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Do calorie-controlled portion sizes of snacks reduce energy intake?

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Abstract

In a cross-over study, participants (n=59) were randomly assigned to receive either 100 kcal packs or standard size packages of snacks for 1-week. After a minimum of a 1-week washout period, participants received the other form of the snack for 1 week. Snack consumption was recorded by participants in a diary. Participants consumed an average of 186.9 fewer grams of snacks per week when receiving 100 kcal snack packs compared to standard size packages of snacks. Post-hoc comparisons revealed the effect of package size depended on both randomization order and study week. Total grams of snacks consumed in week 1 differed significantly between the two randomized groups. In week 2, however, grams of snacks did not differ significantly between the two groups. This interaction was primarily due to a significantly lower consumption of snacks from standard size packages in the week following the portion-controlled packages. The results suggest that portion-controlled packaging reduce total intake from the provided snacks. Further, initial exposure to portion-controlled packages might have increased awareness of portion size such that less was consumed when larger packages were available.

Keywords

Portion size control; snacks; packaging; food intake

Introduction

The rise in obesity throughout the world is a result of energy intake which, over time, exceeds energy expenditure (Hill, Wyatt, & Melanson, 2000). Thus, strategies to reduce the global burden of obesity can focus both on reducing energy intake and increasing physical activity. Ecological/environmental views of obesity suggest that increases in food intake may be caused in part by environmental factors such as increased energy density of the food supply and portion size (French, Story, & Jeffrey, 2001). The portion size of food consumed has been consistently shown to influence total energy intake (Devitt & Mattes, 2004; Ello-Martin, Ledikwe, & Rolls, 2005; Fisher, Arreola, Birch, & Rolls, 2007; Ledikwe, Ello-Martin, & Rolls, 2005). Extensive research both in laboratory studies and free-living conditions has shown that when a larger

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amount of food is presented, a greater amount is consumed (Levitsky & Youn, 2004; Rolls, Roe, & Meengs, 2006a). People tend to eat more food when more is offered independent of age, gender, length of exposure or weight status (Levitsky & Youn, 2004; Rolls, Roe, & Meengs, 2006a; Rolls, Roe, & Meengs, 2007). Reduced portion size on the other hand appears to decrease energy intake (Rolls, Roe, & Meengs, 2006b).

The influence of snacking and eating frequency on body weight is controversial (Drummond, Crombie, & Kirk, 1996; Bellisle, 2004; Louis-Sylvestre, Lluch, Neant, & Blundell, 2003). Some studies suggest that frequent eating is associated with lower body weight and better diet quality (Whybrow & Kirk, 1997; Kirk, & Cursiter, 1999; Kerver et al., 2006). Other studies, however, have found an inverse relationship between eating frequency and body weight (Drummond, Crombie, Cursiter, & Kirk, 1998; Yannakoulia, Melistas, Somomou, & Yiannakouris, 2007). Body weight is clearly influenced by the amount and composition of food eaten in relationship to the amount of physical activity performed (Louis-Sylvestre, Lluch, Neant, & Blundell, 2003). The influence of snacking on total energy intake and energy balance is, at present, unclear.

The size of food packaging has steadily increased over the past 30 years (Young & Nestle, 2002; Wansink, 2004) and could be an important factor contributing to higher energy intake and increased rates of overweight and obesity. Research suggests that the size of a package can increase consumption independent of the type of packaging or even the quality of food (Rolls et al., 2004; Wansink, 1996; Wansink, van Ittersim, & Painter, 2006). The food industry has responded to this issue by introducing single serving packaged portions of many different foods, particularly snack foods. The 100-calorie packs of snack foods have gained popularity with consumers and are now available from many food companies. However, there is limited research on the impact of these on energy intake.

Rolls et al. (2004) found that ad libitum consumption of potato chips increased as snack package size increased. Raynor and Wing (2007) found that the amount of food consumed increased with amount provided, but found no effect of package unit size on total energy intake. The aim of the study was to determine whether or not the portion controlled packages of snack foods result in less consumption as compared to larger packages when the amount of food provided was held constant.

Methods

Participants were men and women between the ages of 18 and 65 years recruited through an email distributed through the University of Colorado Denver to participate in a study investigating the differences in snack foods and food packaging on eating behavior in adults. Interested participants contacted recruitment staff via email or by phone. Eligibility criteria included a Body Mass Index (BMI) between 23–40 kg/m², being a frequent snacker (2+ snacks per day), living in a 1–2 person household (to reduce the likelihood of other individuals eating the provided food), currently taking no weight loss medications, no history of binge eating, being non-diabetic and not pregnant or breastfeeding. Based on previous research, people in Western societies tend to eat around 2.5 snacks per day (Whybrow & Kirk, 1997; Bellisle, et al., 2003; Kant & Graubard, 2006)

A total of 63 participants enrolled in the study, but 3 participants did not return after the first 7-day period and one participant recorded both periods inaccurately. Therefore, 59 participants, 41 women and 18 men, completed the study. All participants provided written consent, and the study protocol was reviewed and approved by the Colorado Multiple Institutional Review Board. Participants received \$20.00 in compensation for time and travel expenses.

Study Procedures

After completion of a screening questionnaire, participants eligible for the study were invited to a 45-minute information session at the research facility. During this session informed consent was obtained, height and weight were measured, and participants were asked to fill out a) the binge-eating questionnaire (BES)(Gormally, Black, Daston, & Radin, 1982), b) a demographic questionnaire including age, ethnicity, gender, marital status, education, and to c) indicate the three brands of snack foods they would like to take home for consumption. Participants' weights were assessed by use of an electric scale, and heights were assessed with a stadiometer, using standard procedures. BMI was calculated as weight in kilograms divided by height in meters². Height and weight were measured only at the first visit for eligibility assurance.

In addition, the participants were trained in using the 7-day snacking diary. Participants were asked to record each snack occasion including the brand and amount of snack chosen, the consumption location, the time of day, whether the television was on or off, and the presence of other people. During the 100kcal snack package week, participants were asked to simply record the number of 100kcal pouches they were eating on each eating occasion. During the standard size package unit week, participants were provided with a digital food scale (Escali, MN, USA) and were asked to measure each food bag before and after consumption. Furthermore, participants were instructed to maintain their regular eating habits even if this would lead to days when no snacks were consumed to reflect real life conditions as accurate as possible. Participants were encouraged to eat the provided snacks but additional snacks such as fruits or vegetables, etc. were not prohibited but were to be recorded in the snacking diary if consumed. They were also instructed to not share their snacks with anyone else during the study period. The researchers clarified the study's definition of a snack as a light, small meal in-between meals using various explanatory examples.

At the second visit, participants were asked to return the snacking diary and the same food brands chosen during the first visit were provided in the other packaging size. Participants were asked not to eat any snack foods out of the previously provided boxes during the second week of recording. Depending on the snack order, the digital food scale was included in the box of snack foods. The same instructions about consumption and sharing were given. After recording their snacks again for 7 days, participants returned one last time to the research facility. The last visit was simply used to compensate the participants and to collect the snacking diaries and the digital scale where appropriate. For both visits, participants were asked to record the amount of snacks remaining after each week. For the 100kcal packages, they were asked to count the number of pouches left. For the standard size packages, participants were asked to count the remaining unopened snack bags and to return those bags that were opened. The opened bags were weighed by the research personnel. These measures were used to assess the reliability of the snacking diaries. The correlation between weights taken by the research personnel and intake derived from the food diaries was high (0.88 for standard size packages and 0.80 for 100kcal packages).

Experimental Design

To examine the effect of package size on amount of snack food consumed, a randomized two-period cross-over design was used by assigning unit size (standard size packages vs. 100kcal packages) in random order for two 7-day study periods. Participants were given a box of food containing three different snacks brands chosen out of ten different available snacks (Cool Ranch Doritos, Baked Cheetos, Harvest Cheddar Sunchips, Goldfish, Baked Ritz Chips, Snyder's Pretzels, Cheese Nips, Multigrain Wheat Thins, Cinnamon Teddy Grahams, Lorna Doone shortbread cookies). Participants were asked to take the box home and to consume as much and whenever they would like over a 7-day period. After the 7-day consumption period and a minimum of a one-week washout period, participants were asked to return to the research

facility to receive the same amount of their chosen snack foods provided in the other size of packaging. The 100kcal snack package units ranged from 19.2g to 26g per package whereas the standard size package units ranged from 187g to 368.5g. On average, 4 packages of regular snacks and the according number of 100kcal snack packages were provided to ensure enough snacks so that the participants did not feel like they could run out of snacks during the 7-day period. All foods were provided to participants in food manufacturer's original packaging.

Statistical Analysis

The total grams of the provided snack foods consumed was determined by either adding up the consumed 100kcal snack packages or by subtracting pre- and post consumption weight of standard size packages both recorded in snacking diaries. Energy per grams of the snack foods was determined from manufacturer information.

Repeated measures mixed models (SAS version 9.1 MIXED Procedure) were used to analyze the data with package size, study week, and the package size $\times$ study week interaction as fixed factors. Package size was used as the repeated factor with an unstructured covariance to allow for a different variance for standard size versus 100kcal packages. Restricted maximum likelihood estimation was used and the Satterthwaite method was used to calculate degrees of freedom. Estimate statements were used to calculate the overall effect of package size as well as perform post-hoc tests for the package size $\times$ randomization order interaction, package size $\times$ week interaction, as well as the difference between standard size and 100kcal package both within randomization group and by week. We examined grams of snack food consumed as the outcome.

Results

We included 59 participants in the analysis. Twenty seven participants were randomized to receive standard size packages during the first study week, and 32 participants were randomized to receive 100 kcal snack packs during the first study week. There were no significant differences between the two randomized groups in terms of age, gender, BMI, BES, or race, as shown in Table 1. The brands of snacks chosen by the two groups (snack types chosen prior to randomization) did not differ. The consumption of additional snacks such as fruits and vegetables also did not differ between the two groups. Both groups had approximately two additional snacks during the 7-day period. The study results reported below were similar when data from the laboratory weighing was used in place of the information acquired from the snacking diaries.

Differences in consumption of snacks

Participants consumed an average of 186.9 fewer grams of snacks per week when receiving 100kcal snack packs compared to standard size packages of snacks, 95% confidence interval (CI): -258.9 to -114.9 g, $p < 0.0001$. Post-hoc comparisons revealed the effect of package size depended on both randomization order, $p = 0.046$, and study week, $p = 0.058$. Total grams of snacks consumed in week 1 differed significantly between the two randomized groups with almost half the amount of grams of snacks (302.5g) consumed when provided with the 100kcal snack packs compared to standard size packages, 675.7 ± 61.5 g vs. 373.3 ± 35.6 g, 95% CI: -443.9 to -161.1 g, $p < 0.0001$. In week 2, however, grams of snacks did not differ significantly between the two groups with a difference of only 71.4g, 415.3 ± 38.8 g vs. 486.7 ± 56.5 g, 95% CI: -207.6 to -64.8 g, $p = 0.300$. This interaction was primarily due to a significantly lower consumption of snacks from standard size packages in week 2 compared to week 1, 373.3 ± 35.6 g vs. 486.7 ± 56.5 g, CI: -210.9 to -16.1 g, $p = 0.023$. Specifically, participants receiving standard size packages of snacks during week 2 (who had previously consumed 100kcal snack packs) consumed an average of only 486.7g of snacks from the standard size packages,

compared to the 675.7g of snacks consumed by the other randomization group when they received the standard size packages in week 1. Additionally, participants who received the standard size packages during week 1 ate significantly less when switching to the 100kcal snack packs with a difference of 260.4g, 675.5 ± 61.5 g vs. 415.3 ± 38.8 g, 95% CI: -366.4 to -154.4 , $p < 0.0001$. There was no significant difference between the two randomization groups in the amounts consumed from the 100kcal snack packs, 373.3 ± 35.6 g vs. 415.3 ± 38.8 g, $p = 0.428$. Similar results were found when caloric energy was used as outcome variable.

Figure 1 shows the grams of snacks consumed per week by package size and study week.

Discussion

These results suggest that people do eat significantly less snack foods when provided with portion-controlled 100kcal snack packs than when provided larger, regular sizes packages. However, we found that the order and week in which the packages were received also played a role in energy consumption. Receiving the 100kcal snack packs first seemed to reduce the amount eaten from standard size packages later, suggesting that the portion-controlled packages may increase awareness of portion size that lasted when the larger packages were available.

The overall impact of portion control in this study was 186.9g per week (840.7kcal/week), which would be equivalent to about 120 kcal/day. This is an amount of energy intake reduction that has been suggested to be effective in preventing the gradual weight gain that is occurring in much of the population (Hill, Wyatt, Reed, & Peters, 2003). Further, this difference was observed under semi-naturalistic conditions when participants were eating in their usual environment.

Potentially even more important, it appears that having one week of 100 calorie packages might help make participants aware of portion sizes and might lead to lower energy intake even without portion controlled packaging. Participants receiving the 100 kcal snack packs first ate only 113.5g more of the standard sized snacks during the second week whereas those participants receiving the standard size packages first ate 260.4g less when receiving the snack packs. Over a week, this would be a difference of 1146.9g, which translates into 673.5 kcal/week and averages to about 100 calories per day. Training on accurately estimating food quantity seems to be promising (Yugas, Bolland, & Bolland, 1989; Ayala, 2005). A study on teaching people about portion control by using portion control plates appears to promote weight loss (Pedersen, Kang, & Kline, 2007). These results are consistent with Raynor and Wing's statement (2007) that unit size may assist in accuracy of consumption monitoring and therefore might be important for those people who are actively monitoring their intake. It is possible that portion controlled foods can initially help with intake amounts and weight management until the person has learned to regulate and limit her/his own portions accordingly.

One possible limiting factor in this study could have been a habituation effect. Although a washout period of at least one week was in place it could be that participants ate less of the product in the second week because they got used to the offered snack products and this could explain part of the package size $\times$ order interaction. However, the magnitude of the effect observed between the groups in week 1 and the additional interaction between package size and week appears to contradict the possibility that habituation explains all of the observed effect. A second limitation is that the study did not collect information on the amount of food consumed during mealtimes. Thus, there is no way of knowing whether participants may have eaten larger meals to compensate for eating fewer calories when receiving the 100kcal snack packs. Certainly, longer and more comprehensive studies would be indicated.

Ecological models (Eggers & Swinburn, 1997; Lake & Townshend, 2006) would suggest that energy intake is influenced by many factors within the environment. These results are consistent with the notion that the size of food available is one environmental factor that can impact energy intake and that interventions aimed at changing environmental factors could be effective in changing behavior. Purchasing portion-controlled snacks, while more expensive than purchasing in bulk, could become a routing for many individuals and families and could help in lowering total energy intake. This could be one important strategy, particularly in those who are regular snackers, for controlling food intake.

In summary, these results suggest that the introduction of portion-controlled 100 kcal portions of snack foods may have had a positive impact on reducing energy intake of the population. There are indications that obesity rates in some adults (Ogden, Carroll, McDowell, & Flegal, 2007) and in children and adolescents (Ogden, Carroll, & Flegal, 2008) may have stabilized (or are at least increasing more slowly than before). It is possible that environmental changes such as portion-controlled packages could have made a contribution to these findings. Following Cohen and Farley's concept of eating behavior as an automatic behavior, shaping the food environment by reducing portion size might be one potentially successful approach to fight today's obesity epidemic (Cohen & Farley, 2008).

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References

- Ayala GX. An experimental evaluation of a group- versus computer-based intervention to improve food portion size estimation skills. *Health Education Research* 2005;21:133–145. [PubMed: 16100228]
- Bellisle F. Impact of the daily meal pattern on energy balance. *Scandinavian Journal of Nutrition* 2004;48:114–118.
- Bellisle F, Dalix AM, Mennen L, Galan P, Hercberg S, de Castro JM, et al. Contribution of snacks and meals in the diet of French adults: a diet-diary study. *Physiology & Behavior* 2003;79:183–189. [PubMed: 12834789]
- Cohen DA, Farley TA. Eating as an automatic behavior. *Preventing Chronic Disease* 2008;5:1–7.
- Devitt AA, Mattes RD. Effects of food unit size and energy density on intake in humans. *Appetite* 2004;42:213–220. [PubMed: 15010185]
- Drummond SE, Crombie NE, Kirk T. A critique of the effects of snacking on body weight status. *European Journal of Clinical Nutrition* 1996;50:779–783. [PubMed: 8968697]
- Drummond SE, Crombie NE, Cursiter MC, Kirk TR. Evidence that eating frequency is inversely related to body weight status in male, but not female, non-obese adults reporting valid dietary intakes. *International Journal of Obesity and Related Metabolic Disorders* 1998;22:105–112.
- Egger G, Swinburn B. An 'ecological' approach to the obesity pandemic. *BMJ* 1997;315:477–480. [PubMed: 9284671]
- Ello-Martin JA, Ledikwe JH, Rolls BJ. The influence of food portion size and energy density on energy intake: implications for weight management. *American Journal of Clinical Nutrition* 2005;82(suppl): 236–241.
- Fisher JO, Arreola A, Birch LL, Rolls BJ. Portion size effects on daily energy intake in low-income Hispanic and African American children and their mothers. *American Journal of Clinical Nutrition* 2007;86:1709–1716. [PubMed: 18065590]
- French SA, Story M, Jeffery R. Environmental influences on eating and physical activity. *Annual Review of Public Health* 2001;22:309–335.
- Gormally J, Black S, Daston S, Rardin D. The assessment of binge eating severity among obese persons. *Addictive Behavior* 1982;7:47–55.

- Hill JO, Wyatt HR, Melanson EL. Genetic and environmental contributions to obesity. *Medical Clinics of North America* 2000;84:333–346. [PubMed: 10793645]
- Hill JO, Wyatt HR, Reed GW, Peters JC. Obesity and the environment: where do we go from here? *Science* 2003;299:853–855. [PubMed: 12574618]
- Kant AK, Graubard BI. Secular trends in patterns of self-reported food consumption of adult Americans: NHANES 1971–1975 to NHANES 1999–2002. *American Journal of Clinical Nutrition* 2006;84:1215–23. [PubMed: 17093177]
- Kerver JM, Yang EJ, Obayashi S, Bianchi L, Song WO. Meal and snack patterns are associated with dietary intake of energy and nutrients in US adults. *Journal of the American Dietetic Association* 2006;106:46–53. [PubMed: 16390666]
- Kirk TR, Cursiter MC. Long-term snacking intervention did not lead to weight gain in free-living man. *Scandinavian Journal of Nutrition* 1999;2 (Suppl 34):3–17.
- Lake A, Townshend T. Obesogenic environments: exploring the built and food environments. *Journal of the Royal Society of Health* 2006;126:262–267.
- Ledikwe JH, Ello-Martin JA, Rolls BJ. Portion size and the obesity epidemic. *Journal of Nutrition* 2005;135:905–909. [PubMed: 15795457]
- Levitsky DA, Youn T. The more food young adults are served, the more they overeat. *Journal of Nutrition* 2004;134:2546–2549. [PubMed: 15465745]
- Louis-Sylvestre J, Lluch A, Neant F, Blundell JE. Highlighting the positive impact of increasing feeding frequency on metabolism and weight management. *Forum Nutrition* 2003;56:126–128.
- Ogden CL, Carroll MD, McDowell MA, Flegal KM. Obesity among adults in the United States – No statistically significant change since 2003–2004. *NCHS Data Brief* 2007;1:1–6. [PubMed: 19389313]
- Ogden CL, Carroll MD, Flegal KM. High body mass index for age among US children and adolescents, 2003–2006. *Journal of the American Medical Association* 2008;299:2391–400. [PubMed: 18505948]
- Raynor HA, Wing RR. Package unit size and amount of food: Do both influence intake? *Obesity* 2007;15:2311–2319. [PubMed: 17890500]
- Rolls BJ, Roe LS, Kral TVE, Meengs JS, Wall DE. Increasing the portion size of a packaged snack increases energy intake in men and women. *Appetite* 2004;42:63–69. [PubMed: 15036784]
- Rolls BJ, Roe LS, Meengs JS. Larger portion sizes lead to a sustained increase in energy intake over 2 days. *Journal of the American Dietetic Association* 2006a;76:1207–1213.
- Rolls BJ, Roe LS, Meengs JS. Reductions in portion size and energy density of foods are additive and lead to sustained decreases in energy intake. *American Journal of Clinical Nutrition* 2006b;83:11–17. [PubMed: 16400043]
- Rolls BJ, Roe LS, Meengs JS. The effect of large portion sizes on energy intake is sustained for 11 days. *Obesity* 2007;15:1535–1543. [PubMed: 17557991]
- Wansink B. Can package size accelerate usage volume? *Journal of Marketing* 1996;60:1–14.
- Wansink B. Environmental factors that increase the food intake and consumption volume of unknowing consumers. *Annual Review of Nutrition* 2004;24:455–479.
- Wansink B, van Ittersum K, Painter JE. Ice cream illusions bowls, spoons, and self-served portion sizes. *American Journal of Preventive Medicine* 2006;31:240–243. [PubMed: 16905035]
- Whybrow S, Kirk TR. Nutrient intakes and snacking frequency in female students. *Journal of Human Nutrition and Dietetics* 1997;10:237–244.
- Yannakoulia M, Melistas L, Somomou E, Yiannakouris N. Association of eating frequency with body fatness in pre- and postmenopausal women. *Obesity* 2007;15:100–106. [PubMed: 17228037]
- Young LR, Nestle M. The contribution of expanding portion sizes to the US obesity epidemic. *American Journal of Public Health* 2002;92:246–249. [PubMed: 11818300]
- Yuhas JA, Bolland JE, Bolland TW. The impact of training, food type, gender and container size on the estimation of food portion sizes. *Journal of the American Dietetic Association* 1989;89:1473–1477. [PubMed: 2794306]

Fig. 1.

Grams of snacks (g) consumed per week by package size and study week. Repeated measures mixed models showed a significant difference by package size during week 1 ($p < 0.0001$), but not for week 2 ($p = 0.30$)

Table 1

Baseline characteristics, by randomization order.

	Week 1 Randomization		Total Sample (n = 59)
	Standard Size Packages first (n = 27)	100 Kcal Snack Packs first (n = 32)	
Age	38.7 ± 13.2	36.1 ± 11.0	37.3 ± 12.0
Gender (% Male)	25.9 %	34.4 %	30.5 %
BMI	28.0 ± 4.0	27.4 ± 3.8	27.7 ± 3.9
BES	13.1 ± 8.1	12.6 ± 7.2	12.8 ± 7.6
Race/Ethnicity			
Caucasian	74.1 %	75.0 %	74.6 %
African American	14.8 %	15.6 %	15.3 %
Asian	0.0 %	6.3 %	3.4 %
Other	7.4 %	3.1 %	5.1 %
Missing	3.7 %	0.0 %	1.7 %
Ethnicity			
Non-Hispanic Whites	85.2 %	90.6 %	88.1 %
Hispanic Whites	11.1 %	9.4 %	10.2 %
Missing	3.7 %	0.0 %	1.7 %