HHS Public Access

Author manuscript

Appetite. Author manuscript; available in PMC 2016 May 01.

Published in final edited form as:

Appetite. 2015 May ; 88: 33–38. doi:10.1016/j.appet.2014.12.001.

Environmental Strategies for Portion Control in Children

Thomas N. Robinson, MD, MPH and **Donna M. Matheson, PhD**

Solutions Science Lab, Division of General Pediatrics, Department of Pediatrics and Stanford Prevention Research Center, Department of Medicine, Stanford University School of Medicine, 1265 Welch Road, MSOB X129, Stanford, CA 94305

Abstract

Evidence from laboratory and field studies indicates that large portions lead to greater food and energy intake relative to small portions. However, most children and adults demonstrate limited abilities to estimate and control the amounts of food they serve and consume. Five potential environmental strategies appear promising for improving portion control in children: (1) using tall, thin, and small volume glasses and mugs, (2) using smaller diameter and volume plates, bowls and serving utensils, (3) using plates with rims, (4) reducing total television and other screen watching and (5) reducing or eliminating eating while watching television and/or other screens. Further experimental research in real world settings is needed to test these interventions as strategies for portion control and their roles in prevention and treatment of obesity.

Keywords

Portion size; eating; children; dishes; bowls; glasses; television

Introduction

Since the 1960's behavioral interventions to change eating behavior have primarily focused on exerting cognitive control over food choices and amounts of consumption – intentionally and consciously eating less of some foods and more of others, or a different mix of macronutrients and/or energy. This has been particularly true for weight control interventions (Dietz & Robinson, 2005; Epstein, Myers, Raynor, & Saelens, 1998; Epstein, Valoski, Wing, & McCurley, 1990, 1994; Stuart, 1967; Summerbell et al., 2003). These interventions are thought to succeed through planned, cognitively driven, intentional behaviors including self-monitoring, goal setting, rewarding successful behavior change, cognitive reframing, problem solving, and parenting skills (Dietz & Robinson, 2005). Because children and adolescents display less self-control and future orientation than adults (Green, Fry, & Myerson, 1994), these approaches may be more difficult for children and

Corresponding author: Thomas N. Robinson, tom.robinson@stanford.edu, Phone: 650-723-5331.

adolescents than for adults. Relatively less attention, however, has been paid to environmental factors influencing what and how much is eaten without conscious awareness. Recently, researchers have started to identify environmental factors that may act as external cues to influence intake without requiring conscious, cognitive control (Thaler & Sunstein, 2008; Wansink, 2004) -- what has been called “mindless eating” (Wansink, 2006). These external cues may result from social, physical, or policy factors that influence the environments that accompany eating. Evidence is mounting that small changes in the eating environment may alter food choices and reduce food and energy consumption, without cognitive awareness. Some evidence suggests this may be an effective strategy for helping children control the amounts of food, beverages and energy they consume.

In a review of the extant literature, at least five promising environmental strategies emerge to improve portion control in children: (1) using tall, thin, and small volume glasses and mugs, (2) using smaller diameter and volume plates, bowls and serving utensils, (3) using plates with rims, (4) reducing total television and other screen watching and (5) reducing or eliminating eating while watching television and/or other screens. Although the focus of this review is on strategies for portion control in children, findings from studies in adults are also included where relevant and where data from children are more limited.

Portion Sizes and Intakes

The first three of these strategies depend on the assumption that portion sizes and/or perceived portion sizes influence food consumption. Substantial evidence has accumulated to support this contention. Ecologically, the obesity epidemic has accompanied concurrent increases in portion sizes. (Nielsen & Popkin, 2003; Young & Nestle, 2002) Substantial increases have occurred both in restaurant and fast food portions and among foods consumed in the home (Nielsen & Popkin, 2003), suggesting an opportunity for parents to control children’s portions in the home setting. However, these epidemiological studies cannot demonstrate a causal role of portion size in promoting increased intake or obesity.

To test causality, a number of research groups have performed experimental studies of the effects manipulating portion sizes on intake. A growing number of these studies demonstrate that adults and children consume more food and total energy when served large portions relative to small portions (Rolls, 2003; Small, Lane, Vaughan, Melnyk, & McBurnett, 2013). For example, a series of experimental studies by Wansink, et al have found that doubling the size of a package increased consumption by about 18% to 25% for meal-related foods and about 30% to 45% or more for a number of snack-related foods (Wansink, 1996). In one study with a 2×2 design, adult moviegoers were randomly assigned to receive either a free medium (120 grams) or large (240 grams) container of popcorn that was either fresh or stale (14 days old). Among those who received the fresh popcorn, those who received the large container ate 45% more than those who received the medium container. Similarly, although those who received the stale popcorn generally reported that it didn’t taste good, those who received the large container still ate an average of 34% more than those who received the medium container (Wansink & Kim, 2005). In another set of closely-controlled experimental laboratory studies, Rolls and colleagues found similar effects of portion size on intake. In one study, 51 adults were served lunch one day per week for four weeks with 4

different portions of a macaroni and cheese entrée. The participants consumed 30% more energy when given the largest portion compared to the smallest portion (Rolls, Morris, & Roe, 2002). In a subsequent study of 13 college students, serving portions 100%, 125% and 150% of the amount they served themselves from a buffet of the same foods the week before also resulted in progressively greater increases in intake in all 4 of the foods included in the meal (Levitsky & Youn, 2004). Subsequent studies demonstrated these effects are sustained over the short- to medium-term, without compensation during subsequent meals or days. For example, in a randomized crossover study among 32 adults, serving 150% standard portions of all foods and beverages at main meals for two consecutive days increased daily energy intake by 16% compared to standard portions, and doubling the portions served increased daily energy intake by 26%, with these effects persisting over the entire 2 days (Rolls, Roe, & Meengs, 2006). In a longer study with 23 adults, participants were randomized to standard portion sizes or 150% standard portion sizes supplied for all meals over two 11-day periods separated by a 2-week gap. Intakes during the period of 150% portion sizes were greater during all meals, resulting in greater average intakes of 423 kilocalories per day that persisted over the entire 11 days (Rolls, Roe, & Meengs, 2007). Of particular relevance to the problems of weight gain and obesity, these studies found that participants did not compensate for the increased portions by reducing their intakes at other meals during the same day or on subsequent days. This demonstrates the durability of these portion size effects and the potential to accumulate substantially greater excess energy intake over time.

Although fewer studies have been conducted among children than with adults, the findings are similar to those among adults. Research to date suggests that the emergence of the influence of portion size on consumption occurs during the toddler and preschool years and is observable at least through mid-childhood. In an early study of the effects of portion sizes at a single meal, a small sample of 3–6 year old children were served small, medium or large portions of an entrée at three different lunches. In response, the five year olds but not the 3 year olds consumed progressively more food if they were served a larger entrée portion (Rolls, Engell, & Birch, 2000). In another study, however, 2–5 year olds were served two times the age-appropriate portion of an entrée at one lunch per week for four consecutive weeks. On the large portion days, the children consumed an average of 25% more of their entrées and 15% more total energy than on the regular portion days (Fisher, Rolls, & Birch, 2003). Interestingly, their greater intakes were associated with larger average bite sizes of the entrée and occurred without compensatory lower intakes of other foods at the same meal. In a further study of 5–6 year olds performed by the same research group, the effects of larger portion sizes on greater intakes were also found to be independent of the energy density of the food (Fisher, Liu, Birch, & Rolls, 2007). Longer-term studies in children are not available but, like adults, children do not appear to compensate for the greater intake from larger portions relative to smaller portions by lessening their intake of other foods during the same meal or throughout the rest of a day. In a sample of low-income, Hispanic and African-American preschool children and their mothers, doubling portions of entrées at breakfast, lunch, afternoon snack and dinner on a single day, resulted in average 23% greater energy intakes from the entrees and 12% greater total energy intakes for the children, and 21% and 6% greater intakes among the mothers, respectively (Fisher, Arreola, Birch, & Rolls, 2007). These effects of large portions also appear to be consistent through the mid-

childhood years. When a similar study design was applied to a broader age ranged sample of 2–9 year olds, they responded by consuming more of their larger entrées and more total energy, with no significant differences by age (Fisher, 2007). Similar data are sparse among older children and adolescents but the consistency of these findings among both young children and adults suggests that similar results would be expected. However, longer-term studies and additional studies in other age groups are still warranted to confirm the durability of these effects over longer periods of timing and across all age groups.

If larger portion sizes lead to greater consumption, why can't we just tell people to serve themselves and/or eat smaller portions? Unfortunately, both children and adults also perform poorly when estimating the amount of food they serve themselves and consume (Thompson & Byers, 1994; Wansink, 2004). One of our own studies of portion size estimation in preadolescent girls is an example (Matheson, Hanson, McDonald, & Robinson, 2002). Eight to twelve year old African American girls (n=54) were served a weighed test meal of spaghetti, salad, bread and a drink. They ate as much as they wanted, including additional helpings, and plate waste was measured to assess actual consumption. Immediately after completing their meals dietitians collected food recall interviews from the girls, using two types of portion size measurement aids, manipulative props and 2-D food portion visuals. The dietitians and order of the measurement aids were randomly assigned and there were no statistically significant dietitian or order effects. Percent errors and standard deviations for the absolute value differences between actual and estimated total grams and total energy of food consumed were calculated. The mean ± standard deviation errors in girls' reports were 58% ± 103% for total grams of food and 68% ± 109% for total energy consumed when using the manipulative props, and 33% ± 73% for total grams of food and 54% ± 96% for total energy consumed when using the 2-D food portion visuals. The differences between the two methods were not statistically significant. For individual foods and drinks the average absolute value errors varied from 48% ± 90% for the beverage to 222% ± 524% for the bread. In addition to such large average errors, the large standard deviations of the differences demonstrated the large variations in errors among the girls. In a different study of adults estimating the energy they consumed in a fast food meal and the energy in 15 different sizes of the same fast food meal, overestimates and underestimates worsened as the meal portion size increased (Wansink & Chandon, 2006). This inaccuracy was independent of body weight. Therefore, larger portion sizes may be making it even more difficult to accurately estimate and control how much one serves and consumes.

Although evidence in children is lacking, research to date suggests that adults do not overcome the effects of large portions through awareness, knowledge or education. Even being taught about the bias created by packaging and portion sizes on intake does not protect one from its effects. In one study, graduate students received 90 minutes of lecture, demonstrations and discussion about the effects of packaging and serving size on consumption and methods to overcome it (Wansink & Cheney, 2005). At a social gathering six months later they were systematically randomized to one of two rooms with snacks in either two large serving bowls or four small serving bowls, with the same total amount displayed. All students received the same size plates and scoops to serve themselves but students serving themselves from the large bowls took an average of 53% more and

consumed and average of 56% more than students who took their portions from the smaller bowls (Wansink & Cheney, 2005).

Three main explanations have been suggested for greater consumption from larger portion sizes. All three rely on portion sizes as visual cues for consumption. One is the “clean your plate” effect where children are expected to eat all food served to them (Birch, McPhee, Shoba, Steinberg, & Krehbiel, 1987). Another is that packaging and portion sizes shift our consumption norms and expectations – large sized packages, larger plates and glasses, and larger servings all change our perceptions of what is considered a normal portion (Wansink & van Ittersum, 2007). Third, larger portions may lead to greater underestimation of the amount of energy consumed (Wansink & Chandon, 2006). There is evidence that visual environmental cues can provide one way of signaling appropriate portion size. People tend to use visual clues as cognitive shortcuts and/or visual illusions that trigger decisions of how much to serve and when to stop eating (Van Ittersum & Wansink, 2007). In one creative experiment to test this process, Wansink et al served adults tomato soup in bowls that were slowly refilled as they ate, through tubes that were concealed underneath the table. Participants who ate from the “bottomless bowls” consumed 73% more soup than those eating from normal bowls but, when asked, reported eating the same amount with the same level of satiety (Wansink, Painter, & North, 2005). It turns out that some of our mothers were correct when they told us as children, “you are eating with your eyes instead of your stomach.”

The findings above suggest that large portions provide visual cues that can exert an important effect on intake that is beyond most cognitive awareness and control for both children and adults. The bulk of the research in this area is convincing that large portions increase consumption. People are susceptible to large portion sizes and have much difficulty accurately estimating how much they consume. Therefore, the challenge is to identify strategies to help individuals overcome these limitations to help them serve and consume smaller portions. Some of the studies of large portions reviewed above provide some useful clues. Just as people eat more of large portions without compensating with reduced energy intake of other foods or meals, it might be possible to manipulate visual cues to promote less consumption without eaters being aware that they are consuming less or compensating with greater intakes at other times.

Using tall, thin, lower volume glasses and mugs

Sugary drinks are frequently highlighted as one of the key targets of obesity prevention and treatment. Energy derived from Liquids, particularly those from carbohydrates, result in excess energy intakes because the body does not compensate for them with subsequent decreases in intake as much as it does for solid foods (DiMeglio & Mattes, 2000; Maurao, Bressan, Campbell, & Mattes, 2007). One well-known visual illusion is the conservation of volume. In the 1960’s, Piaget and others showed that children perceived tall thin containers as holding more than short wide containers of the same volume (Piaget, Inhelder, & Szeminska, 1960). This powerful illusion holds for adults and children when estimating volumes, and has been demonstrated for glasses, bottles and cans containing liquids (Van Ittersum & Wansink, 2007). As a result, manipulating the shapes of beverage containers can

produce substantial differences in consumption. In one study at a weight loss camp for adolescents, for example, 12–17 year old campers poured and drank 74% more kilocalories of juice and soft drinks when they poured into short wide glasses than when they poured into tall narrow glasses with the same total volume, even though after estimating they drank significantly smaller amounts from the short wide glasses (Wansink & van Ittersum, 2003). This illusion also appears to be resistant to practice and attention. Even college students practicing pouring and bartenders with an average of six years of experience poured about 20% more into short wide glasses than tall thin glasses (Wansink & van Ittersum, 2005). These studies suggest that replacing short wide glasses and cups with taller and thinner glasses and cups has the potential to help control portions and total intakes of beverages.

There are few available data on the sizes of glassware that children are typically using in their homes and the potential to reduce their volumes. In a small pilot study with five families with 8–12 year old obese children participating in a six-month behavioral weight control program, we asked children and parents to pour their usual portions of a typical drink into their existing glasses. We then replaced their glasses with smaller volume, tall thin glasses. Six weeks later, we again asked them to pour their usual portions of a drink into the smaller, tall thin glasses they were now using. The volume differences between their poured drink portions decreased by about 20% among parents and more than 25% among children. In a larger subsequent study of replacing existing glasses and mugs with lower volume, tall thin drinking glasses and mugs among families with 8–12 year old obese children participating in a six-month behavioral weight control program, the new glasses (10.5 ounces [about 311 milliliters] or less with external height 2 or more times the internal diameter) were found to hold an average of more than 30% less volume than their original glasses and the new mugs (8.5 ounces [about 251 milliliters] or less with external height 2 or more times the internal diameter) were found to hold an average of more than 40% less than their original mugs (unpublished data). Thus, we have found that substantial reductions in drinking glass volumes are possible providing a potential opportunity to exploit this visual illusion to reduce liquid calorie intake. Thus, longer-term experimental studies in natural are needed to test whether replacing short wide glasses and cups with taller and thinner glasses and cups will reduce intakes of high-energy beverages and total energy intake.

Using smaller diameter and volume plates, bowls and serving utensils

The surface areas of typical household dinner plates have increased by more than a third since the 1960’s (Wansink, 2006). As noted in the studies of portion size and intake above, larger serving containers result in increased intakes. Estimates of portion sizes of food appear to depend on the relative difference between the size of the food portion and the size of the plate or bowl upon which the food is served. Overestimates of the amount of food consumed occur if it covers more of the surface area of the plate or bowl, and underestimates occur when it covers less of the plate’s or bowl’s surface area (Van Ittersum & Wansink, 2007). In a recent study (DiSantis et al., 2013), 42 first graders served themselves amorphous (pasta with meat sauce) or unit (chicken nuggets) entrees, onto child-size (7.25 inch or 18.4 centimeter diameter) or adult-size (10.25 inch or about 26.0 centimeter diameter) plates along with side dishes of apple sauce and mixed vegetables with butter onto child-size (8 ounce or about 237 milliliter) and adult-size (16 ounce or about)

bowls, representing 100% increases in surface area and volume, respectively. The children served themselves an average of about 90 kilocalories more for lunch when using the adult-size plates and bowls than with the child-size plates and bowls(DiSantis et al., 2013). The effects of plate and bowl sizes were greater among children from food insecure households but did not differ by BMI z-score or gender. However, total energy consumption did not differ between child and adult plate and bowl sizes. In two other studies in all-you-can-eat cafeterias, overweight children and normal weight adults served themselves more cereal into larger 34 ounce (about 1 litre) bowls than smaller 17 ounce (about 500 millilitre) bowls. Furthermore, when asked to estimate their portions, they underestimated the amounts they served themselves in the larger bowls and overestimated the amounts served into and consumed from the smaller bowls (Van Ittersum & Wansink, 2007). In another study, 85 members of the faculty, graduate students and staff of a university department of food science and nutritional science, arguably nutrition experts, were randomly given either larger or smaller bowls and either larger or smaller serving scoops to serve themselves ice cream at a social gathering. Those given larger bowls served themselves 31% more than those given the smaller bowls, without perceiving larger servings, and those given larger scoops served themselves 15% more. The combination of a large bowl and a large scoop led to 57% larger portions than the small bowl and small scoop (Wansink, van Ittersum, & Painter, 2006). These results demonstrate that people will serve themselves and consume less without being aware of it when eating from smaller plates and bowls and using smaller serving utensils. Therefore, using smaller diameter plates and smaller bowls and using smaller serving utensils is another promising strategy for portion control.

In our small pilot study with five families with 8–12 year old obese children participating in a six-month behavioral weight control program, we also asked children and parents in their homes to serve their usual portions of meat (formed from modeling clay) and mixed vegetables onto their own existing plates, and cereal, soup, and yogurt into their existing bowls. We then replaced their existing plates and bowls with smaller ones. Six weeks later, we again asked them to serve their usual portions onto and into the new plates and bowls. Among children, the quantity differences between their self-served usual portions decreased by about 5% for simulated meat, 12% for vegetables, 36% for cereal, 22% for soup and 31% for yogurt. Among adults, the quantity differences between their self-served usual portions decreased by about 34% for simulated meat, 12% for vegetables, 32% for cereal, 30% for soup and 6% for yogurt. In addition, at the end of the six weeks neither children nor parents reported any increases in taking second or third helpings, or feeling hungry after meals. In our subsequent larger study with families with obese children participating in a weight control program, we also replaced families' existing dishware with smaller plates (9-inches or less diameter) and bowls (12-ounces or less volume and 6-inches or less diameter). The new plates were found to be an average of more than 20% smaller in surface area and the new bowls were found to hold almost 50% less volume than their original plates and bowls (unpublished data). Thus, we found that substantial reductions in plate and bowl sizes volumes are possible and present a potential opportunity to help control portion sizes.

An obvious question is whether children and their families will simply increase their intakes because they know they are using smaller glasses, plates, bowls and servings utensils. However, assuming the cognitive processes for over- and under-estimating portion sizes are

the same, the studies reported above from graduate students previously taught about the effects of larger serving portions (Wansink & Cheney, 2005), college students with practice pouring drinks and experienced bartenders (Wansink & van Ittersum, 2005), and nutrition experts serving themselves ice cream (Wansink et al., 2006), suggest that these effects are resistant to knowledge, education and training. Consumers fail to acknowledge that their own estimates may be susceptible to these biases even when informed that larger packaging leads to underestimates of intakes.

It should be noted, however, that not all studies have found the expected effects of plate size on intake. In a series of three laboratory-based cross-over studies with adults, Rolls, et al found no significant effect of plate size on differences in a single meal total intake when adult participants (1) served themselves a macaroni and cheese main course for lunch onto small (6.75 inch diameter), medium (8.5 inch diameter) and large (10.25 inch diameter) plates, (2) were served a fixed quantity of a macaroni and cheese main course for lunch on a medium plate (with a regular spoon) and a large plate (with a 50% larger soup spoon), and (3) served themselves onto small, medium and large plates for lunch from a personal buffet of five different foods matched in energy density (Rolls, Roe, Halverson, & Meengs, 2007). In the third experiment the participants made more trips to the buffet with the small plate than with the medium or large plate. In yet another study, 57 pairs of female college students also did not serve themselves or consume more pasta from large plates versus small plates when eating together, except when serving themselves from a common serving bowl (Koh & Pliner, 2009). It is unclear whether these results differ from other related studies because of the laboratory setting, eating alone in a cubicle, the foods served, eating in pairs, etc., but the results suggest that additional intervention studies with small plates and bowls are needed in natural, non-laboratory settings and over time to test the effectiveness of reducing plate and bowl size for long-term portion control and potential effects on weight.

Using plates with rims

Most studies of plate size focus on plate diameters and/or surface areas. However, other plate design characteristics may also impact perceptions of portion sizes and therefore serving size and intake. The Delboeuf illusion is a well-known visual illusion that may be relevant to plate design. In the Delboeuf illusion, a circle appears larger when circumscribed by a slightly larger circle and smaller when circumscribed by a much larger circle (Delboeuf, 1865). The effect is also enhanced with increased color contrast between the concentric circles (Weintraub & Cooper, 1972). This led us to conduct two experiments to examine the effects of plate rim widths and coloring on perceived portion sizes (McClain et al., 2014). In both experiments, adult participants were shown a series of side-by-side photographic images of the same sized plates with varying rim widths and/or rim colors and varying amounts of the same amorphous food, either macaroni and cheese or fruit salad, and asked to select the plate with more food. By varying both the plate design characteristics and the food sizes it was possible to estimate when the food sizes appeared equal and thus, the magnitudes of the illusion on perceived portion sizes. Both rim width and rim coloring produced statistically significant effects on perceived portion sizes. Participants perceived the visual area of a food portion to be about 10% greater on plates with a wide rim (three-eighths or one-half the radius) compared to a very thin rim (one-eighth the radius) or no rim.

When color was added to the rim for contrast, either solid color or a line outlining the inner rim or inner and outer rim, the perceived visual area of food portions were exaggerated by about 3% compared to an uncolored rim (McClain et al., 2014). These findings suggest that plates with wider rims, particularly those with coloring to highlight the rim, exaggerate perceptions of food amounts and may therefore be an additional strategy for controlling food portions. Experimental studies are needed to test the effects of these plate designs on actual portion and energy intakes in both laboratory and field settings.

Reducing total television and other screen watching and reducing or eliminating eating while watching television and/or other screens

Like plate, bowl and glass size, television and other screen media are yet other environmental factors in children's lives that influence eating behavior, energy intake and weight. In fact, the evidence now suggests that television and other screen watching may be one of the most modifiable causes of obesity in children (Robinson, 1998, 2001). American children spend an average of about one-third of their waking hours during childhood in front of a television set (Robinson, 2001). Epidemiological studies find positive associations between television and other screen time and childhood obesity (Robinson, 2001). In addition, a number of experimental studies have demonstrated that reducing screen time, as part of interventions to increase physical activity and improve diet, can promote weight loss in obese children (Epstein, Paluch, Gordy, & Dorn, 2000; Epstein et al., 1995), and reduce the prevalence of obesity among middle school girls (Gortmaker et al., 1999). A randomized controlled school-based study of reducing television viewing specifically tested the exclusive effects of an intervention to reduce screen time for obesity prevention and established a causal relationship (Robinson, 1999). The intervention significantly decreased children's screen time, and decreasedBMI, triceps skinfold, waist circumference and waist-to-hip ratio, compared to controls. In a subsequent two-year study of screen time reduction, 4–7 year old children with BMI ≥ 75th percentile for age and sex were randomized to an intervention to reduce their screen time by 50%, using an electronic television time manager, or to an assessments only control group (Epstein et al., 2008). Children in the screen time reduction group significantly reduced their screen time and age- and sex-adjusted BMI (BMI-Z) compared to controls, over the entire 2-year period.

One of the potential mechanisms linking television and other screen time with obesity is increased dietary energy intake during viewing (Robinson, 2001). In epidemiological studies with multiple samples, Matheson et al found that elementary school children consume an average of about 17%-27% of their total daily weekday energy and 26%-32% of their total daily weekend energy while watching television (Matheson, Killen, Wang, Varady, & Robinson, 2004; Matheson, Wang, et al., 2004). In our school-based trial of reducing screen time and reduced weight gain, the intervention group significantly reduced meals eaten while watching TV (Robinson, 1999). In the two-year study of reducing screen time among 4–7 year olds, the intervention group significantly decreased their energy intake, compared with the monitoring only control group, and the change in television viewing was related to the change in energy intake but not to the change in physical activity (Epstein et al., 2008).

These findings suggest that the effects of television and screen time on childhood obesity may be primarily mediated through effects on eating behavior.

Food advertising is another environmental factor linking screen time with eating. Substantial epidemiological and experimental evidence indicate that exposure to television food advertising influences children's food preferences (Borzekowski & Robinson, 2001; Institute of Medicine Committee on Food Marketing and the Diets of Children and Youth, 2006; Robinson, Borzekowski, Matheson, & Kraemer, 2007). Another factor linking screen time with eating is the effect of television and other screen time as an environmental distraction. Distraction is thought to increase eating during television and other screen viewing through two different mechanisms: (1) triggering eating independent of hunger through the habitual association between television watching and eating, (2) extending the duration of eating (e.g., eating until the show ends rather than until full) or increasing the amount of intake by obscuring self-monitoring of eating and awareness of satiety cues (Wansink, 2004). Distraction from watching television may interfere with habituation to gustatory and olfactory cues which are important to developing satiety, slow the rate of habituation, and lead to additional eating after habituation occurs (Epstein, Paluch, Smith, & Sayette, 1997; Epstein, Rodefer, Wisniewski, & Caggiula, 1992; Temple, Giacomelli, Kent, Roemmich, & Epstein, 2007). In one experiment, 9–12 year old children watching television with ad lib access to a favorite snack food spent more time eating and consumed more grams and energy of food compared to children spending the same amount of time without watching television or watching repeated 1.5 minute segments of the same television show, to control for the audiovisual stimulation but requiring less attention (i.e., less distraction) (Temple et al., 2007). In another laboratory study (Hetherington, Anderson, Norton, & Newson, 2006), 37 adults consumed an average of about 14% more energy from a buffet lunch on a tray with a variety and abundance of foods while eating alone watching a game show on television than while eating alone without television (mean difference of about 490 kilojoules). A non-significant trend towards selecting more sweet high fat food while watching television was also observed. There also is evidence that eating may be more susceptible to distraction among obese than normal weight persons (Rodin, 1974). The sum of this research suggests reducing television viewing and other screen time can reduce total dietary intake through several different potential mechanisms. In particular, reducing or eliminating the exposure to advertising and distraction from eating while watching television and/or other screens should be considered another promising strategy for controlling excessive portions and intake. This may be accomplished by limiting or eliminating access to screens as a part of children's eating environments. As the screen media environment continues to evolve, particularly with mobile screen technologies available children, additional long-term experimental studies are needed to test the effects of interventions to reduce total screen time and eating while watching screens on energy intake and weight changes at all ages among children and adolescents.

Summary

Substantial evidence indicates that larger portions lead to increased food intake. Laboratory studies and some field studies have shown that both adults and children will serve themselves and eat more in response to larger amounts of food. As a result,

recommendations to control portion sizes have become standard components of both public health and clinical communications promoting weight control and weight loss. One strategy to control portions is to teach participants standard portion sizes and then expect them to exert conscious control over serving sizes and intake. However, children and adults display a poor ability to estimate amounts of food they serve and consume. Furthermore, the research to date suggests the effects of large portions cannot be overcome through awareness, knowledge or education. Contextual factors, such as television or other screen watching, have also been demonstrated to influence intake and contribute to weight gain. As an alternative, evidence is mounting for environmental strategies that may be effective for helping children and adults control the amounts of food and beverages they consume. The consistency of results across both laboratory and field studies, with their complementary strengths and weaknesses, lends further credibility to these approaches. In a review of the extant literature, five potential environmental strategies emerge that appear most promising for improving portion control in children: (1) using tall, thin, and small volume glasses and mugs, (2) using smaller diameter and volume plates, bowls and serving utensils, (3) using plates with rims, (4) reducing total television and other screen watching and (5) reducing or eliminating eating while watching television and/or other screens. Further experimental research is needed to test these interventions in real world settings as strategies for long-term portion control and prevention and treatment of obesity.

Acknowledgments

This work was supported in part by award numbers R01HL096015 and U01HL103629 from the National Heart, Lung, and Blood Institute, National Institutes of Health and the Children's Health Research Institute at Stanford University. The sponsors were not involved in this manuscript and the content is solely the responsibility of the authors and does not represent the official views of the National Heart, Lung, and Blood Institute, the National Institutes of Health or Stanford University.

References

Birch LL, McPhee L, Shoba BC, Steinberg L, Krehbiel R. Clean up your plate: effects of child feeding pracices on the conditioning of meal size. Learning and Motivation. 1987; 18:301–317.

Borzekowski DLG, Robinson TN. The 30-second effect: An experiment revealing the impact of television commercials on food preferences of preschoolers. Journal of the American Dietetic Association. 2001; 101:42–46. [PubMed: 11209583]

Delboeuf F. Note Sur Certaines Illusions d'Optique:Essai d'une Theorie Psychophysique de la Maniere don't l'Oeil Apprecie les Distances et les Angles [Note on Certain Optical illusions: Essay on a Psychophysical Theory Concerning the Way in Which the Eye Evaluates Distances and Angles]. Bulletins de l'Académie Royale des Sciences, Lettres et Beaux-arts de Belgique. 1865; 19:195–216.

Dietz WH, Robinson TN. Overweight Children and Adolescents. New England Journal of Medicine. 2005; 352:2100–2109. [PubMed: 15901863]

DiMeglio D, Mattes R. Liquid versus solid carbohydrate: effects on food intake and body weight. International Journal of Obesity and Related Metabolic Disorders. 2000; 24:794–800. [PubMed: 10878689]

DiSantis KI, Birch LL, Davey A, Serrano EL, Zhang J, Bruton Y, Fisher JO. Plate size and children's appetite: Effects of larger dishware on self-served portions and intake. Pediatrics. 2013; 131:e1451–e1458. [PubMed: 23569096]

Epstein LH, Myers MD, Raynor HA, Saelens BE. Treatment of pediatric obesity. Pediatrics. 1998; 101:554–570. [PubMed: 12224662]

Epstein LH, Paluch R, Smith JD, Sayette M. Allocation of attentional resources during habituation to food cues. Psychophysiology. 1997; 34:59–64. [PubMed: 9009809]

Epstein LH, Paluch RA, Gordy CC, Dorn J. Decreasing sedentary behaviors in treating pediatric obesity. Archives of Pediatrics and Adolescent Medicine. 2000; 154:220–226. [PubMed: 10710017]

Epstein LH, Rodefer JS, Wisniewski L, Caggiula AR. Habituation and dishabituation of human salivary response. Physiology and Behavior. 1992; 51:945–950. [PubMed: 1615055]

Epstein LH, Roemmich JN, Robinson JL, Paluch RA, Winiewicz DD, Fuerch JH, Robinson TN. A randomized trial of the effects of reducing television viewing and computer use on body mass index in young children. Archives of Pediatrics and Adolescent Medicine. 2008; 162:239–245. [PubMed: 18316661]

Epstein LH, Valoski A, Wing RR, McCurley J. Ten-year follow-up of behavioral, family-based treatment for obese children. JAMA. 1990; 264(19):2519–2523. [PubMed: 2232019]

Epstein LH, Valoski A, Wing RR, McCurley J. Ten-year outcomes of behavioral family-based treatment for childhood obesity. Health Psychology. 1994; 13:373–383. [PubMed: 7805631]

Epstein LH, Valoski AM, Vara LS, McCurley J, Wisniewski L, Kalarchian MA, Shrager LR. Effects of decreasing sedentary behavior and increasing activity on weight change in obese children. Health Psychology. 1995; 14:109–115. [PubMed: 7789345]

Fisher JO. Effects of age on children's intake of large and self-selected food portions. Obesity. 2007; 15:403–412. [PubMed: 17299114]

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; 86:1700–1716. [PubMed: 18065589]

Fisher JO, Liu Y, Birch LL, Rolls BJ. Effects of portion size and energy density on young children's intake at a meal. American Journal of Clinical Nutrition. 2007; 86:174–179. [PubMed: 17616778]

Fisher JO, Rolls BJ, Birch LL. Children's bite size and intake of an entree are greater with large protions than with age-appropriate or self-selected portions. American Journal of Clinical Nutrition. 2003; 77:1164–1170. [PubMed: 12716667]

Gortmaker SL, Peterson K, Wiecha J, Sobol AM, Dixit S, Fox MK, Laird N. Reducing obesity via a school-based interdisciplinary intervention among youth: Planet Health. Archives of Pediatrics and Adolescent Medicine. 1999; 153:409–418. [PubMed: 10201726]

Green L, Fry A, Myerson J. Discounting of delayed rewards: a life-span comparison. Psychological Science. 1994; 5(1):33–36.

Hetherington MM, Anderson AS, Norton GNM, Newson L. Situational effects on meal intake: A comparison of eating alone and eating with others. Physiology and Behavior. 2006; 88:498–505. [PubMed: 16757007]

Institute of Medicine Committee on Food Marketing and the Diets of Children and Youth. Food Marketing to Children and Youth: Threat or Opportunity?. Washington, DC: The National Academies Press; 2006.

Koh J, Pliner P. The effets of degree of acquaintance, plate size, and sharing on food intake. Appetite. 2009; 52:595–602. [PubMed: 19501755]

Levitsky DA, Youn T. The more food young adults are served, the more they overeat. Journal of Nutrition. 2004; 134:2546–2549. [PubMed: 15465745]

Matheson DM, Hanson KA, McDonald TE, Robinson TN. Validity of children's food portion estimates: A comparison of 2 measurement aids. Archives of Pediatrics and Adolescent Medicine. 2002; 156:867–871. [PubMed: 12197792]

Matheson DM, Killen JD, Wang Y, Varady A, Robinson TN. Children's food consumption while watching television. American Journal of Clinical Nutrition. 2004; 79:1088–1094. [PubMed: 15159240]

Matheson DM, Wang Y, Klesges LM, Beech BM, Kraemer HC, Robinson TN. African-American girls' dietary intake while watching television. Obesity Research. 2004; 12:32S–37S. [PubMed: 15489465]

Maurao D, Bressan J, Campbell W, Mattes R. Effects of food form on appetite and energy intake in lean and obese young adults. International Journal of Obesity and Related Metabolic Disorders. 2007; 31:1688–1695.

McClain A, van den Bos W, Matheson D, Desai M, McClure SM, Robinson TN. Visual illusions and plate design: the efffects of plate rim widths and rim coloring on perceived food portion size. International Journal of Obesity and Related Metabolic Disorders. 2014; 38:657–662.

Nielsen SJ, Popkin BM. Patterns and trends in food portion sizes, 1977–1998. JAMA. 2003; 289:450–453. [PubMed: 12533124]

Piaget, J.; Inhelder, B.; Szeminska, A. The Chiild's Conception of Geometry. New York: Harper Torchbooks; 1960.

Robinson TN. Does television cause childhood obesity? JAMA. 1998; 279:959–960. [PubMed: 9544774]

Robinson TN. Reducing children's television viewing to prevent obesity. JAMA. 1999; 282:1561–1567. [PubMed: 10546696]

Robinson TN. Television viewing and childhood obesity. Pediatric Clinics of North America. 2001; 48(4):1017–1025. [PubMed: 11494635]

Robinson TN, Borzekowski DLG, Matheson DM, Kraemer HC. Effects of fast food branding on young children's taste preferences. Archives of Pediatrics and Adolescent Medicine. 2007; 161:792–797. [PubMed: 17679662]

Rodin, J. Effects of distraction on the performance of obese and normal subjects. In: Schachter, S.; Rodin, J., editors. Obese Humans and Rats. Potomac, MD: Erlbaum; 1974. p. 97-107.

Rolls BJ. The supersizing of American: Portion size and the obesity epidemic. Nutrition Today. 2003; 38:42–53. [PubMed: 12698053]

Rolls BJ, Engell D, Birch LL. Serving portion size influences 5-year-old but not 3-year-old children's food intakes. Journal of the American Dietetic Association. 2000; 100:232–234. [PubMed: 10670398]

Rolls BJ, Morris EL, Roe LS. Portion size of food affects energy intake in normal-weight and overweight men and women. American Journal of Clinical Nutrition. 2002; 76(6):1207–1213. [PubMed: 12450884]

Rolls BJ, Roe LS, Halverson KH, Meengs JS. Using a smaller plate did not reduce energy intake at meals. Appetite. 2007; 49:652–660. [PubMed: 17540474]

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. 2006; 106:543–549. [PubMed: 16567150]

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]

Small L, Lane H, Vaughan L, Melnyk B, McBurnett D. A systematic review of the evidence: The effects of portion size manipulation with children and portion education/training interventions on dietary intake with adults. Worldviews on Evidence-Based Nursing. 2013; 10:69–81. [PubMed: 22703240]

Stuart RB. Behavioral control of overeating. Behaviour Research and Therapy. 1967; 5:357–365.

Summerbell CD, Ashton V, Campbell KJ, Edmunds L, Kelly S, Waters E. Interventions for treating obesity in children. Cochrane Database Syst Rev. 2003; 3:Art. No. CD001872. 001810.001002/14651858.CD14001872.

Temple JL, Giacomelli AM, Kent KM, Roemmich J, Epstein LH. Television watching increases motivated responding for food and energy intake in children. American Journal of Clinical Nutrition. 2007; 85:355–361. [PubMed: 17284729]

Thaler, RH.; Sunstein, CR. Nudge: Improving Decisions About Health, Wealth, and Happiness. New Haven, Connecticut: Yale University Press; 2008.

Thompson FE, Byers T. Dietary assessment resource manual. Journal of Nutrition. 1994; 124:2245s–2317s. [PubMed: 7965210]

Van Ittersum K, Wansink B. Do children really prefer large portions? Visual illusions bias their estimates and intake. Journal of the American Dietetic Association. 2007; 107:1107–1110. [PubMed: 17604739]

Wansink B. Can package size accelerage 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. Mindless Eating: Why We Eat More Than We Think. New York: Bantam Dell; 2006.

Wansink B, Chandon P. Meal size, not body size, explains errors in estimating calorie content of meals. Annals of Internal Medicine. 2006; 145:326–332. [PubMed: 16954358]

Wansink B, Cheney MM. Super bowls: Serving bowls size and food consumption [Research Letter]. JAMA. 2005; 293:1727–1728. [PubMed: 15827310]

Wansink B, Kim J. Bad popcorn in big buckets: Portion size can influence intake as much as taste. Journal of Nutrition Education and Behavior. 2005; 37:242–245. [PubMed: 16053812]

Wansink B, Painter JE, North J. Bottomless bowls: why visual cues of portion size may influence intake. Obesity Research. 2005; 13:93–100. [PubMed: 15761167]

Wansink B, van Ittersum K. Bottom's up! The influence of elongation on pouring and consumption volume. Journal of Consumer Research. 2003; 30:455–463.

Wansink B, van Ittersum K. Shape of glass and amount of alcohol poured: comparative study of effect of practice and concentration. British Medical Journal. 2005; 331:1512–1514. [PubMed: 16373735]

Wansink B, van Ittersum K. Portion size me: Downsizing our consumption norms. Journal of the American Dietetic Association. 2007; 107:1103–1106. [PubMed: 17604738]

Wansink B, van Ittersum K, Painter JE. Ice cream illusions: Bowls, spoons and self-served portions. American Journal of Preventive Medicine. 2006; 31:240–243. [PubMed: 16905035]

Weintraub D, Cooper L. Coming of age with the Delboeuf illusion: brightness contrast, cognition, and perceptual development. Developmental Psychology. 1972; 6:187–197.

Young LR, Nestle M. The contribution of portion sizes to the US obesity epidemic. American Journal of Public Health. 2002; 92:246–249. [PubMed: 11818300]

Highlights

- Large portions lead to greater food and energy intake relative to small portions
- Promising strategies include using tall, thin, and small volume glasses and mugs
- Promising strategies include using small plates with rims, bowls and serving utensils
- Promising strategies include reducing total screen time and eating with screens
- Further experimental research in real world settings is needed