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An intervention study targeting energy and nutrient intake in worksite cafeterias

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ABSTRACT

Modifying the food environment is a promising strategy for promoting healthier eating behavior. This study aimed to evaluate nutritional and weight changes in a program that used worksite cafeterias to reduce employees' calorie content of purchased foods and improve their macronutrient intake. Participants were randomly assigned to one of two conditions: 1) only environmental change (i.e., the introduction of 10 new low-energy-density (ED) foods and provision of labels for all foods sold at lunch, which listed ED, calories, and macronutrient content) or 2) the environmental change plus pricing incentives for purchasing low-ED foods and education about low-ED eating delivered in four, 1-hour group sessions. Participant lunch choices were monitored electronically at the point of purchase for 3 months before the intervention was instituted (i.e., the baseline period) and for 3 months afterward (i.e., intervention period). Participants were adults ($n=96$, BMI $=29.7 \pm 6.0$ kg/m^2) who regularly ate lunch at their workplace cafeteria. There was no difference between groups in total energy intake over the study period. Across groups, energy and percent of energy from fat decreased and percent of energy from carbohydrate increased from baseline to the intervention period (all $p<.01$). Follow-up analyses, conducted by averaging Baseline Months 1 and 2 and comparing them to Intervention Month 3 as a conservative estimate of overall impact of the intervention, indicated that change in energy, carbohydrate, and fat intake remained significant ($p<.001$). Providing nutrition labels and reducing the ED of selected foods was associated with improved dietary intake.

1. Introduction

The food environment has a powerful influence on eating behavior. Modifying the food environment is a novel approach for facilitating changes in eating behavior, such as reductions in energy intake that might ultimately prevent weight gain (Lowe, 2003). One such method is to reduce the energy density (ED) of foods available in a particular environment, such as a worksite cafeteria. ED, or the amount of energy in a given weight of food, influences energy intake. Dietary fat increases the ED of a food more than either carbohydrate or protein, while water decreases ED by adding weight but little or no energy. Reducing the ED of a diet can reduce energy intake without increasing hunger or producing short-term energy compensation (Ello-Martin, Ledikwe, & Rolls, 2005; Rolls et al., 1999). When people were given diets varying in ED over the course of several days and allowed to eat *ad libitum*, those on the reduced-energy-dense diet consumed less energy than those on the higher-energy-dense-diet (Rolls et al., 1999). Data from several randomized clinical trials have found that reductions in dietary ED are associated with weight loss (Ello-Martin, Roe, Ledikwe, Beach, & Rolls, 2007; Ledikwe et al., 2007; Rolls, Roe, Beach, & Kris-Etherton, 2005).

Reduced ED eating interventions can be combined with other environmental changes for weight gain prevention. Manipulating financial incentives for making particular food choices may be an effective way to modify food intake. There is preliminary evidence that the cost of food has a significant impact on food choices (French, Jeffery, Story, Hannan, & Snyder, 1997; French et al., 2001; Ledikwe et al., 2007). Another readily modifiable aspect of the food environment is the nutritional information provided to consumers at the point of purchase. This approach has promise but does not yet have strong research support (Engbers, van Poppel, Paw, & van Mechelen, 2005; Steenhuis, van Assema, van Breukelen, & Glanz, 2004).

This study was designed to test innovative, environmental approaches to changing eating behaviors in worksite cafeterias. After an observation-only baseline period, all participants were exposed to two environmental changes in their worksite cafeteria: 1) the ED of some foods was reduced, and 2) nutritional labels (including ED information) were provided for all foods sold in the cafeterias. One aim of the study was to determine if these environmental interventions resulted in changes in food intake over time. In addition, half the participants were assigned at random to a training and incentive program that provided specific guidance on how to reduce the ED of the diet both inside and outside of the worksite cafeteria and provided

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discounts on low-ED foods purchased in the cafeteria. The second aim of the study was to determine if this educational and incentive program produced greater dietary change than the ED and labeling intervention alone. The primary outcome of the study was the food choices that participants made in the cafeteria. This outcome variable was measured in a novel way: by electronically capturing food choice data continuously and automatically at the point of purchase in the cafeteria.

2. Methods and procedures

2.1. Participants and recruitment

This study took place at two hospital cafeterias in Philadelphia, PA. Eligible participants included male and female hospital or university employees between the ages of 21 and 65 years. Participants were eligible if they reported eating lunch in the hospital cafeteria at least two times each week, on average. We chose a minimum of twice a week to ensure a representative sample from Hospital A and B that would provide frequent enough data to get a sense of what participants were purchasing throughout the course of the study without requiring a significant increase in the amount of food participants purchased. Initial data from Hospital A suggested that 60% of employees ate in the cafeteria at least twice a week. Individuals were excluded from the study if they had a current diagnosis of a chronic disease or condition known to affect appetite or body weight, were taking medication known to affect appetite or body weight, were pregnant or planning to become pregnant within the next 24 months, were enrolled or had plans to enroll within the next 24 months in an organized weight management program, and/or had plans to terminate hospital employment within the next 12 months. Recruitment at Hospital A took place in June, 2003. Recruitment at Hospital B took place in July, 2004 and September, 2004 (see Table 1).

Participants were recruited through letters distributed to cafeteria patrons that provided an overview of the study along with inclusion and exclusion criteria. At Hospital B, cafeteria patrons also were invited to attend one of four “free lunch” information sessions at which the details of the study were provided. After a phone screening, participants attended the baseline assessment. The Drexel University Institutional Review Board approved the study and all participants provided written informed consent. Monetary reimbursement ($25) was provided to all participants for completing each assessment.

2.2. Procedures

The study began with a 3-month period of baseline data collection, which was followed by a 3-month intervention period and then a 6-month and 12-month post-intervention follow-up. After baseline data collection, participants were randomly assigned into one of two intervention groups: Environmental Change (EC) or Environmental Change Plus Energy Density Education and Incentives (EC-Plus). Randomization of participants occurred within each worksite.

When the intervention period began, participants in both groups were exposed to two environmental changes: reductions in the ED of some foods offered in the cafeteria and introduction of nutritional labels for all foods sold in the cafeterias. (Prior to the introduction of our intervention, food labels were provided on less than 10% of the foods sold in the cafeterias.) Participants in the EC-Plus condition received two additional intervention components: training in reducing the ED of their diet and discounts on low-ED foods purchased in the cafeteria. Intervention procedures are described next.

2.2.1. EC components

The changes made to the cafeteria were designed to provide more options for making healthier food choices rather than to limit access to more energy-dense foods. Thus, the intervention added healthier foods without removing any of the existing, more energy dense foods. As part of the intervention new ingredients and foods lower in energy density were made available. The foods that were added were low-fat mayonnaise for hand-made deli sandwiches, low-fat cheese for sandwiches, whole wheat buns, baked potato wedges, steamed vegetables, a reduced-fat personal pizza, and low-fat frozen yogurt. In addition, several recipes for existing food items were modified to offer a healthier alternative. Thus, in addition to the existing options, the cafeteria made available a “Wellness burger” which was prepared with lean meat, whole grain bun, low-fat cheese, lettuce, tomato (no fried onions and no French fries) and a “Wellness sub” which was prepared with lean chicken or turkey breast, whole wheat bun, low-fat mayonnaise, low-fat cheese, and two vegetable toppings. In addition, the weekly cafeteria menu was designed to include at least one main entrée and one side dish that were either very low in energy density (0.0–0.5 kcal/g) or low in energy density (0.6-1.5 kcal/g) (Rolls & Barnett, 2000).

As part of the environmental intervention, a food labeling system was introduced in the two hospital cafeterias that paired food labels with each food and beverage item. The food labels contained a color coding system which identified each item as very low in energy density (< 0.6 kcal/g, green), low-energy density (0.6–1.5 kcal/g, yellow), medium energy density (1.6–3.9 kcal/g, orange), or high energy density (4.0–9.0 kcal/g, red). The labels also showed the total calories, fat (g), carbohydrate (g), protein (g), and energy density (kcal/g) for the portion of food being sold.

2.2.2. EC-Plus components

In addition to being exposed to all EC components, participants in the EC-Plus condition attended four, 60-minute group sessions during which they were taught the principles of energy density. The contents of the group sessions were based on the book “Volumetrics” by Rolls and Barnett (Rolls & Barnett, 2000). Each participant also received a copy of the book. Topics of the group sessions included education and instruction about energy density of different foods, how to compute energy density from a food label, a variety of ways to lower a food's energy density, and meal planning and grocery shopping strategies for reducing the energy density of the diet. As part of their group sessions the new food labeling system in the cafeteria was also explained so participants could take advantage of the energy density information to guide their food purchases. After each of the four group sessions, subjects were provided with additional handouts which summarized the contents of each session in detail. Participants were instructed to use

Table 1
Study timeline.

A1	Baseline	Intervention	A2	Follow-up	
Dietary recalls, height/weight, waist circumference, body composition, blood lipids, blood pressure, and cognitive restraint	Months 1–3 Measurement of cafeteria intake only	Months 3–6 Environmental Change (EC) or EC + Energy density education + Incentives	Immediately post-intervention (Month 6) Dietary recalls, height/weight, waist circumference, body composition, blood lipids, blood pressure, and cognitive restraint	A3 (6 months post-intervention or Month 12) Dietary recalls, height/weight, waist circumference, body composition, blood lipids, blood pressure, and cognitive restraint	A4 (12 months post-intervention or Month 18) Dietary recalls, height/weight, waist circumference, body composition, blood lipids, blood pressure, and cognitive restraint

the knowledge they gained from the group sessions and from reading “Volumetrics” to modify their food choices both inside and outside the cafeteria to improve the healthfulness of their diet and avoid future weight gain.

Participants in the EC-Plus group also received financial discounts (15% off for “low-energy density”) or 25% off (for “very low-energy density”) for purchasing food items that were lower in energy density (whether they were existing menu items or items introduced as part of the intervention). These discounted items included soups, salad, a newly created “Wellness burger” and “Wellness sub”, diet soda, and any main entrées and side dishes labeled as very low or low in energy density.

2.3. Measures

2.3.1. Cafeteria intake

Assessment of cafeteria intake utilized scan card technology coupled with computerized cafeteria cash registers (Infogenesis, North Sydney, Australia). Participants swiped their identification (scan) cards at a cash register with each cafeteria purchase. Their ID numbers, along with unique codes associated with all foods sold in the cafeteria, were automatically saved every time they purchased a lunch. This Sodexho database contained the macronutrient content of all foods served, enabling the measurement of calorie, and nutrient, intake of individual selections (and therefore full meals) for each participant.

There were several limitations to the use of the cafeteria intake data. Baseline Month 3 data were not captured due to technical failure, so information on cafeteria intake is available only for Baseline Months 1 and 2 and Intervention Months 1, 2, and 3. Additionally, Baseline Month 2 cafeteria register macronutrient data from Hospital B contained a calculation error that resulted in the percentage of total calories from each macronutrient being slightly inflated relative to the total recorded kilocalories. Because the exact cause of the inflation could not be determined, the percentages of calories from fat, carbohydrate, and protein were recalibrated to sum to 100% for Baseline Month 2 only, Hospital B only. We were unable to calculate ED from any cafeteria intake data because information on the weights of all foods served was not available.

Data from participants who did not scan their cards an average of at least four times per month were excluded from analyses (average scans per month: 6.9 ± 3.6). In the baseline phase of the study, estimates of amount of food eaten were obtained from digital photographs of finished food trays; however, participant non-compliance precluded the utility of photography data in final analyses. Therefore, analyses are based on foods purchased, which assumes that participants consumed all foods purchased.

2.3.2. Naturalistic food intake

Dietary recalls were conducted at all 4 assessment points in order to determine if participants' food intake outside of the cafeteria changed as a result of the interventions, particularly because the EC-Plus participants were given information about how change their eating behavior both inside and outside of the cafeteria. Dietary recalls were conducted by the Diet Assessment Center at The Pennsylvania State University to collect information on total food intake (both inside and outside the cafeteria). Three 24-hour food recalls were obtained at each assessment by the multiple-pass method via telephone on 3 random days, one of which was a weekend day (Jonnalagadda et al., 2000). Participants were given printed portion-size aids and trained to provide accurate descriptions of food intake (preparation methods, brand of commercially prepared foods, etc.). Portion-size estimates were clarified and completeness of food recalls was assured through query by a registered dietitian. Dietary intake data were collected and analyzed using Nutrition Data System for Research software versions 35 (© 2004, Nutrition Coordinating Center, University of Minnesota, Minneapolis, MN) to obtain ED and energy and macronutrient composition of food intake averaged across the 3 days. Energy density was calculated by dividing the number of calories in a food by the food's weight (in grams). The optimal method of calculating energy density has not firmly been established; the concern is how and whether to include beverages in the calculations. A full review of this issue can be found in Ledikwe, Blanck, Khan, Serdula, Seymour and Tohill (2005). For the present study, energy density was calculated using two methods: foods only and foods plus “caloric” beverages (defined as those having >20 calories per serving).

2.3.3. Height and weight

Height and weight were measured with participants in street clothing, without shoes, using a standardized stadiometer and an electronic Seca® scale (Hamburg, Germany) accurate to 0.1 kg.

2.3.4. Waist circumference

Waist circumference was assessed during minimum respiration using a measuring tape placed at the midpoint between the bottom of the rib and the tip of the iliac crest (Gibson, 1990).

2.3.5. Body composition

Percent body fat and fat free mass (FFM) were assessed using Bioelectrical Impedance Analysis (BIA), Biodynamics Model 310e, Washington, USA. Participants were assessed in a supine position in the morning after a 12-h overnight fast. Results from BIA show good agreement with both dual energy x-ray absorbitometry and underwater weighing in overweight individuals (Pateyjohns, Brinkworth, Buckley, Noakes, & Clifton, 2006; Powell et al., 2001).

2.3.6. Blood lipids and blood pressure (BP)

Blood draws were conducted following an overnight 12-h fast. Cholesterol and triglyceride assays were performed at the MCP Hahnemann University Hospital Clinical Laboratory. Blood pressure was measured on the same schedule as blood lipids by nursing staff using a tabletop sphygmomanometer with a size appropriate cuff. Three readings were taken at 1-min intervals after participants have rested for at least 5 min; systolic and diastolic BP was calculated as the average of the second and third readings (Wadden, 1984).

2.3.7. Cognitive restraint (CR)

The Cognitive restraint subscale of the Three Factor Eating Questionnaire is a psychometrically established self-report measure designed to assess degree of conscious restriction of food intake (Safer, Agras, Lowe, & Bryson, 2004; Stunkard & Messick, 1985). This subscale has been validated and its ability to predict differing aspects of eating behavior has been demonstrated (Westenhoefer, Stunkard, & Pudel, 1999). The CR subscale has been further divided into rigid and flexible subscales, as suggested by Westenhoefer et al. and we examined both total and subscale scores (Westenhoefer et al., 1999).

2.4. Statistical analyses

T-tests (for continuous dependent measures) and chi square (for categorical dependent measures) were used to evaluate group differences at baseline. Attrition rates were analyzed using Fisher's exact test. All analyses of change in outcomes over the course of the study were conducted using mixed model repeated measures ANOVAs (multivariate, Pillai's trace method). Time served as the within-subjects factor in the model and the precise time points that were used varied depending on the data being analyzed; cafeteria register data were collected monthly (Month 1 thru 6, a total of five time points with the exclusion of Month 3 data) while anthropometric data was collected pre-baseline, post-intervention, 6 months post-intervention, and 12-months post-intervention (four points in time, although some analyses used just two: pre-baseline and post-intervention). Register data were analyzed both as an average aggregate of baseline (Months 1 and 2) versus the last month of intervention data (Month 6) (with just two levels of time) and, for more specific analysis of time trends, using individual monthly data (Baseline 1 and 2, Intervention 1, 2, and 3).

Intervention group (EC versus EC-Plus) was the primary between subjects factor; study site (Hospital A versus Hospital B) was also evaluated to see if results differed by site. For analyses of weight change, macronutrient intake and calorie content of purchased foods over time, baseline weight was used as a covariate because BMI has been a predictor of weight change and caloric intake in past intervention studies (Teixeira et al., 2004; Teixeira, Going, Sardinha, & Lohman, 2005). Evaluation of findings between two specific time points in the repeated measures ANOVA was conducted using tests of within-subjects contrasts. Effect sizes for repeated measures analysis is reported using partial eta^2 (η_p^2). Cutoffs of 0.01, 0.06, and 0.14 for small, medium, and large effect sizes, respectively, were used (Green, Salkind, & Akey, 2000). Two-tailed tests were conducted. All analyses were conducted using the Statistical Package for the Social Sciences (SPSS for Windows, version 15.0; SPSS, Chicago, IL).

3. Results

3.1. Demographics and attrition

Ninety-six employees of the two hospitals volunteered to take part (mean age = 44.2; SD = 9.9). The sample was composed of 54% Whites, 39% Blacks, 3% Asian, 2% Hispanics, and 1% who reported mixed or "other" racial heritage. The average body mass index (BMI = kg/m^2) of participants at the start of the study was 29.7 (SD = 6.0). Fifty-three individuals participated from Hospital A and 43 participated from Hospital B. There were 18 men and 78 women who were randomly assigned to either the EC (11 men and 38 women) or EC-Plus group (7 men and 40 women). There were no statistically significant differences in gender, ethnicity, weight, or BMI between the two conditions or between the two hospitals.

Total attrition rates were 19.8% at post-intervention (6 months after study initiation), 34.4% at 6-month follow-up (6 months after the conclusion of the intervention), and 42.7% at 12-month follow-up. At each assessment point, significantly more participants dropped out of the EC-Plus group than the EC group (all p-values <0.05). Significantly more participants from Hospital B dropped out than from Hospital A at all follow-up time points (all p-values <0.05). African-Americans were less likely to provide cafeteria register data than were Whites at Baseline Month 1 ($p<0.05$) and Intervention Month 1 ($p<0.05$). No such ethnicity patterns were observed for attendance at clinical assessments, nor were there any attrition differences in age, sex, weight, or BMI.

3.2. Objective measures of intake: cafeteria register data

On food purchase measures recorded in the two cafeterias, there were no condition-by-group interactions in measures of energy intake or the nutritional composition of purchased foods. Over the baseline (2 months) and intervention periods (3 months), both the EC and EC-Plus groups decreased the overall energy content of their lunch purchases ($F(4,66)=7.20$, $p<0.001$; $\eta_p^2=0.30$) (see Fig. 1 and Table 4). The largest change in energy intake occurred between Baseline Month 1 and Baseline Month 2 ($F(1,69)=13.07$, $p<0.001$; $\eta_p^2=0.16$) during which mean energy intake decreased from 656.09 kcal (±183.83) to 585.47 kcal (±170.09). All time points showed a statistically significant main effect of time when compared to Baseline Month 1 ($ps<0.001$); however, there were no further month-to-month statistically significant changes. Percentage of energy from fat in purchased lunches also showed a main effect of time over the 5-month period ($F(4,66)=5.04$, $p=0.001$; $\eta_p^2=0.23$). There was no statistically significant change between any two consecutive months, but rather, a general downwards trend was noted during the intervention months. This trend became a statistically significant main effect of time when comparing Baseline Month 1 to Intervention Month 3 ($F(1,69)=8.51$, $p=0.005$; $\eta_p^2=0.11$ — see Fig. 2).

Overall, there was no statistically significant main effect of time over the 5-month study period in percentage of energy from dietary protein ($F(4,66)=1.87$, $p=0.13$; $\eta_p^2=0.10$). There was a significant change in percentage of energy from carbohydrates over time ($F(4,66)=3.79$, $p<0.01$; $\eta_p^2=0.19$), such that it decreased marginally from Baseline Month 1 to Baseline 2 ($F(1,69)=3.02$, $p=0.09$), and exhibited a

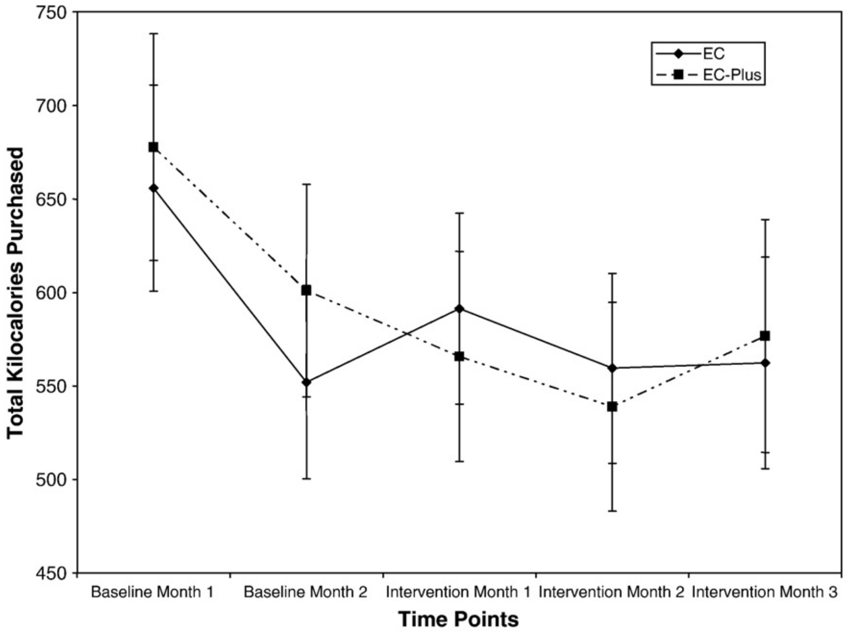

Fig. 1. Using cash register data, the energy content of participants' lunch purchases in the cafeteria was measured. Over the baseline and intervention periods, participants in the Environmental Change (EC; $n=49$) and Environmental Change Plus Pricing Incentives and Education (EC-Plus; $n=47$) groups were compared. Participants in both groups significantly decreased the overall energy content of their lunch purchases. Baseline Months 1–2 were baseline with no nutrition labels in the cafeteria, and Intervention Months 1–3 included education and labeling.

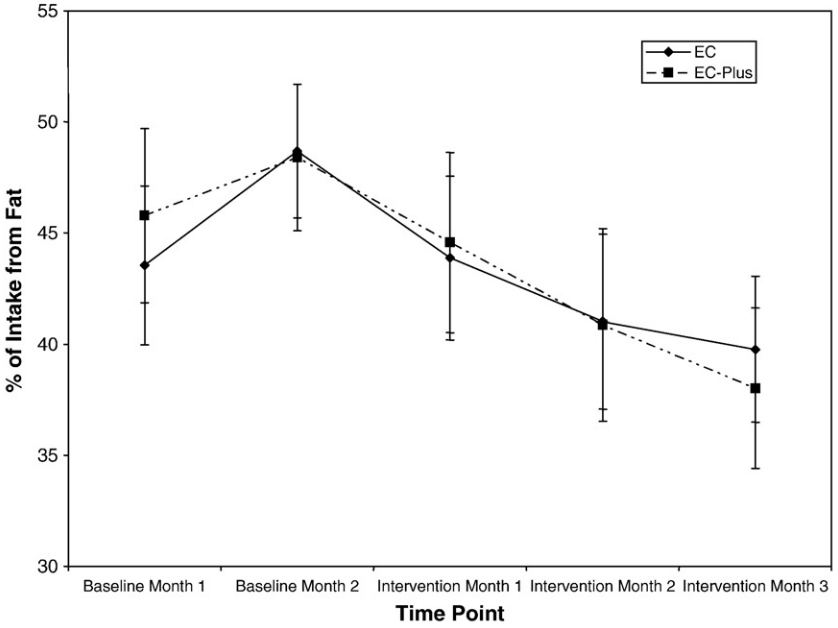

Fig. 2. Using cash register data, the percent of fat in participants' lunch purchases in the cafeteria was measured. Over the baseline and intervention periods, participants in the Environmental Change (EC; $n = 49$) and Environmental Change Plus Pricing Incentives and Education (EC-Plus; $n = 47$) groups were compared. Percent of energy from fat in purchased lunches was significantly higher at Baseline Month 1 than at Intervention Month 3.

concomitant rebound trend between Baseline Month 2 and Intervention Month 1 ($F(1,69) = 3.44$, $p = 0.07$).

Dietary intake was also evaluated by averaging Baseline Months 1 and 2, and comparing them to Intervention Month 3, as a conservative estimate of overall impact of the intervention (assuming that by Intervention Month 3, participants might start reverting to former eating habits). The only finding that became evident in this analysis was a significant main effect of time on the percentage energy from carbohydrates ($F(1,73) = 11.18$, $p < 0.001$; $\eta_p^2 = 0.13$), with an increase from 37.66 (±7.21) g to 42.67 (±13.13) g.

3.3. Self-report measures of intake: 24 h food recalls

The 24-hour food recalls comparing the pre-study baseline to the end of the study period showed no significant main effect of time ($F(1,71) = 1.15$, $p = 0.29$; $\eta_p^2 = 0.02$) or a condition-by-time interaction effect ($F(1,71) = 0.27$, $p = 0.60$; $\eta_p^2 = 0.00$) on energy density when it was calculated using food only. No main effect of time ($F(1,71) = 0.39$, $p = 0.54$; $\eta_p^2 = 0.01$) or condition-by-time interaction ($F(1,71) = 0.84$, $p = 0.36$; $\eta_p^2 = 0.01$) on energy density was evident when calculated using both solid food and caloric beverages.

We were also interested in whether participants changed their food selections in their overall daily eating habits. There were no statistically significant changes over time in reported intake of total energy, vegetables, bread products, or dairy products. There was a significant condition-by-time interaction on reported fruit intake ($F(1,71) = 5.41$, $p < 0.05$; $\eta_p^2 = 0.07$), such that the EC-Plus group increased their fruit intake (from 0.77 servings to 0.98 servings) while the EC group decreased theirs (from 1.41 servings to 0.96 servings). Since there was such a large between-groups difference in fruit intake at baseline, it is impossible to know if this represents a treatment effect or regression toward the mean. There was a significant main effect of time on reported servings of meats by all participants ($F(1,71) = 4.49$, $p < 0.05$; $\eta_p^2 = 0.06$), indicating that, on average, participants in both groups decreased their meat intake during the cafeteria monitoring period. For servings of fats and sweets, there was a site by time interaction, such that participants at Hospital A decreased their fat and sweet servings, whereas participants at Hospital B increased theirs ($F(1,67) = 8.34$, $p = 0.005$; $\eta_p^2 = 0.11$).

3.4. Cognitive restraint

A repeated measures analysis over the four assessment points showed a main effect of time on dietary cognitive restraint, on average, for all participants ($F(3,41) = 9.96$, $p < 0.001$; $\eta_p^2 = 0.42$). It increased during the cafeteria monitoring period ($F(1,43) = 10.78$, $p < 0.005$; $\eta_p^2 = 0.20$), but then exhibited a marginally significant decrease after the cafeteria monitoring period, up to the 6-month follow-up assessment point ($F(1,43) = 3.44$, $p = 0.07$; $\eta_p^2 = 0.07$). After the 6-month assessment, cognitive restraint appeared to level off and remain steady ($p = 0.11$). This finding was accounted for almost exclusively by a main effect of time time on the subscale of rigid restraint ($F(3,43) = 7.49$, $p < 0.001$; $\eta_p^2 = 0.34$), which increased significantly during the cafeteria monitoring period ($F(1,45) = 4.66$, $p < 0.05$; $\eta_p^2 = 0.09$), but during the 6-month follow-up, leveled out or decreased a bit ($F(1,45) = 2.58$, $p = 0.12$; $\eta_p^2 = 0.05$). Flexible restraint exhibited no significant main effect of time ($F(3,46) = 1.00$, $p = 0.41$; $\eta_p^2 = 0.06$).

3.5. Anthropometric and blood lipid measures

Anthropometric measures are reported for two time points: pre-baseline and post-intervention. There was no statistically significant change in weight during the cafeteria monitoring phase in either intervention condition, when controlling for baseline weight ($F(1,70) = 2.56$, $p = 0.11$; $\eta_p^2 = 0.04$). There was a statistically significant site by time interaction, where, on average, participants at Hospital B gained approximately 1 kg during that period while those at Hospital A remained weight stable ($F(1,70) = 6.85$, $p = 0.01$; $\eta_p^2 = 0.09$). At 12-month follow-up, there was no significant condition-by time effect on weight change ($F(3,45) = 0.91$, $p = 0.44$; $\eta_p^2 = 0.06$) nor a main effect of time (see Table 2). (Site differences at 12-month follow-up could not be analyzed due to high attrition at Hospital B, which had fewer than 10 participants per intervention group at that point.) There were no significant interactions or main effects on body fat or waist circumference over time.

Changes in blood cholesterol are reported in Table 3. The two groups were not significantly different in their blood cholesterol levels at baseline ($t(70) = 1.35$, $p = 0.18$). However, there was a significant condition-by-time interaction for total cholesterol ($F(1,66) = 5.06$,

Table 2
Change in measured weight over time[a].

Condition	Pre-monitoring	Post-monitoring	6 months	12 months
EC	78.7 ± 21.0	79.1 ± 20.5	79.6 ± 20.6	80.2 ± 22.0
EC-Plus	85.5 ± 16.2	85.9 ± 16.8	86.7 ± 16.8	86.3 ± 16.9

[a] Weight change did not significantly differ between participants in the Environmental Change (EC; $n = 49$) and Environmental Change Plus Pricing Incentives and Education (EC-Plus; $n = 47$) groups. Values are mean ± standard deviation. These values are unadjusted means (unlike in the repeated measures analyses, which controlled for baseline weight).

$p < 0.05$; $\eta_p^2 = 0.07$), where, on average, the total cholesterol levels increased for participants in the EC-Plus group and decreased for participants in the EC group from baseline to post-monitoring assessment. This difference remained significant when baseline weight or BMI was added as a covariate. This group difference in total cholesterol levels could be accounted for in part by a condition-by-time interaction on HDL cholesterol levels ($F(1,66) = 4.38$, $p < 0.05$; $\eta_p^2 = 0.06$) wherein the EC-Plus group increased and the EC group decreased slightly (see Table 3). Of note, there also was a statistical trend for a condition-by-time interaction on LDL cholesterol ($F(1,66) = 3.17$, $p = 0.08$; $\eta_p^2 = 0.05$), again showing the EC-Plus group increase and the EC group decrease (see Table 3). Therefore, it is not clear whether the increase in cholesterol was a positive or negative finding for the EC-Plus group. There was no interaction effect on triglycerides ($F(1,66) = 0.19$, $p = 0.67$; $\eta_p^2 = 0.00$).

4. Discussion

The results of this study demonstrated that relatively minor modifications to worksite cafeterias may produce improvements in macronutrient and energy intake, but that more intensive environmental changes are likely necessary to produce larger effects. Both total energy intake from purchased cafeteria foods and the percent of energy from fat in purchased foods declined significantly during the 6-month study period, but total energy intake assessed with 3-day food records did not change. The timing of the decrease in total energy intake in the cafeteria (primarily in baseline Month 2) suggests that neither of the interventions accounted for the decline (though they may explain the maintenance of the decrease in total energy intake during the 3 months of intervention). The decrease in the percentage of energy from fat, on the other hand, coincided with the introduction of the experimental conditions (between the first month of baseline and the third month of intervention), suggesting that some combination of the food labels and the availability of more foods lower in energy density could be responsible for this improvement. However, because Month 3 of baseline data were not available, we cannot say exactly when this reduction occurred or the extent to which the beneficial changes were due to introduction of food labels, introduction of new food options, the cumulative effect of having lunchtime purchases monitored, or a combination of these changes.

The reduction of percentage fat in lunches was accompanied by a significant increase in carbohydrate intake. The substitution of carbohydrates such as fruits and vegetables for fat is desirable, especially given the high percentage of energy from fat in typical cafeteria lunches. Since fat has more than twice the energy per gram as carbohydrate, such a substitution may have also contributed to the reduction in total energy intake during the study. It is apparent that the addition of the nutrition education groups and the financial incentives for purchasing foods lower in energy density did not contribute to the improvements found because changes in both conditions were similar across the 6-month study period.

It is possible that the improvements noted could be due to a Hawthorne effect (i.e., that participants reduced their fat and energy intake because they knew these outcomes were being studied) (Table 4). However, the improvements were sustained for 3-4 months, with no sign of regression back to baseline levels, which suggests that some aspect of the intervention was responsible for initiating or maintaining the improvements in food choices. If an individual ate in the cafeteria 3 times per week on average, if they saved the average number of calories per lunch found here (~70 kcal/lunch), and if these energy savings were not compensated for at other times, then such an individual would experience energy savings that would translate into a weight loss (or the avoidance of weight gain) of a little over 1 kg over 1 year. Participants in both groups gained a small amount of weight at the 12-month follow-up and it is impossible to know if their weight gain would have been greater in the absence of the cafeteria interventions. EC participants gained almost twice as much weight (1.5 kg) as EC-Plus participants (0.8 kg) but this was not significant.

Another possible reason for the noted dietary improvements could be from a cumulative effect of having participant's lunchtime purchases monitored. It is possible that by being aware that their purchases would be scanned and reviewed by the research team, participants became more aware of their lunch habits in general and thereby adjusted their purchases. Previous research examining the effect of self-monitoring in obese participants has found that self-monitoring of food intake can produce reactive effects, which would manifest as improvements in caloric or nutritional intake (Goris, Westerterp-Plantenga, & Westerterp, 2000). However, reactive effects of self-monitoring are typically short-lived and so the longer-lasting improvements noted here may be due to more than participants' awareness that their food purchases were being monitored.

The significant increase in dietary restraint in both groups during the study was somewhat surprising because participants were not advised to restrict their overall energy intake. Because most participants were overweight or obese, their participation in the study may have caused them to increase their efforts to curb their overall energy intake. The fact that the increase in restraint was mainly reflected in rigid rather than flexible eating control strategies is perhaps a sign that the increase in restraint was self-generated. Of note, the finding that restraint scores significantly increased during monitoring of food intake and then decreased when foods were no longer being monitored provides further support for the interpretation that monitoring of foods may have had a significant effect on the reported dietary improvements.

Table 3
Changes in blood lipid levels (mg/dL) over[a] time.

	Pre-monitoring (Baseline Month 1)	Post-monitoring (after intervention Month 3)
Total cholesterol		
EC	204.1 ± 41.8	197.4 ± 42.3
EC-Plus	192.4 ± 32.4	201.8 ± 28.9
HDL		
EC	58.7 ± 19.5	57.0 ± 16.9
EC-Plus	58.4 ± 16.6	60.9 ± 16.6
LDL		
EC	124.1 ± 34.4	120.1 ± 37.5
EC-Plus	115.4 ± 31.6	121.5 ± 31.3
Triglycerides		
EC	106.5 ± 68.1	101.6 ± 45.0
EC-Plus	92.9 ± 42.2	96.8 ± 41.9

[a] Blood lipids did not significantly change over time for participants in the Environmental Change (EC; $n = 49$) or Environmental Change Plus Pricing Incentives and Education (EC-Plus; $n = 47$) groups. Values are mean ± standard deviation. Analyses were not conducted at 6- and 12-month follow-up due to lack of data from Hospital B. Statistics include only those patients who participated in the post-monitoring assessment.

Table 4
Selected nutritional outcomes.

	Pre-baseline	Baseline Mo 1	Baseline Mo 2	Int. Mo 1	Int. Mo 2	Int. Mo 3	Post-Tx
Purchased kcal		665.1 ± 185.1	572.2 ± 163.4	580.4 ± 159.2	548.5 ± 158.7	570.0 ± 179.9	
Purchased % calories from fat		44.7 ± 11.4	45.3 ± 9.3	44.5 ± 12.2	40.9 ± 12.3	38.9 ± 10.2	
Purchased % calories from protein		16.7 ± 6.2	19.3 ± 5.1	18.1 ± 4.7	18.4 ± 5.1	18.6 ± 7.7	
Purchased % calories from carbohydrate		38.9 ± 11.6	35.4 ± 10.5	38.5 ± 11.9	41.0 ± 12.6	42.8 ± 13.2	
Food recall total calories	1650.6 ± 541.5						1571.0 ± 506.0

It is difficult to interpret the significant increases in both HDL and LDL cholesterol in the EC group. The increase in HDL is desirable but the increase in LDL is not. Furthermore, the EC group did not show greater improvements in either nutritional intake or in body weight, so it is probably unwise to attach much importance to these findings.

This study was designed to 1) beneficially influence cafeteria patrons' food choices at lunchtime in ways that could ultimately have weight gain prevention effects, and 2) accurately quantify the energy and macronutrient content of their food purchases before and after experimental interventions were introduced. This latter goal is important because of the well-known difficulty in accurately measuring naturalistic food intake (Lissner, 2002). The average percentage of energy from fat in purchased lunches was very high (~46% of total calories) and so the opportunity existed to reduce both fat intake and total energy intake during lunch. Assuming that sufficient changes in food selection were undertaken and maintained, then such changes were also expected to slow the rate of weight gain participants experienced.

Perhaps the most significant implication of this study is that it is possible to meaningfully reduce energy and fat intake in the cafeteria setting, where millions of people eat meals every day. The changes involved were rather minor — the addition of food labels to all items sold and the addition of ten new foods or ingredients. Furthermore, only lunch purchases were targeted. Far more widespread changes in the fat content, energy density, and portion size of foods available in these cafeterias could have been made and, at least in some cafeterias, these changes could be expanded to foods purchased at other meals and for snacks. These changes would require an up-front investment by food companies, but once made they would be easy to maintain, thereby affording long-lasting benefits to cafeteria patrons. Furthermore, because such changes make it simple for consumers to permanently make healthier choices, there is less need to rely on psychoeducational approaches that are difficult to instill and maintain (Lowe, 2003). Making small changes in the environment did not produce a weight gain prevention effect in this study, indicating that more intensive environmental changes may be necessary to achieve clinically significant changes in weight.

There were strengths and weaknesses in this study. On the positive side, it is rare to find cafeteria-based studies that institute major environmental changes (introducing new foods, instituting nutritional labeling on all foods, offering discounts for low-energy-dense foods) that are sustained over several months. Furthermore, the electronic system for recording and storing participants' food purchases was novel and allowed us to quantify actual food purchases and their macronutrient and caloric values more accurately than has been possible in most past nutrition intervention studies. Another positive feature was the relatively high percentage of African-American participants included in the study.

On the negative side, the attrition rate was high, particularly at the 6- and 12-month follow-ups. In addition, a greater percentage of EC-Plus than ED participants dropped out, which could have introduced bias in the results at the two follow-ups. Although we experimented with methods for quantifying plate waste, we were unable to develop a procedure to do so. Thus estimates of food intake are likely to be overestimated to some degree, but this should be equivalent across conditions. We also had no way of knowing the extent to which participants who reduced their lunchtime energy intake compensated for it during other times of the day. It would have been desirable to know how participants reacted to the changes made in the cafeteria since such information would help determine the sustainability of the intervention over time. The absence of a no-intervention control group limits the conclusions that can be definitively drawn from these results. It also is possible that contamination occurred across the EC and EC-Plus conditions, because participants were employees at the same worksites.

In conclusion, we showed that a cafeteria-based intervention produced desirable reductions in energy and fat intake over a 3–4 month period among mostly overweight and obese patrons. A major potential advantage of this type of environmental intervention is that, once established, the maintenance of the intervention is far easier to achieve than has been the case with changes in nutritional intake produced by lifestyle change programs. Future research of this type would benefit from demonstrating a stable baseline before the interventions are implemented, in order to determine the extent to which changes were due to the specific cafeteria manipulations. Additionally, in order to better determine the effect of self-monitoring alone, it would be useful to include a matched control group at, for example, a third hospital site. Future research should also further assess the impact of incorporating nutritional labels on all foods and of making more widespread and sustained reductions in energy density of foods served in cafeterias.

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Contributors

The authors' responsibilities were as follows: MRL and BJR: study concept and design; MLB, KT, MCC, and CNO: acquisition of data; MRL, MLB, KAT, and BJR: statistical analysis and interpretation of the data; MRL, KAT, MLB, MCC, and CNO: draft of the manuscript; MRL and BJR: funding; MRL, MLB, RAA, MCC, and CNO: administrative, technical, and material support; MRL: study supervision; and all authors: final approval of the version to be published.

Conflict of interest

Dr. Lowe is a member of the Scientific Advisory Board for Weight Watchers and has been a consultant to Pfizer for their development of a weight loss medication. Barbara Rolls is the author of the book *Volumetrics*. All other authors declare that they have no conflicts of interest.

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