supported by the finding that, with few exceptions (12, 13), food cravings decrease during periods of food restriction (9, 10, 14, 15, 16, 17), which is expected if the conditioning model of foods cravings is valid. Specifically, food restriction during dieting limits conditioning opportunities and extinguishes existing associations between stimuli and food intake. Importantly, at least one study found that restriction of certain food groups (carbohydrates) during diets resulted in larger reductions in cravings for the restricted foods (9).

The Preventing Overweight Using Novel Dietary Strategies (POUNDS Lost) study evaluated four weight loss diets that varied in macronutrient composition over two years (18). Each of the diets resulted in clinically meaningful weight loss with no weight loss differences among the 4 diets (18). Using craving data collected via the Food Craving Inventory (FCI) (1) during the POUNDS Lost study, Anton et al. (2012) found a significant reduction in cravings for high fat foods, fast food fats, sweets, and carbohydrates/starches, and an increase in cravings for fruits and vegetables among all diets during the study (19). Similar to the study's main findings for weight, there were no differences in change in cravings among the diets (19). One possible reason Anton and colleagues did not detect differential change in cravings among the diets may have been the result of suboptimal adherence to the macronutrient specifications of the diets, particularly at the end of the trial. Nonetheless, if the conditioning model of food cravings is valid, then changes in the frequency of consumption of certain foods should be positively related to changes in cravings for those foods. The purpose of the present analysis was to test this hypothesis using the POUNDS Lost data set. It was predicted that: 1) decreased frequency of consuming foods from the FCI would be associated with decreased cravings for those foods, and 2) increased frequency of consumption of FCI items would be associated with increased cravings for those foods. Also, the present study examined if change in the amount of energy (kcal) consumed from

FCI food items altered cravings for those foods, as well as if change in body weight altered cravings.

Methods

The study reported herein was conducted according to the guidelines in the Declaration of Helsinki and all subjects were given verbal and written explanations about the study, provided signed informed consent, and received a monetary stipend. The study was approved by both the Pennington Biomedical Research Center's Institutional Review Board and the Harvard School of Public Health Institutional Review Board. The study was registered at clinical trials.gov NCT 00072995.

Subjects

Inclusion criteria were 1) overweight or class I/II obese (25 – 40 kg/m^2), 2) 30 – 70 years of age, and 3) willingness to participate in the two year study. Exclusion criteria were 1) diabetes treated with oral medications or insulin, 2) unstable cardiovascular disease, 3) use of medication that affects body weight, or 4) insufficient motivation.

Study Design

The POUNDS Lost study has been previously described, including a CONSORT diagram (18). It was a two-site randomized controlled trial (RCT) that included Harvard T.H. Chan School of Public Health and Brigham & Woman's Hospital in Boston, MA and Pennington Biomedical Research Center (PBRC) in Baton Rouge, LA. The study had four groups, each being prescribed a 750 kcal/d energy reduced diet from baseline. The four diets were: 1) 20% fat, 15% protein, and 65% carbohydrate (low-fat, average-protein); 2) 20% fat, 25% protein, and 55% carbohydrate (low-fat, high protein); 3) 40% fat, 15% protein, and 45% carbohydrates (high-fat, average protein); and 4) 40% fat, 25% protein, and 35% carbohydrate (high-fat, high-protein). The goal for physical activity (90 minutes of moderate exercise per week) was the same among groups.

Included in this analysis was the subset of participants who had dietary recall data at months 6 and/or 24.

Food Craving Inventory (FCI)

The Food Craving Inventory (FCI) is a 33-item measure of food craving (1). The FCI assesses the frequency of cravings for particular foods over the previous month. The FCI used in POUNDS Lost included a 5-item fruit and vegetable scale, which was not included in the final form of the FCI described in White et al. 2002 (1). The FCI produces a total craving score and craving scores for five empirically-derived factors: 1) high fats (i.e. fried chicken, gravy, sausage); 2) sweets (i.e. cake, cinnamon rolls, ice cream); 3) carbohydrates/starches (i.e. sandwich bread, rice, biscuits); 4) fast food fats (i.e. pizza, French fries, hamburger); and 5) fruits/vegetables (i.e. cooked vegetables, fruit juice, raw vegetables). All items are scored in a 1 (Never) to 5 (Always) multiple choice format with higher values representing higher cravings. The measure has been shown to be reliable and support has been found for its validity (1). The FCI was administered at baseline, month 6, month 12, and month 24 during the POUNDS Lost trial; however, only the data from baseline, month 6, and month 24 were utilized in the present analysis since those time points had dietary assessment data.

Dietary Assessment

During the first screening visit, eligible subjects began a 7-day food record to quantify usual nutrient and dietary intake. Subjects were instructed to record food intake immediately after eating, measuring portions using standard implements (measuring cups, measuring spoons, and a food scale), keeping track of food labels, and then returning the food diary at their next screening visit. At least 5 days of completed food records were required to proceed with study enrollment. At the second screening visit, the dietitian reviewed the food records for clarification purposes. This included the number of days completed, missing data, timeliness, accuracy, specific amounts of food, food descriptions, and cooking/preparation methods. An example would be that the person may have recorded "chicken" but inquiring about the preparation information in more detail (fried, baked, etc.; chicken part; with or without skin; any additions).

In a subset of subjects, additional dietary data were collected at 6 and 24 months (18). Three 24-hour dietary recalls were collected at each time point. These interviews were collected via telephone by the dietary assessment staff at PBRC for subjects at both study sites. Each set of recalls were to occur within a 3-week period, on noncontiguous days, one of which was a weekend day. Every effort was made to complete three recalls on appropriate days but this was not always the case. Each subject was provided necessary materials to complete the 24-hour dietary recall which included a Food Interview Instruction sheet and a booklet that depicted two-dimensional representations of food portions to show common portion sizes. These dietary recalls were used to assess the subject's food intake and adherence to the POUNDS Lost dietary guidelines for each treatment arm.

The 7-day food records from baseline were analyzed to compare with the 24-hour recalls collected at 6 and 24 months using USDA's Automated Multiple Pass Methodology (AMPM) – a computer assisted interview process currently used for dietary data collection in the National Health And Nutrition Examination Survey (NHANES). This methodology has been previously described (20, 21).

Coding

Food records and dietary recalls required study staff (RDs) to identify a match for each consumed food item from the Food and Nutrient Database Dietary Studies 3.0 (FNDDS) (22), published by the Food Survey Research Group of the United States Department of Agriculture. Thus, this database was used for the assessment of food composition including energy (kcals). Consumed FNDDS codes were matched to individual FCI questions for the purpose of FCI item categorization. Specifically, every food item coded into FNDDS (from subjects' food records and dietary recalls) went through an iterative process by researchers (CMC, CAM, and JWA) to decide whether to pair a specific food item with an FCI food item (individual FCI question). Each food item from the food records and dietary recalls was examined and discussed (if necessary). This provided the average daily frequency of FCI food consumption, as well as the average daily amount (kcal) of food consumed from each food item which was coded to an FCI food item (individual question). All coding decisions were made prior to statistical analysis.

Statistical Analysis

We examined the association between craving foods from each of the FCI categories (carbohydrates, sweets, fats, fast food fats, and fruits and vegetables) with: 1) the frequency of consuming those foods, 2) the amount of energy consumed from those foods, and 3) body weight. A series of multi-level repeated measures linear models were used to model change in cravings over from baseline with change in frequency of consumption of FCI foods, change in amount of consumption (kcals) of FCI foods, and change in body weight as the main predictors of interest. The outcomes for each model consist of two levels: time (change from 6 months-baseline and change from 24 months-baseline) and scores for each FCI category within each time. Thus, a subject must have data at baseline and either 6 months or 24 months. An unstructured covariance matrix was used to account for the correlation of a subject over both levels of data. The a-priori covariates included study site, race, sex, dietary treatment group, and age. Degrees of freedom for tests based on covariates used the Kenward and Roger approximation method. Each of the variables of interest (frequency of consumption, energy from consumption, and weight) were each used to create three separate models, with all the covariates listed above, to avoid collinearity problems (Table S1, S2, and S3). Residuals of the final models were checked for normality. Positive associations indicate that decreased frequency of consumption of foods from the FCI, for example, would be associated with a reduction in food cravings (and vice versa). Data are presented as mean ± SEM (SEM = SD / sqrt (N)) in text. T-tests based on the linear models were used to analyze differences from baseline and between month 6 and 24.

Results

There were 367 subjects included in the analyses. At baseline, subjects were ~56% female (n=204) and ~86% non-white (n=316). Dietary treatments were similarly distributed with ~25–26% of subjects in each treatment group (low-fat, average-protein, n=96; low-fat, high protein, n=90; high-fat, average protein, 90; high-fat, high-protein n=91). The PBRC site had slightly more subjects with ~54% (n=189) of the study population for these analyses. The mean age was 52.3 ± 0.5 years and the baseline body weight was 93.84 ± 0.84 kg. Table 1 includes baseline values and change at months 6 and 24 for body weight, FCI total score, frequency of consuming FCI items (number per day), and amount of energy consumed (kcal per day) from FCI items.

When modeling the change in food craving with the change in frequency of FCI food item consumption, changes in cravings were positively associated with change in the frequency of consuming FCI items ($p < 0.01$). Specifically, the associations between change in frequency of consuming FCI items at month 6 (β *0.032 ± 0.010, Effect Size (ES) 0.060*) and month 24 (β *0.027 ± 0.011, ES 0.043*) were significant. However, there was no significant difference in change in frequency of consumption of FCI items from month 6 to 24 ($p = 0.65$). Also, as shown in Table 2A, change in cravings was positively associated with change in the frequency of consuming fast food fats and sweets items at month 6 and frequency of consuming sweets at month 24. The only covariate to have a significant effect was site, which demonstrated a higher change in craving at PBRC than at the Harvard T.H. Chan School of Public Health and Brigham & Woman's Hospital ($\beta = 0.09; p = 0.02$). The remaining covariates were nonsignificant.

Changes in cravings were not associated with the change in amount of energy (kcals) consumed per FCI item across time (month 6, β *0.00005 ± 0.00005, ES 0.020*; month 24, β *0.00007 ± 0.00006, ES 0.0236*). Also, as shown in Table 2B, change in cravings was positively associated with change in the amount of energy (kcals) consumed from sweets items at month 6 and high fat and sweets at month 24. The PBRC site was the only covariate to have a significant effect when modeling craving with kcals consumed ($\beta = 0.02; p = 0.02$). The remaining covariates were nonsignificant.

Changes in cravings were positively associated ($p < 0.05$) with change in body weight at month 6 (β *0.0079 ± 0.0029; ES 0.048;* $p < 0.01$) but not at month 24 (β *0.0038 ± 0.0030; ES 0.023*). As shown in Table 2C, change in cravings was positively associated with change in body weight for high fat, fast food fats, and sweets at months 6 and 24. Change in cravings was negatively associated with change in body weight for fruits and vegetables at month 24. Again, the PBRC site was the only covariate to have a significant effect when modeling changes in cravings with change in body weight ($\beta = 0.10; p = 0.01$). The remaining covariates were nonsignificant.

Discussion

This study included multiple measures of consumption and craving and tested if the conditioning model of food cravings is valid in the context of a long-term weight loss intervention where the consumption of food items will increase and decrease over time. We posited that changes in the frequency of consumption of certain food groups would be positively associated with changes in cravings for those foods. In the previously published analysis with all subjects and an additional time point (month 12), energy restriction did lower cravings for fats, sweets, and starches and increased cravings of fruits and vegetables, although changes in food cravings did not differ by diet type (14). Others have found similar results during lifestyle interventions (10, 12, 17). This study, however, tested a different hypothesis: if decreases in the frequency of consuming food items (and, conversely, increases in the frequency of consuming foods) was associated with decreases or increases in cravings for those foods, respectively, during a period of weight loss (Table 1; month 6) and weight regain (month 24). Our study found that during energy restriction cravings decreased for specific foods when there was a reduction in the frequency of consuming those foods albeit with a small but significant effect size. Additionally, the study indicated that the change in amount (kcal) consumed of specific foods did not influence change in cravings for the foods. These results support the conditioning model of food cravings. Based upon these associative results, to reduce cravings, people should decrease the frequency of consumption of the desired/craved foods rather than lessen the amount of consumption. This coincides with previous research in women who were normal weight and overweight who demonstrated that successful dieters gave into cravings less frequently following six months of energy restriction (12).

Previously, it has been shown in several animal studies that reductions in reinforcement (consumption) are related to reductions in conditioned responses (craving) (23, 24). Other animal studies suggest that consuming a greater amount of food would be associated with more reward and stronger conditioning (25, 26) although less data are available in humans. These animal studies further support our bidirectional hypothesis and results. There is literature to support conditioning models of cravings with humans in lab-based settings, however (27, 28). This study translates the lab-based literature into a longitudinal, free-living RCT in a 'real-world' setting which involved persons being randomized to 1 of 4 different diets. Last, extinction may not be extremely effective or long-lasting, but in the present study the effect lasted over the duration of the 2 year trial.

The results of this study are consistent with previous studies. First, during medium-term energy restriction, decreased dietary variety decreases intake of those foods but doesn't affect weight loss (29, 30). However, compared to a low calorie diet (LCD), less variety during energy restriction (very low calorie diet; VLCD) causes a further decrease in cravings (10). Secondly, previously Gibson and Desmond induced cravings by having people eat certain foods at a specific time for a few days (8). The present study reinforces these findings and also specifies that to reduce food cravings most effectively people should reduce the frequency of consumption of craved foods, not limit the amount of the craved foods consumed.

Previous research suggested sex was a factor related to food craving (31, 32). However, when the frequency of consuming craved food items is decreased, cravings are not affected by sex. Thus, sex is not a factor in this aspect of craving. Furthermore, it did not matter if persons were attempting to follow a low or high fat or average or high protein diet. Dietary treatment did not affect these results. Thus, macronutrient prescription did not alter the outcome.

The hypothesis that consuming less energy from certain foods would result in a reduction in cravings for those foods was not supported. One reason could be the variability or validity of the self-report methods used to estimate energy intake from specific food items. If the conditioning model of food cravings is valid, the act of consuming the food would be more important in creating or maintaining cravings versus the amount of food ingested since the model relies on stimuli being conditioned or paired with consumption of certain types of foods. Thus we support the conditioning model of tonic food cravings. Previously, Harvey et al. discussed that possibility of overconsumption of a specific item may decrease craving for that item (14). However, their study utilized the craving questionnaire and the present results do not support this assertion.

This study had numerous strengths including being a large, well-powered, two-site RCT with broad inclusion criteria (age, sex, race) to increase the generalizability of results. Second, the study used the FCI, a valid and reliable measure of general cravings and cravings for specific types of foods. The study also has limitations. One such possible study limitation was that food records were utilized at baseline while months 6 and 24 incorporated the 24 hour dietary recall method. These are slightly different methods, but produce the same outcome variables since the same database was utilized. Second, the study relied on self-report food records and dietary recall data which have questionable validity. A third possible limitation was the differing number of people at baseline, month 6, and month 24, but this was accounted for with the statistical analysis. Lastly, these data are correlational and further trials should be performed to confirm these findings. Future research may examine how directly altering the frequency and amount of consumption of specific items on a craving subscales alters cravings.

In conclusion, this is the first paper to demonstrate that during weight loss treatment, reductions in the frequency of consuming certain foods resulted in decreased cravings for those foods. Thus, based upon the presented associations, to reduce cravings, subjects or patients should be instructed to decrease the frequency of eating items on the Food Craving Inventory rather than targeting the amount consumed, though it is recognized that reducing the frequency of eating a food typically results in eating less of it. During weight loss and weight loss maintenance overweight and obese individuals should cut FCI items out of their diet not consume small ‘tastes’. Further, during a period of energy restriction, associations demonstrate if cravings are reduced so is body weight. These findings support the conditioning model of food cravings and indicate that people should decrease the frequency of consuming craving foods if they wish to reduce cravings for those foods. Further research is needed to examine these effects in the context of restrained eaters, where it has been posited that food restriction could lead to overconsumption of those foods (33).

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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What is already known about this subject?

- Cravings occur in the majority of the population.
- It is thought that food cravings are a result of conditioning.
- Food cravings decrease during weight loss.

What does your study add?

- This is the first study to test if the conditioning model of food cravings is valid in the context of a long-term weight loss intervention where the consumption of food items increase and decrease over time.
- This study tested if decreases in the frequency of consuming food items (and, conversely, increases in the frequency of consuming foods) was associated with decreases or increases in cravings for those foods, respectively, during a period of weight loss and weight regain.
- The present study also examined if change in the amount of energy consumed from FCI food items altered cravings for those foods, as well as if body weight altered cravings.

Table 1

Baselines values and change at months 6 and 24 for body weight, Food Craving Inventory total score, frequency of consuming FCI items (number per day), and amount of energy consumed per day from FCI items

	Baseline	ΔM6	ΔM24
Subjects (n)	367	330	164
Body Weight (kg)	93.84 ± 16.00	−7.51 ± 5.57*	−5.82 ± 7.69*
FCI Total Score	2.41 ± 0.76	−0.64 ± 2.19*	−0.19 ± 2.39
Frequency of Consumption (n)	8.58 ± 1.93	0.68 ± 2.68*	−0.45 ± 2.58
Amount Consumed (kcals)	2023.6 ± 556.6	−411.2 ± 537.4*	−465.1 ± 496.0*

Data are Mean ± SD. FCI, Food Craving Inventory; M6, month 6; M24, month 24.

* denotes a significant change from baseline ($p \leq 0.0001$).

Table 2A

Betas for change at months 6, 24 and the difference between months 24 and 6 for frequency of consuming FCI items (number per day)

Parameter	Beta	Standard Error	t-Value	p-value
M6 Carbohydrates/Starches	0.005	0.016	0.32	0.75
M6 High Fats	0.017	0.017	0.96	0.34
M6 Fast Food Fats	0.067	0.022	3.13	*0.002*
M6 Fruits/Vegetables	−0.012	0.010	−1.2	0.23
M6 Sweets	0.083	0.021	3.89	*0.0001*
M24 Carbohydrates/Starches	−0.007	0.015	−0.44	0.66
M24 High Fats	0.033	0.019	1.76	0.08
M24 Fast Food Fats	0.0253	0.024	1.04	0.30
M24 Fruits/Vegetables	0.005	0.011	0.4	0.69
M24 Sweets	0.077	0.019	4.02	*<0.0001*
M24 vs. M6 Carbohydrates/Starches	−0.012	0.021	−0.58	0.56
M24 vs. M6 High Fats	0.016	0.020	0.81	0.42
M24 vs. M6 Fast Food Fats	−0.043	0.026	−1.65	0.10
M24 vs. M6 Fruits/Vegetables	0.017	0.014	1.16	0.25
M24 vs. M6 Sweets	−0.006	0.024	−0.23	0.81

M = Months. Degrees of Freedom = 3142. Italicized values are significant at $p<0.05$.

Table 2B

Betas for change at months 6, 24 and the difference between months 24 and 6 for amount of energy consumed per day from FCI items

Parameter	Beta	Standard Error	t-Value	p-value
M6 Carbohydrates/Starches	0.000049	0.000064	0.76	0.45
M6 High Fats	0.000092	0.000053	1.74	0.08
M6 Fast Food Fats	0.000083	0.000055	1.5	0.13
M6 Fruits/Vegetables	−0.00025	0.000157	−1.6	0.11
M6 Sweets	0.00028	0.000081	3.45	*0.0006*
M24 Carbohydrates/Starches	−0.00001	0.000071	−0.17	0.86
M24 High Fats	0.000117	0.000059	1.98	*0.05*
M24 Fast Food Fats	0.000008	0.000065	0.13	0.90
M24 Fruits/Vegetables	−0.00004	0.000185	−0.24	0.81
M24 Sweets	0.000301	0.000083	3.62	*0.0003*
M24 vs. M6 Carbohydrates/Starches	−0.00006	0.000088	−0.69	0.49
M24 vs. M6 High Fats	0.000025	0.000061	0.41	0.68
M24 vs. M6 Fast Food Fats	−0.00007	0.000071	−1.05	0.29
M24 vs. M6 Fruits/Vegetables	0.000205	0.000225	0.91	0.36
M24 vs. M6 Sweets	0.00002	0.000093	0.22	0.83

M = Months. Degrees of Freedom = 3142. Italicized values are significant at $p<0.05$.

Table 2C

Betas for change at months 6, 24 and the difference between months 24 and 6 for body weight

Parameter	Beta	Standard Error	t-Value	p-value
M6 Carbohydrates/Starches	0.0033	0.0036	0.93	0.3533
M6 High Fats	0.0073	0.0031	2.36	*0.0182*
M6 Fast Food Fats	0.0155	0.0036	4.26	*<.0001*
M6 Fruits/Vegetables	−0.0023	0.0045	−0.52	0.6007
M6 Sweets	0.0156	0.0035	4.5	*<.0001*
M24 Carbohydrates/Starches	0.0004	0.0038	0.11	0.9135
M24 High Fats	0.0104	0.0032	3.22	*0.0013*
M24 Fast Food Fats	0.0108	0.0039	2.77	*0.0056*
M24 Fruits/Vegetables	−0.0115	0.0048	−2.39	*0.0169*
M24 Sweets	0.0090	0.0037	2.45	*0.0144*
M24 vs. M6 Carbohydrates/Starches	−0.0029	0.0035	−0.82	0.4125
M24 vs. M6 High Fats	0.0031	0.0029	1.06	0.2902
M24 vs. M6 Fast Food Fats	−0.0047	0.0037	−1.28	0.2003
M24 vs. M6 Fruits/Vegetables	−0.0092	0.0047	−1.96	0.0503
M24 vs. M6 Sweets	−0.0066	0.0034	−1.95	0.0515

M = Months. Degrees of Freedom = 3142. Italicized values are significant at $p<0.05$.