



Published in final edited form as:

Int J Obes (Lond). 2017 March ; 41(3): 434–442. doi:10.1038/ijo.2016.217.

Does the incorporation of portion-control strategies in a behavioral program improve weight loss in a one-year randomized controlled trial?

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Abstract

Background/Objectives—Controlling food portion sizes can help reduce energy intake, but the effect of different portion-control methods on weight management is not known. In a one-year randomized trial, we tested whether the efficacy of a behavioral weight-loss program was improved by incorporating either of two portion-control strategies instead of standard advice about eating less.

Subjects/Methods—The Portion-Control Strategies Trial included 186 women with obesity (81%) or overweight (19%). Participants were randomly assigned to one of three equally intensive behavioral programs consisting of 19 individual sessions over 12 months. The Standard Advice Group was instructed to eat less food while making healthy choices, the Portion Selection Group was instructed to choose portions based on energy density using tools such as food scales, and the Pre-portioned Foods Group was instructed to structure meals around pre-portioned foods such as single-serving main dishes, for which some vouchers were provided. In an intention-to-treat analysis, a mixed-effects model compared weight loss trajectories across 23 measurements; at Month 12, weight was measured for 151 participants (81%).

Results—The trajectories showed that the Pre-portioned Foods Group initially lost weight at a greater rate than the other two groups ($P=0.021$), but subsequently regained weight at a greater rate ($P=0.0005$). As a result, weight loss did not differ significantly across groups at Month 6 (mean \pm SE 5.2 ± 0.4 kg) or Month 12 (4.5 ± 0.5 kg). After one year, measured weight loss averaged 6% of baseline weight. The frequency of using portion-control strategies initially differed across groups, then declined over time and converged at Months 6 and 12.

Conclusions—Incorporating instruction on portion-control strategies within a one-year behavioral program did not lead to greater weight loss than standard advice. Using pre-portioned foods enhanced early weight loss, but this was not sustained over time. Long-term maintenance of behavioral strategies to manage portions remains a challenge.

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POTENTIAL CONFLICT OF INTEREST

LSR, BLJ, and CES declare no conflict of interest.

SUPPLEMENTARY INFORMATION

Supplementary information is available at International Journal of Obesity's website.

INTRODUCTION

The rise in obesity prevalence has occurred in parallel with increases in food portion size¹⁻³. In addition, many controlled studies have shown that offering individuals larger portions leads to substantial and sustained increases in energy intake⁴⁻⁹. These data demonstrate that the availability of large portions can override the regulation of energy balance and could have persistent effects that promote obesity. Dietary guidelines^{10,11} recommend portion control to help limit energy intake, but little is known about the efficacy of different portion-control strategies for weight management¹². In this randomized controlled trial, standard advice to eat less was compared with two focused portion-control strategies: one that uses knowledge and tools to select satisfying portions while restricting energy intake, and another that changes the personal eating environment in order to limit exposure to large portions.

Weight-loss recommendations often advise reducing energy intake by simply eating less¹⁰. Recent research indicates that such advice should include the influence of energy density (ED) on amounts that can be consumed¹³⁻¹⁷. When restricting energy intake, individuals can eat their usual amount of food by consuming larger portions of low-energy-dense foods (vegetables, fruits, lean proteins) while limiting portions of higher-energy-dense foods (high-fat, low-water foods). The use of tools such as food scales and household measures could improve the implementation of such recommendations^{18,19}. Surprisingly few studies have examined whether use of portion-control tools is sustained over time and whether they facilitate weight management; however, promising results have been found using plates that indicate appropriate proportions of meal components²⁰⁻²². We tested whether providing education and tools to limit intake of high-ED foods and promote intake of low-ED foods improved weight loss when incorporated into a standard behavioral program.

Another portion-control strategy is to structure the eating environment to limit exposure to large portions¹². This can be achieved using pre-portioned foods that are packaged for a single eating occasion, such as frozen main dishes, single-serving snacks, and liquid meal replacements. Studies show that just as the availability of large portions leads to overconsumption, using pre-portioned foods helps to limit energy intake and promotes weight loss²³⁻²⁵. Several evidence-based reports support the use of pre-portioned meals for weight management, although the evidence for this comes primarily from studies of liquid meal replacements^{11,26,27}. In the few studies that have tested the long-term effects of pre-portioned foods, the items were provided throughout the study^{24,25,28-30}. For example, several studies found that providing portion-controlled main dishes twice a day for the 8- to 12-week duration of the trial led to greater weight loss than a self-selected diet²⁸⁻³⁰. We examined whether use of pre-portioned foods is sustained over a longer period as provision is reduced, and whether this strategy facilitates long-term weight loss.

There is a need for evidence-based strategies to help individuals limit energy intake for obesity management in an environment characterized by large portions of energy-dense foods. The Portion-Control Strategies Trial helps fill this gap by systematically comparing the effects of different portion-control strategies on weight loss over one year. We tested the hypothesis that participants who were taught to use tools to select portions based on ED or

to structure meals with pre-portioned foods would have greater weight loss than those following standard advice to eat less.

SUBJECTS AND METHODS

Subjects

Participants were recruited through local advertisements; eligibility was determined by telephone interview and screening sessions. Eligible participants were women aged 20–65 years with a body mass index (BMI) of 28–45 kg/m². Potential subjects were excluded if they had blood pressure >160/100 mm Hg, reported a weight change >4.5 kg in the past three months, had a medical condition that precluded participation or that limited physical activity, were following a special diet or weight-loss program, were pregnant or lactating, scored >19 on the Eating Attitudes Test³¹, or scored >25 on the Beck Depression Inventory³². To be enrolled, potential subjects were required to complete three daily food and activity diaries and a two-week run-in period.

Participants were stratified by BMI and age and randomly assigned to one of three groups using blocks of six sequences from a random number generator. Participants and interventionists were informed of the group assignment for instructional purposes; assignment was masked from those who assessed outcomes including dietary recalls and blood analyses. The sample size was determined by using a mixed-effects model³³ to analyze the trajectories of weight loss in exemplary data sets based on trials of behavioral programs in similar populations^{13,23}. Power was determined from the non-centrality parameter and the critical F-value for a two-sided Type 1 error rate of 0.05. It was estimated that differential rates of weight loss (linear and quadratic coefficients) could be detected between any two groups with 80% power by testing 48 participants per group (144 in total). To allow for a 20% non-completion rate, the sample size was set at 180 participants.

The trial protocol was approved by the Office for Research Protections of The Pennsylvania State University and registered at www.clinicaltrials.gov as NCT01474759. Participants provided signed informed consent and were financially compensated for participation. The trial was conducted at the Clinical Research Center on the University Park campus of The Pennsylvania State University from July 2012 to March 2015.

Behavioral programs

In this parallel-group trial, participants met individually with registered dietitians and trained interventionists for 19 sessions over one year. Each interventionist used standard instruction manuals, received regular training to ensure fidelity to program content, and had equal contact with the groups. Thirty-minute sessions were scheduled weekly in Month 1 and biweekly in Months 2–6, and one-hour sessions were scheduled monthly in Months 7–12. In each group, energy balance was explained as the basis for weight loss, but in order to test the influence of different portion-control strategies, instruction focused on following the assigned dietary program and making behavioral changes. The specific principles of each program were reinforced within basic lessons about food categories (fruit, vegetables, fats, whole grains and fiber, lean protein, and dairy foods) as well as meal planning and managing

behavior change. All participants received similar instruction on increasing physical activity through walking, with the goal of achieving 10,000 steps daily. At each session, participants were given written lesson plans and supplemental materials to review and add to their personal binders. For purposes of self-monitoring, subjects were encouraged to keep daily records of body weight, pedometer counts, and foods eaten. During each session, the interventionist reviewed these records with the participant and helped set goals for the next session.

Participants in the Standard Advice Group were instructed to follow dietary guidelines¹⁰ that emphasized eating less while making healthy choices from all food groups. Educational sessions and materials focused on eating recommended amounts of fruits and vegetables for health purposes; choosing foods containing lean protein, whole grains, and healthy fats; and reducing intake of sodium and added sugar. One session provided instruction on standard serving sizes in each food group and on understanding food labels. Throughout the trial, participants were taught to plan meals with a variety of foods in order to achieve a balance of nutrients and maintain a healthy diet while eating less.

Participants in the Portion Selection Group were instructed to choose food portions based on energy density in order to eat satisfying portions of low-ED foods and to control portions of higher-ED foods^{13,34}. Over several sessions, individuals were taught the concepts of ED and methods for modifying the ED of dishes and meals by altering portions of low- and high-ED foods. To facilitate choosing portions, participants were given a portion-selection tool at each of the first four sessions and instructed in its use: a digital food scale, a set of household measures (cups and spoons), a placemat that illustrated appropriate proportions of meal components, and a card illustrating portion estimation using common objects (such as the hand or a computer mouse). Participants were instructed to continue using the tools that they found helpful; throughout the trial, advice to choose portions based on ED was reinforced.

Participants in the Pre-portioned Foods Group were instructed to structure their meals and to learn appropriate food portions by using pre-portioned foods such as individual servings of main dishes, side dishes, snacks, yogurt, and whole fruits. Participants were instructed to eat pre-portioned main dishes daily for lunch and dinner during Months 1–3 of the trial and were encouraged to continue this practice subsequently. To facilitate this, participants were given prepaid vouchers for single-serving main dishes at the rate of 14 vouchers per week in Month 1, which was gradually reduced to four per week during Months 4–12. Throughout the trial, participants were taught about selecting all types of pre-portioned foods and snacks and how to prepare their own.

Outcome assessments

In addition to the instructional sessions, four assessment sessions were conducted at the end of Months 1, 3, 6, and 12. Blood samples were collected at Months 3, 6, and 12 only.

Anthropometry and blood samples—Weight was measured at the 19 instructional sessions and the four assessment sessions. Subjects were weighed to the nearest 0.1 kg while

wearing a lightweight outfit kept for them at the center. Height was measured with a stadiometer; waist circumference was measured at the right iliac crest³⁵.

Fasting blood samples were analyzed by Quest Diagnostics (Pittsburgh, Pennsylvania, USA) for serum lipids, glucose, and insulin. Insulin resistance was calculated from glucose and insulin values using a HOMA calculator³⁶.

Diet and physical activity—Because it was expected that dietary change and the rate of weight loss would be maximal in the first three months of the trial^{13,23}, 24-hour dietary recalls were administered at baseline and Month 3. Recalls were scheduled on two weekdays and one weekend day for a sample of 124 participants (67%) and completed by 123 participants. Recalls were administered by telephone by the Diet Assessment Center of The Pennsylvania State University and analyzed using Nutrition Data System for Research software³⁷. In addition to nutrient intakes, recalls were analyzed for food group servings and number of pre-portioned foods. Reported items were categorized according to ED as Very low (0.0–0.59 kcal/g), Low (0.6–1.49 kcal/g), Medium (1.5–3.99 kcal/g), or High (4.0–9.0 kcal/g)³⁴.

Physical activity was assessed using pedometers provided to participants (Yamax-Digiwalker Model SW-200, Warminster, Pennsylvania, USA). At baseline and prior to each of the four assessment sessions, participants recorded pedometer counts for two weekdays and one weekend day.

Questionnaires—Participants completed questionnaires at the research center on computers using Qualtrics software (Provo, Utah, USA). Questionnaires included the Eating Inventory³⁸ (assessing dietary restraint, disinhibition, and tendency toward hunger) and a 45-item Diet Satisfaction Questionnaire³⁹. Participants also reported the frequency of 34 weight-control strategies, including four practices of eating low-energy-dense fruit and vegetables, four practices of eating low-fat foods, four practices of using portion-selection tools, and two practices of consuming pre-portioned foods.

Statistical analyses

The main outcome was the trajectory of weight change over time, analyzed by a random coefficients model on all measurements from randomized subjects, regardless of the number of sessions attended (an intention-to-treat analysis). Group assignment was treated as a fixed factor in the model and time (trial week) was treated as a continuous covariate. Time was also included as a random factor to account for correlation of repeated measures within subjects; thus the trajectory of weight change was characterized separately for each participant. Polynomial factors of time were tested as both fixed and random factors and included if they improved the fit of the model. Additional baseline characteristics such as restraint score were tested as covariates, and their interactions with polynomial factors of time were included if significant.

Secondary outcomes that were measured at several time points (cardiometabolic factors, dietary intakes, questionnaire responses, and pedometer counts) were analyzed by a linear mixed-effects model with categorical fixed factors of group, time, and their interaction, if

significant. Correlation of repeated measures within subjects was accounted for by modeling the covariance structure of the data. All models included the randomization variables of baseline BMI and age. Tests of group means were adjusted for multiple comparisons by the Tukey-Kramer method. Differences across groups in baseline characteristics were tested by a fixed-effects model for continuous variables and by Fisher's exact test for categorical variables; differences in retention rates in the trial were assessed by the log-rank test. Analyses were performed using SAS software (version 9.4, SAS Institute Inc., Cary, North Carolina, USA). Results were considered significant at $P < 0.05$ and are reported as mean \pm SD unless otherwise noted.

RESULTS

Participant characteristics

There were 186 participants enrolled in the trial (62 per group); their baseline characteristics did not differ significantly across groups (Table 1). At baseline, participants had mean age of 50 ± 11 years and weight of 91 ± 13 kg; 81% had obesity and 19% had overweight. The majority of participants had some college education and had attempted to lose weight multiple times in the past year. A participant flow diagram is shown in Figure 1. Retention rates in the trial did not differ across groups ($P = 0.86$). For the subset of participants who completed dietary recalls, baseline characteristics did not differ across groups, nor did baseline characteristics differ between those who did and did not complete recalls (data not shown).

Trajectory of weight loss

As shown in Figure 2, there were significant differences in trajectories of weight loss across groups. Participants in the Pre-portioned Foods Group had a greater rate of initial weight loss (linear coefficient -0.47 kg/week; $P = 0.021$) than those in the other two groups (both -0.33 kg/week). At Month 3, for example, modeled weight loss (mean \pm SE) in the Pre-portioned Foods Group was 5.1 ± 0.4 kg compared to 3.7 ± 0.4 kg in the Standard Advice Group and 3.8 ± 0.4 kg in the Portion Selection Group. The Pre-portioned Foods Group also had a greater rate of weight regain (quadratic coefficient 0.013 kg/week²; $P = 0.0005$) than the other two groups (0.008 and 0.009 kg/week², respectively). As a result, mean weight loss did not differ significantly across groups at Month 6 (mean \pm SE 5.2 ± 0.4 kg) or Month 12 (4.5 ± 0.5 kg). The trajectories for observed weight loss showed a similar pattern to the intention-to-treat analysis, but the magnitude of weight loss was greater since it did not include estimated trajectories for participants who withdrew from the trial (Supplemental Figure S1).

Dietary restraint score was the only baseline characteristic found to influence the trajectory of weight loss. Across all groups, lower baseline restraint score led to a greater rate of weight loss ($P = 0.006$) and a lower rate of weight regain ($P = 0.03$). In addition, participants who completed a greater number of self-monitoring records over the trial had a greater rate of weight loss ($P < 0.0001$) and a lower rate of weight regain ($P = 0.003$).

At the end of the trial, weight was measured for 151 participants (81%); their baseline characteristics did not differ from those participants without a final measure, except for having a higher restraint score (9.3 ± 3.6 versus 7.4 ± 3.4 ; $P=0.006$). Mean measured weight loss in these subjects was 5.2 ± 6.5 kg, equivalent to 6% of baseline weight; 45% had lost 5% of baseline weight and 20% had lost 10%.

Cardiometabolic risk factors

All groups had beneficial changes in cardiometabolic risk factors over the trial, with no significant differences across groups (Table 2). There were decreases in diastolic blood pressure, waist circumference, fasting glucose and insulin, total cholesterol, triglycerides, and insulin resistance from baseline to Month 3. HDL cholesterol increased from baseline to Month 6 and again to Month 12. There were no significant differences in LDL cholesterol over time.

Diet and physical activity

In the subset of participants with dietary recalls, there were differences across groups in change in reported food consumption from baseline to Month 3 (Table 3). The Standard Advice and Pre-portioned Foods Groups decreased food intake by 116 ± 416 g/d, or 11%; in contrast, the Portion Selection Group maintained food intake (interaction $P=0.002$). Intake of very low-energy-dense foods (including most fruits and vegetables, low-fat yogurt, broth-based soup) increased in the Portion Selection Group by 128 ± 299 g/d (82%), whereas there was no change in the other two groups (interaction $P=0.0007$).

Changes in energy density and energy content of reported food consumption from baseline to Month 3 did not differ significantly across groups. All groups decreased food ED from 1.72 ± 0.51 to 1.45 ± 0.45 kcal/g (16%; $P<0.0001$), and energy intake from 1889 ± 633 to 1504 ± 502 kcal/d, a mean decrease of 387 ± 686 kcal/d (20%; $P<0.0001$). Weight loss at Month 3 was correlated with the decrease in food ED at that time ($r=0.23$; $P<0.0001$) but not with the decrease in energy intake ($r=0.08$; $P=0.14$). At Month 3, all groups consumed fewer servings of grains, protein foods, dairy foods, and fats and oils; had no change in servings of vegetables and sweets; and consumed more servings of fruit ($P=0.001$; Table 3). Intake of pre-portioned foods increased in the Pre-portioned Foods Group from 1.0 ± 1.2 to 2.2 ± 1.4 items/d, whereas in the other two groups it did not change significantly (Table 3; interaction $P<0.0001$).

Pedometer counts increased similarly over time in all groups ($P<0.0001$). Mean counts increased from 6571 ± 3250 steps/d at baseline to 7855 ± 3204 steps/d at Month 1, increased again to 8516 ± 3213 steps/d at Month 3, and were maintained at Months 6 and 12.

Indicators of adherence and satisfaction

As shown in Figure 3, reported use of the targeted portion-control strategies (fruit and vegetable ED strategies, portion-selection tool use, and pre-portioned food use) differed across groups at Months 1 and 3 (all interactions $P<0.0001$). Reported use of these strategies then declined over time ($P<0.03$) and did not differ across groups at Months 6 and 12. In the Portion Selection Group, the most frequently used tool at Month 1 was household measures,

which were used more frequently (1.5 ± 1.5 times/day; $P < 0.014$) than common objects (1.1 ± 1.3 times/day), food scales (1.0 ± 1.4 times/day) and the portion placemat (0.7 ± 1.2 times/day). By Month 6, reported use of tools in this group did not differ from baseline (Figure 3). All groups reported similar increases in the use of fat-reduction strategies, which were maintained during the trial ($P < 0.0001$).

General indicators of adherence were not significantly different across groups: participants attended a mean of 19 ± 4.9 of the 23 sessions, and 50% missed either one or no sessions. Over the year, participants completed a mean of 546 ± 313 daily self-monitoring records of weight, pedometer counts, and diet. The number of self-monitoring records was highly correlated with the number of sessions attended ($r = 0.72$; $P < 0.0001$).

Several ratings of satisfaction with the diet differed across the groups ($P = 0.001$). Compared to baseline, at Month 1 the Pre-portioned Foods Group reported spending less time and effort on meals and feeling more self-conscious and deprived when eating; at Months 1, 3, and 6 they reported spending less money on food (all $P < 0.0001$). The other two groups had no changes over time in ratings of satisfaction with the diet.

DISCUSSION

Although portion control is part of most behavioral weight management programs, little is known about the efficacy or sustainability of different portion-control strategies. The results of The Portion-Control Strategies Trial indicate that within a one-year behavioral program, three strategies led to similar weight loss: the standard message to eat less, using tools to select portions based on energy density, and structuring meals with pre-portioned foods. Across groups, 45% of participants achieved a clinically relevant weight loss of 5%⁴¹, indicating that all three of the programs had utility for weight management; these results are comparable with those of other behavioral programs in non-clinical populations^{13,23,42,43}. The incorporation of specific portion-control strategies did not improve weight loss or cardiometabolic risk factors compared to standard dietary advice to eat less while making healthy food choices. Initial weight loss was enhanced by provision of pre-portioned foods to limit exposure to large portions, but this was not sustained over time. In all groups, reported use of targeted strategies showed adherence during the first several months, but strategy use then declined and converged over the year. The long-term maintenance of behavioral strategies to manage portion size remains a challenge^{12, 44–45}.

Instruction to use pre-portioned foods at several meals each day, supported by provision of vouchers, resulted in more rapid initial weight loss than the other strategies. This may be related to the structured eating environment provided by pre-portioned foods, which led to fewer decisions about amounts to eat^{23–25,28–30}. The initial success may also have occurred because the use of pre-portioned foods could be adopted immediately with minimal instruction, while the other strategies were taught in sessions extending over several weeks. An important question was whether the use of pre-portioned foods would continue when vouchers were not provided. We found that after the frequency of voucher provision was decreased to several per week, the higher rate of weight loss was not sustained. Weight regain during the second half of the trial was likely related to decreased use of pre-portioned

foods, influenced by participant reports of increased cost and feelings of self-consciousness and deprivation. Further work is needed on methods to incorporate portion-controlled options into everyday decisions about what and how much to eat.

One portion-control strategy that is frequently advocated by professional organizations is to use tools such as household measures or common objects to provide guidance on recommended portion sizes^{46,47}. To our knowledge, there are no data on the utility or sustainability of using portion-selection tools for weight management, other than using plates showing appropriate proportions of foods^{20–22}. Most of the research related to such tools has focused on whether they improve the accuracy of portion size estimation^{18,48}. One study, however, assessed the usage of portion-control tools and found that household measures were rated as the easiest to use and reported to be the most likely to be used again¹⁹. The current trial found that household measures were initially the most frequently used tool of the four provided, but after three months their reported use decreased substantially. More data are needed to determine whether such short-term adoption of tools improves understanding of appropriate portions, and whether more sustainable tools can be developed^{49,50}.

An unexpected finding of the trial was the similarity in weight loss trajectories of the Portion Selection and Standard Advice groups. In a previous study, we found that instruction on reducing dietary energy density by increasing intake of water-rich foods led to lower ED and greater weight loss than advice to eat less and reduce fat intake¹³; additionally, other research has found the degree of ED reduction to be associated with the amount of weight loss^{14,51,52}. In the present trial, ED instruction was provided only to the Portion Selection Group, but dietary recalls showed that at three months all groups reported similar decreases in intake of medium-ED and high-ED foods, resulting in substantial reductions in dietary ED. Although the Portion Selection Group additionally reported increased intake of very low-ED foods and maintained the total weight of food eaten, this was insufficient to further reduce dietary ED compared to the other groups. Across the groups, there was also considerable overlap during the later months in the reported use of specific dietary strategies associated with reductions in ED. In this population, the women's familiarity with various weight-loss strategies probably decreased fidelity to the assigned diet programs⁵³ and contributed to convergence in dietary intake patterns. It is likely that the comparable weight loss across groups was related to these similarities in eating behaviors as well as the common instruction on physical activity and self-monitoring.

In this group of experienced dieters, standard advice to eat less was as successful for weight loss as more specific portion-control strategies. Recently published data suggest that including a rigorous usual-care condition in weight loss trials results in substantial attenuation of treatment effects⁵⁴, which may have contributed to the similarity of weight change across groups. The convergence of weight change over the trial may relate to participants' adherence to the program^{55–56}, since frequency of attendance and self-monitoring did not differ across groups and were related to rates of weight loss and regain. It seems likely that the regular individual meetings and the accountability they encouraged were an important driver of weight change; similarly, one commercial program found that participants with >85% attendance had the highest weight loss⁵⁷. The frequency of

instructional sessions was reduced over the trial, and this could account in part for declining rates of weight loss. The trajectories of weight change were also influenced by participant characteristics. Across the programs, weight loss was greater for those with lower baseline restraint scores, which may indicate greater opportunities for beneficial behavior changes.

The Portion-Control Strategies Trial is the first longitudinal comparison of the efficacy of different portion-control strategies for weight management. A strength of the trial was evaluating specific approaches to portion management, accompanied by frequent weight measurement that allowed modeling of trajectories of weight change using an intention-to-treat analysis; however, the generalizability of the findings is limited by the lack of diversity in the sample. The results showed that within a behavioral program, a variety of portion-control approaches can be effective in promoting weight loss, but that over a year strategies such as use of portion-control tools and pre-portioned meals were not well maintained. A goal of future studies should be to find improved techniques for maintaining adherence to dietary programs that incorporate portion-control strategies into sustainable lifestyle changes. Modifications to the eating environment that make it easier to manage large portions of energy-dense foods are needed to support such programs^{16,51,58}.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

This research was supported by the National Institute of Diabetes and Digestive and Kidney Diseases (R01DK059853). The use of the Clinical Research Center was supported by the National Center for Advancing Translational Sciences, National Institutes of Health (UL1TR000127). Food vouchers were provided by unrestricted gifts from ConAgra Foods, Inc. and Nestlé USA. The content is solely the responsibility of the authors and does not necessarily represent the official views of the funding bodies. We thank the participants in the Portion-Control Strategies Trial and the research team at Penn State, particularly interventionists Jennifer Meengs, Kitti Halverson, Cara Meehan, and Amy Ciccarella.

BJR receives royalties from the sale of the Volumetrics books.

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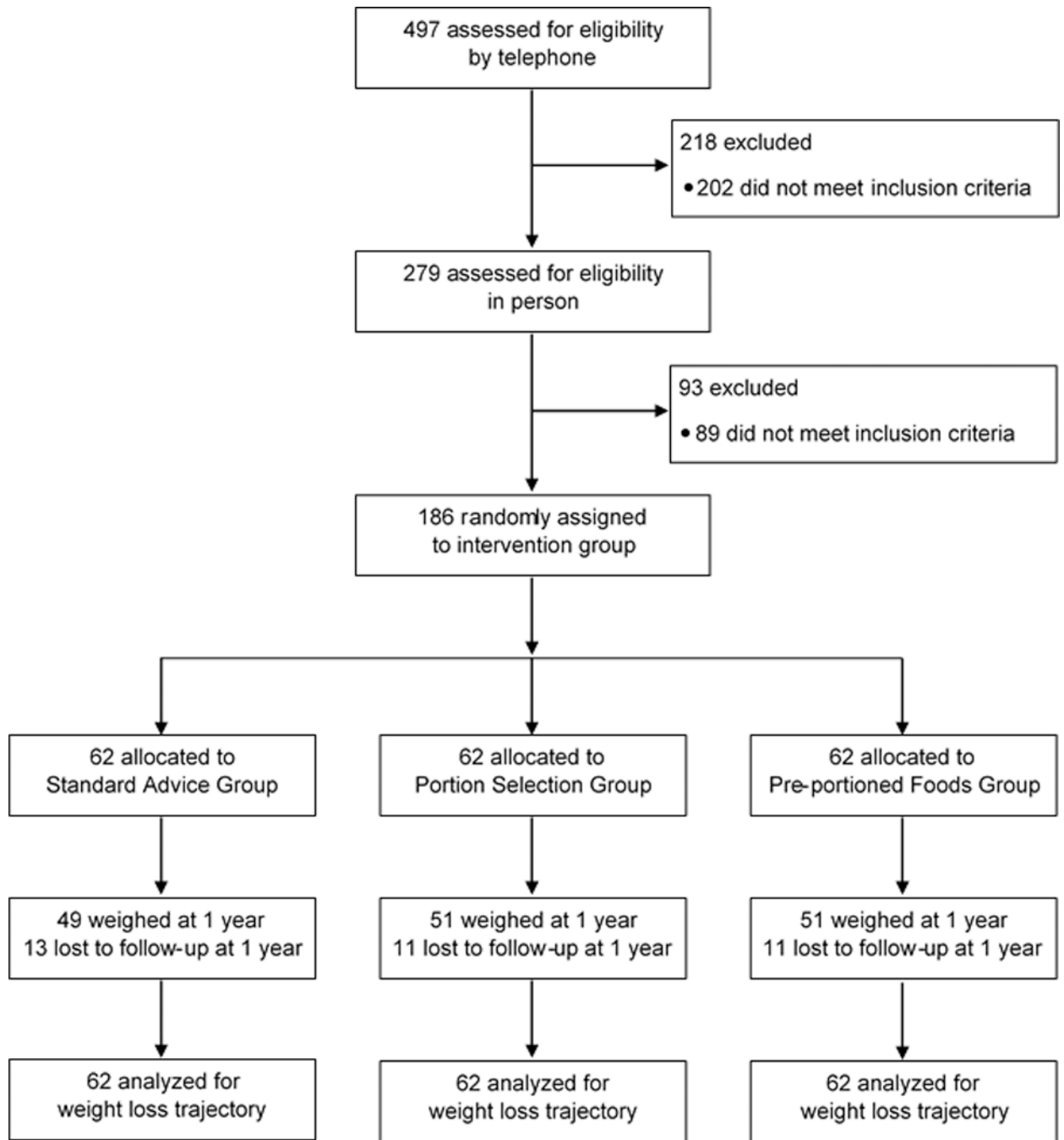


Figure 1.
Participant flow chart of The Portion-Control Strategies Trial

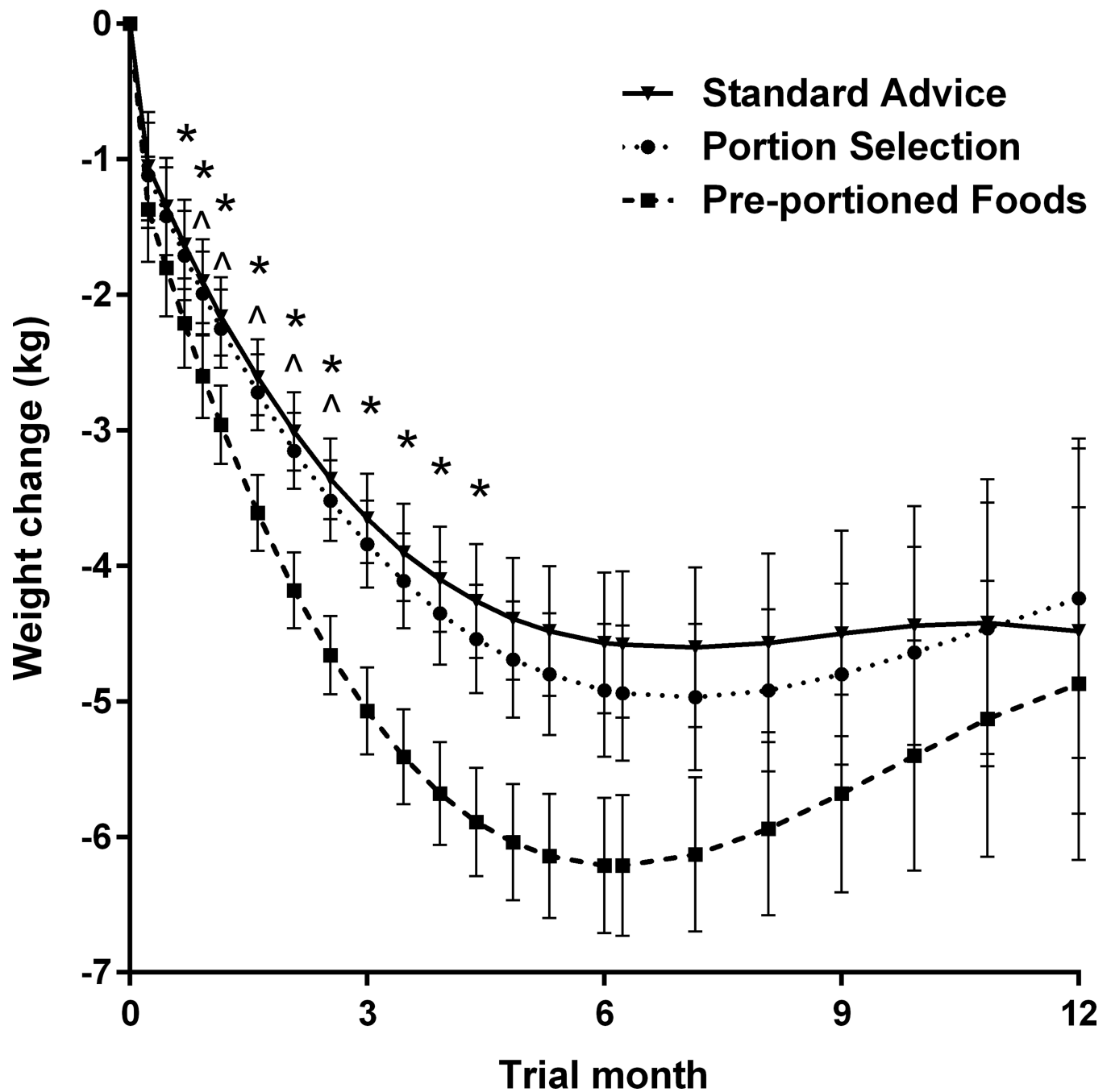


Figure 2. Mean trajectories of weight loss for 186 women in three groups. The curves were modeled from all available data for each subject, regardless of the number of sessions attended (an intention-to-treat analysis). The Pre-portioned Foods Group had a greater rate of weight loss (more negative linear coefficient; $P=0.021$) and a greater rate of regain (more positive quadratic coefficient; $P=0.0005$) than the other two groups. Symbols indicate time points at which weight loss in the Pre-portioned Foods Group differed significantly ($P<0.05$, adjusted for multiple comparisons) from that in the Standard Advice Group (*) and the Portion

Selection Group (^). Error bars represent the standard error of the mean for the modeled data.

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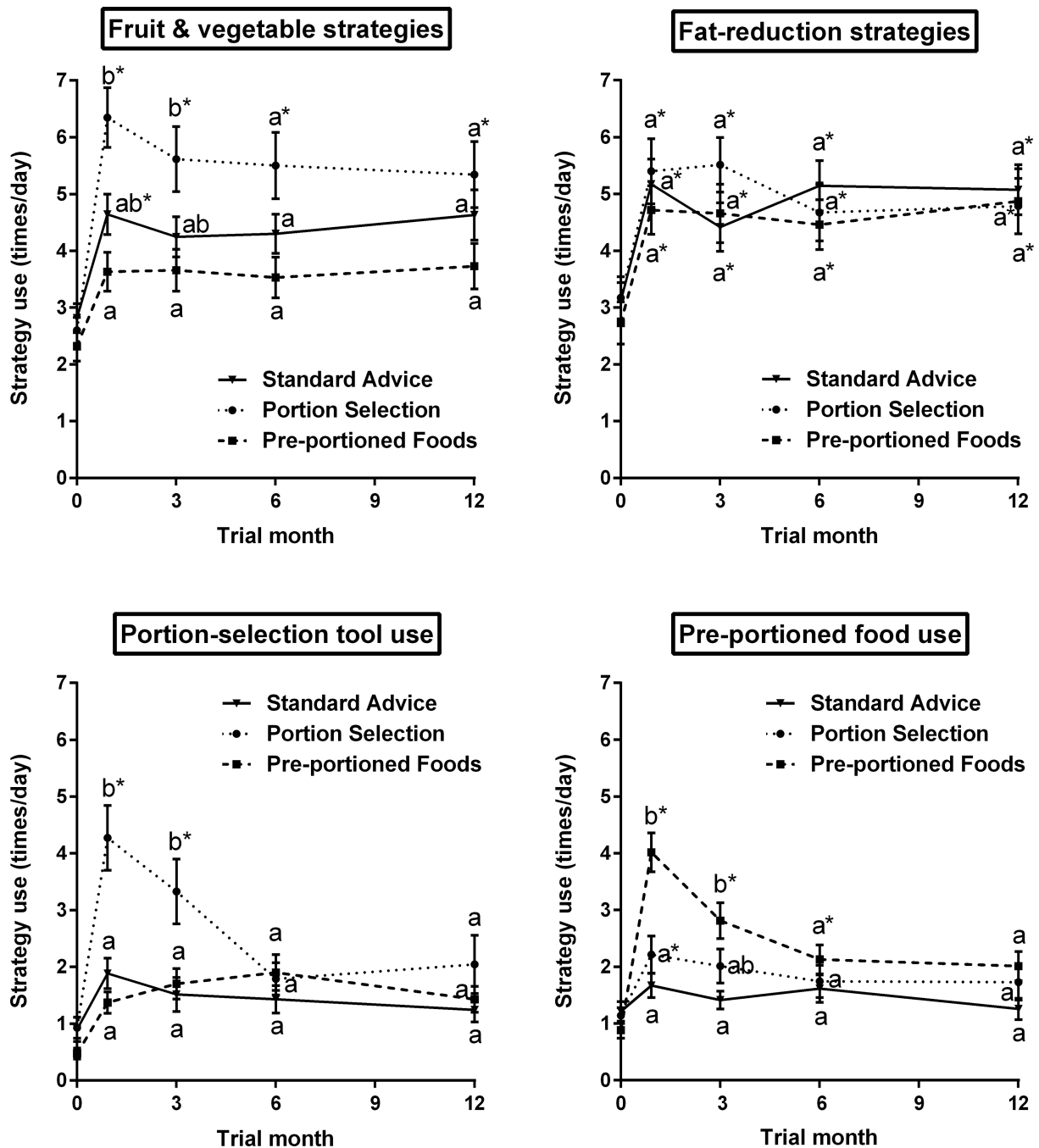


Figure 3. Mean reported daily frequency of use of targeted portion-control strategies by 186 women in three groups. Use of fruit and vegetable strategies and portion-selection tools was taught only to the Portion Selection Group, and use of pre-portioned foods was taught only to the Pre-portioned Foods Group. At a given time point, means with different letters are significantly different from those of other groups ($P < 0.05$, adjusted for multiple comparisons). Within a given group, means with asterisks are significantly different from the

baseline value ($P < 0.03$, adjusted for multiple comparisons). Error bars represent the standard error of the mean.

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Table 1

Baseline characteristics of women in the three groups of The Portion-Control Strategies Trial

Characteristic	Standard Advice (n = 62)	Portion Selection (n = 62)	Pre-portioned Foods (n = 62)	Significance of Group effect (P-value) ^a
Age (y)	49.5 (12.0)	50.4 (9.6)	50.1 (10.1)	0.89
Body weight (kg)	92.1 (12.3)	89.9 (13.8)	91.7 (12.2)	0.59
Body mass index (kg/m ²)	34.1 (4.3)	33.6 (4.2)	34.2 (4.1)	0.68
Pedometer count (steps/d)	6446 (3084)	6531 (3447)	6729 (3253)	0.89
Estimated energy expenditure (kcal/d) ^b	2121 (192)	2082 (218)	2108 (185)	0.54
Weight loss attempts in past year, n	2.3 (2.9)	1.8 (2.0)	2.3 (2.5)	0.49
Menopause status, n (%)				0.66
Pre-menopausal	20 (32%)	22 (35%)	25 (40%)	
Peri- or post-menopausal	42 (68%)	40 (65%)	37 (60%)	
Race, n (%)				0.77
White	62 (100%)	61 (98%)	60 (97%)	
African-American	0 (0%)	1 (2%)	1 (2%)	
More than one race	0 (0%)	0 (0%)	1 (2%)	
Ethnicity, n (%)				0.99
Not Hispanic	61 (98%)	61 (98%)	62 (100%)	
Hispanic	1 (2%)	1 (2%)	0 (0%)	
Education, n (%)				0.40
High school graduate	7 (11%)	8 (13%)	12 (19%)	
Some college education	21 (34%)	16 (26%)	19 (31%)	
College degree	17 (27%)	21 (34%)	19 (31%)	
Professional or graduate degree	17 (27%)	17 (27%)	12 (19%)	
Employment, n (%)				0.24
Employed full-time	42 (68%)	31 (50%)	41 (66%)	
Employed part-time	10 (16%)	14 (23%)	8 (13%)	
Not employed	10 (16%)	17 (27%)	13 (21%)	
Dietary restraint score ^c (range 0–21)	9.3 (3.5)	8.6 (3.6)	8.8 (3.8)	0.60
Disinhibition score ^c (range 0–16)	9.7 (3.1)	9.8 (3.9)	9.8 (3.5)	0.98
Tendency toward hunger score ^c (range 0–14)	6.4 (3.1)	6.7 (3.6)	5.5 (3.3)	0.15

Unless otherwise indicated, values are mean (SD).

^aDifferences across groups were tested by a fixed-effects model for continuous variables and by Fisher's exact test for categorical variables.^bEnergy expenditure was estimated from height, weight, age, sex, and activity level⁴⁰.^cScores from the Eating Inventory³⁸.

Table 2

Cardiometabolic outcomes at assessment time points in 186 women

Outcome measure	Baseline (n = 186)	Month 3 (n = 170)	Month 6 (n = 149)	Month 12 (n = 136)	Significance of Time effect (P-value)
Systolic blood pressure, mm Hg	120.5 (16.7) ^a	118.3 (15.1) ^{ab}	117.1 (14.6) ^b	119.3 (14.1) ^{ab}	0.0061
Diastolic blood pressure, mm Hg	82.1 (11.7) ^a	79.2 (10.0) ^b	78.8 (9.8) ^b	79.8 (9.5) ^{ab}	0.0003
Waist circumference, cm	108.4 (9.8) ^a	105.0 (10.7) ^b	102.4 (10.7) ^c	102.5 (11.2) ^c	<0.0001
Glucose, mmol/l	5.35 (1.02) ^a	5.16 (0.58) ^b	5.12 (0.66) ^b	5.07 (0.65) ^b	0.0015
Insulin, pmol/l	77.0 (51.2) ^a	55.5 (39.4) ^c	60.0 (41.4) ^b	60.4 (41.4) ^b	<0.0001
Insulin resistance, HOMA2	1.45 (0.97) ^a	1.04 (0.74) ^c	1.12 (0.77) ^b	1.13 (0.78) ^b	<0.0001
Total cholesterol, mmol/l	5.28 (0.98) ^a	5.12 (0.92) ^b	5.19 (0.96) ^{ab}	5.36 (0.90) ^a	0.0007
HDL cholesterol, mmol/l	1.37 (0.36) ^a	1.37 (0.31) ^a	1.42 (0.30) ^b	1.51 (0.34) ^c	0.0001
LDL cholesterol, mmol/l	3.22 (0.86) ^a	3.13 (0.82) ^a	3.14 (0.83) ^a	3.20 (0.80) ^a	0.12
Triglycerides, mmol/l	1.50 (0.80) ^a	1.36 (0.62) ^b	1.37 (0.63) ^{ab}	1.41 (0.66) ^{ab}	0.0032

Abbreviation: HOMA2, homeostatic model assessment estimation of insulin resistance from fasting glucose and insulin³⁶. Values are means (SD).

^aWithin each outcome, means marked with different letters are significantly different ($P < 0.05$, adjusted for multiple comparisons using the Tukey-Kramer method). There were no significant differences across groups in these outcomes.

Table 3 Dietary intakes at baseline and Month 3 in the subset of 123 women who were administered 3-day dietary recalls

Intake	Standard advice (n = 44)			Portion selection (n = 38)			Pre-portioned foods (n = 41)			Significance of Time effect of (P-value)
	Baseline	Month 3	Baseline	Month 3	Baseline	Month 3	Baseline	Month 3		
Food weight (g/d)	1102 (425)	984 (321)	998 (290)	1044 (331)	1071 (357)	954 (301)	Group×Time ^a 0.002			
Very low-ED category (g/d)	189 (233)	208 (216)	156 (200)	283 (270)	198 (254)	178 (201)	Group×Time ^b 0.0007			
Low-ED category (g/d)	420 (399)	447 (305)	415 (289)	419 (257)	404 (289)	488 (301)	Time 0.053			
Medium-ED category (g/d)	437 (280)	299 (221)	366 (238)	308 (204)	418 (249)	251 (166)	Time ^c <0.0001			
High-ED category (g/d)	56 (63)	30 (39)	61 (73)	34 (47)	52 (54)	37 (62)	Time ^c <0.0001			
Beverage weight (g/d)	1013 (567)	849 (563)	955 (552)	909 (652)	960 (597)	895 (655)	Time ^c 0.0004			
Food energy (kcal/d)	1798 (639)	1394 (477)	1661 (612)	1402 (499)	1744 (578)	1336 (445)	Time ^c <0.0001			
Beverage energy (kcal/d)	170 (151)	124 (129)	138 (120)	137 (142)	143 (142)	121 (130)	Time ^c 0.004			
Total energy (kcal/d)	1968 (661)	1518 (495)	1799 (635)	1539 (525)	1887 (593)	1458 (487)	Time ^c <0.0001			
Food energy density (kcal/g)	1.73 (0.53)	1.48 (0.43)	1.70 (0.51)	1.40 (0.46)	1.71 (0.49)	1.47 (0.45)	Time ^c <0.0001			
Beverage energy density (kcal/g)	0.18 (0.14)	0.16 (0.15)	0.18 (0.17)	0.17 (0.16)	0.16 (0.15)	0.16 (0.17)	Time 0.51			
Fruit intake (servings/d)	1.45 (1.65)	1.58 (1.57)	1.51 (1.59)	1.87 (1.57)	1.29 (1.46)	1.73 (1.66)	Time ^d 0.0012			
Vegetable intake (servings/d)	3.70 (2.95)	3.66 (2.57)	3.47 (2.07)	3.80 (2.24)	3.71 (2.65)	3.11 (1.94)	Time 0.56			
Grain intake (servings/d)	6.59 (3.38)	5.02 (2.49)	6.10 (3.77)	4.73 (2.89)	6.42 (3.29)	4.79 (2.79)	Time ^c <0.0001			
Protein foods intake (servings/d)	5.47 (3.89)	4.61 (2.74)	5.25 (3.44)	4.79 (2.68)	5.60 (3.73)	4.30 (2.58)	Time ^c 0.0001			

Intake	Standard advice (n = 44)		Portion selection (n = 38)		Pre-portioned foods (n = 41)		Significance of Time effect (P-value)
	Baseline	Month 3	Baseline	Month 3	Baseline	Month 3	
Dairy foods intake (servings/d)	3.11 (2.74)	2.43 (1.92)	3.00 (2.78)	2.49 (2.13)	2.90 (1.95)	2.17 (1.69)	Time ^c <0.0001
Fats and oils intake (servings/d)	2.87 (2.70)	2.38 (2.28)	3.32 (2.78)	2.41 (2.33)	3.39 (3.28)	2.21 (1.91)	Time ^c <0.0001
Sweets intake (servings/d)	1.57 (2.56)	1.16 (1.88)	1.95 (3.09)	2.24 (3.77)	1.98 (2.48)	2.44 (3.12)	Time 0.48
Pre-portioned foods intake (items/d)	1.28 (1.23)	1.43 (1.29)	1.17 (1.22)	1.33 (1.06)	0.99 (1.19)	2.18 (1.42)	Group×Time ^e <0.0001

Abbreviation: ED, energy density. Values are mean (SD). Categories of food energy density are Very low (0.0–0.59kcal/g), Low (0.6–1.49kcal/g), Medium (1.5–3.99kcal/g), and High (4.0–9.0kcal/g).

^aDecrease in Standard Advice and Pre-portioned Foods Groups from baseline to Month 3; no change in Portion Selection Group.

^bNo change in Standard Advice and Pre-portioned Foods Groups from baseline to Month 3; increase in Portion Selection Group.

^cDecrease from baseline to Month 3 in all groups.

^dIncrease from baseline to Month 3 in all groups.

^eIncrease in Pre-portioned Foods Group from baseline to Month 3; no change in Standard Advice and Portion Selection Groups.