



# Comparing the portion size effect in women with and without extended training in portion control: A follow-up to the Portion-Control Strategies Trial

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## ARTICLE INFO

### Article history:

Received 11 October 2017

Received in revised form

8 January 2018

Accepted 8 January 2018

Available online 17 January 2018

### Keywords:

Portion size

Energy density

Portion control

Food intake

Energy intake

Adults

## ABSTRACT

Following a 1-year randomized controlled trial that tested how weight loss was influenced by different targeted strategies for managing food portions, we evaluated whether the effect of portion size on intake in a controlled setting was attenuated in trained participants compared to untrained controls. Subjects were 3 groups of women: 39 participants with overweight and obesity from the Portion-Control Strategies Trial, 34 controls with overweight and obesity, and 29 controls with normal weight. In a crossover design, on 4 different occasions subjects were served a meal consisting of 7 foods that differed in energy density (ED). Across the meals, all foods were varied in portion size (100%, 125%, 150%, or 175% of baseline). The results showed that serving larger portions increased the weight and energy of food consumed at the meal ( $P < .0001$ ), and this effect did not differ across groups. Increasing portions by 75% increased food intake by a mean ( $\pm$ SEM) of  $111 \pm 10$  g (27%) and increased energy intake by  $126 \pm 14$  kcal (25%). Across all meals, however, trained participants had lower energy intake ( $506 \pm 15$  vs.  $601 \pm 12$  kcal,  $P = .006$ ) and lower meal ED ( $1.09 \pm 0.02$  vs.  $1.27 \pm 0.02$  kcal/g;  $P = .003$ ) than controls, whose intake did not differ by weight status. The lower energy intake of trained participants was attributable to consuming meals with a greater proportion of lower-ED foods than controls. These results further demonstrate the robust nature of the portion size effect and reinforce that reducing meal ED is an effective way to moderate energy intake in the presence of large portions.

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## 1. Introduction

Serving larger portions leads individuals to consume more food, and this response results in substantial increases in energy intake across different types of people, foods, and settings (Hollands et al., 2015; Rolls, 2014; Steenhuis & Vermeer, 2009; Zlatevska, Dubelaar, & Holden, 2014). Given the prevalence of large portions of energy-dense foods (Nielsen & Popkin, 2003; Rolls, 2003; Young & Nestle, 2012), which contribute to overconsumption of energy (Kral & Rolls, 2004), strategies are needed to moderate the effect of portion size on intake. One method that is recommended is training in portion control, for example through use of portion-control tools or instruction on appropriate food portions (National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK), 2016;

Centers for Disease Control (CDC), 2006; Centers for Disease Control (CDC), 2016; National Heart, Lung, and Blood Institute (NHLBI), 2015; Ello-Martin, Ledikwe, & Rolls, 2005; Vermeer, Steenhuis, & Poelman, 2014). Although educational interventions can increase the accuracy of portion size estimation (Small, Lane, Vaughan, Melnyk, & McBurnett, 2013), such training in the short-term has not been shown to influence intake (Cavanagh, Vartanian, Herman, & Polivy, 2014). Furthermore, the effect of prolonged portion-control training on intake from large portions has not been systematically evaluated. To address this, we compared the response to portion size in trained individuals (who had been taught to manage food portions as part of a weight loss trial) to the response in individuals without such training. The portion size effect was assessed by measuring food intake from a meal in which all foods were systematically varied in portion size. Thus, the purpose of this study was to determine whether individuals with extended training in portion-control strategies were less responsive to the portion size effect than those without training.

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The Portion-Control Strategies Trial provided a unique population in which to test the influence of training on the portion size effect. In this 1-year randomized controlled trial, women with overweight and obesity received instruction in one of three different targeted strategies for managing food portions. Although the various interventions differed in the content and intensity of instruction in portion control, the total duration of training was equivalent and all strategies were successful in promoting weight loss (Rolls, Roe, James, & Sanchez, 2017). After the trial, we aimed to determine whether the response to portion size under controlled conditions differed between trained subjects and untrained controls of differing weight status. We were also interested in the strategies that trained individuals might adopt in order to moderate energy intake when offered large portions, in comparison to control subjects. At a meal comprised of multiple foods, individuals trained in portion control might limit the amounts of all foods consumed, or instead, make differential adjustments in intake of individual foods according to their perceived healthfulness or energy density (ED) (Rolls, 2014).

The current study used a crossover design to test differences between subject groups in the amounts and types of food consumed in response to increasing portions, with the goal of assessing whether energy intake differed by training or weight status. Previous research showed that the effect of portion size on intake can be comprehensively evaluated by serving a meal of multiple foods that are simultaneously varied across four or more portion sizes. This paradigm allows choices among foods that differ in ED and facilitates assessment of the influence of subject characteristics (e.g. body size, eating behaviors) and food properties (e.g. healthfulness, palatability) on the response to portion size (Roe, Kling, & Rolls, 2016). We hypothesized that the effect of portion size on the weight and energy content of food consumed would be attenuated in participants who were trained in portion control, compared to untrained controls. Additionally, portion size has been implicated as contributing to the obesity epidemic (Rolls, 2003; Young & Nestle, 2012), but there is limited experimental evidence demonstrating a relationship between the portion size effect and weight status. Thus, we also tested the hypothesis that the effect of portion size on intake differed between the untrained controls with overweight and obesity and the controls with normal weight.

## 2. Subjects and methods

### 2.1. Study design

In a crossover design, women from different subject groups came to the laboratory to eat lunch once a week for 4 weeks. Across the 4 meals the same menu was served, but the portions of all foods were simultaneously varied (100%, 125%, 150%, or 175% of baseline amounts). At all meals, weighed intake of each food was determined. The order of presenting the portion size conditions was counterbalanced across subjects using Latin squares, and subjects were randomly assigned a sequence. The study was conducted at the Laboratory for the Study of Human Ingestive Behavior at the University Park campus of The Pennsylvania State University, and all procedures were approved by the Office for Research Protections. Subjects were told that the purpose of the study was to investigate eating behavior. Subjects provided signed informed consent and were financially compensated for their participation.

### 2.2. Subjects

One group of subjects was recruited from among women who had completed the Portion-Control Strategies Trial. In that 1-year

trial, 186 women with overweight and obesity were randomly assigned to receive training in three different strategies to promote weight loss: using pre-portioned foods to structure meals, using measuring tools to select food portions based on ED, or following standard advice to eat less while selecting nutritious foods. Participants in all interventions had frequent individual contact with trained interventionists, received instruction on meal planning and healthful choices within food groups, and were advised to increase physical activity (Rolls et al., 2017). For enrollment in the trial, women were required to be aged 20–65 y with a body mass index (BMI) of 28–45 kg/m<sup>2</sup> and were excluded if they showed evidence of disordered eating (scored >19 on the Eating Attitudes Test (Garner, Olsted, Bohr, & Garfinkel, 1982)) or depression (scored >25 on the Beck Depression Inventory (Beck, Steer, & Brown, 1996)). Recruitment for the current study took place after the trial was completed; it was presented as a separate study unrelated to the trial and was conducted in a different location with different staff. A subset of trial completers from all three intervention groups who were willing to participate in this study were enrolled. The trial participants, hereafter referred to as trained participants, who enrolled in the current study had lost a mean of 5.3 ± 0.9% of their body weight during the trial, comparable to the 6% weight loss in all trial participants (Rolls et al., 2017), but all of them still had overweight or obesity (Table 1).

The control population for the current study consisted of women who had not participated in the weight-loss trial and were recruited through advertisements posted on campus, in the local community, and online. Controls were eligible for the study if they were aged 20–65 y, had a BMI of 19–45 kg/m<sup>2</sup>, and did not show evidence of disordered eating (scored >19 on the Eating Attitudes Test (Garner et al., 1982)) or depression (scored >40 on the Self-Rating Depression Scale (Zung, 1986)). We included control subjects with normal weight as well as those with overweight and obesity in order to assess the effect of weight status on intake in response to increasing food portions. Potential participants were excluded if they had food allergies, restrictions, or dislike for the study foods; did not regularly eat 3 meals per day; were dieting to gain or lose weight; or were smokers, athletes in training, pregnant, or breastfeeding.

The sample size for the experiment was based on data from a related study conducted in the laboratory (Roe et al., 2016). A power analysis was conducted to determine the sample size needed to detect a 40% reduction in the slope of the portion size trajectory in trained participants compared to controls with >80% power at a significance level of 0.05. The analysis showed that it would require 40 trained participants and 60 controls (with normal weight and with overweight and obesity) to detect this difference. A total of 105 subjects were enrolled in the study, but 3 subjects failed to attend all scheduled meals. Thus, 102 subjects completed the study: 39 trained participants and 63 controls. Among the trained participants, 12 were from the pre-portioned foods intervention, 16 from the portion selection intervention, and 11 from the standard advice intervention. Among the controls, 34 had overweight or obesity and 29 had normal weight.

Prior to the first meal, subjects completed the Eating Inventory (Stunkard & Messick, 1985), which consists of 51 items about eating behavior that assess dietary restraint, disinhibition, and tendency towards hunger. Subject energy requirements were estimated from age, sex, height, weight, and activity level (Institute of Medicine and Food and Nutrition Board, 2002).

### 2.3. Test meal

The test meal consisted of 7 commercially available foods that were chosen to represent typical meal components and that

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