

Childhood obesity campaign

Portion and serving sizes – their relationship with

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Foreword

Tackling childhood obesity is a public health priority with 1 in 4 children on the island of Ireland now overweight or obese. Reducing this is a key target for both the Healthy Ireland (Republic of Ireland) and 'A Fitter Future for all' (NI) frameworks.

As part of the response, safefood developed a three year integrated marketing campaign to communicate practical solutions that parents can adopt in order to tackle the everyday habits associated with excess weight in childhood. The campaign also serves to maintain awareness among parents of the health challenges posed by excess weight in childhood, the negative impact this can have on the quality of life, and the importance of tackling this issue for the long-term."

Table of contents

1	Key messages	1
2	Summary of evidence	2
3	Literature	3
4	References.....	17
5	Appendix.....	22

List of tables

Table 1: Summary of data available on portion size trends.....	4
Table 2: Studies examining the effect of varying portion size on food and energy intake (EI) in children and adults	11
Table 3: Additional strategies	16

1 Key messages

Top line

- Give children portion sizes that match their size, they don't need the same amount of food as adults.

US research has shown that if children aged four or more are provided with double size portions they will eat between 25 and 60 percent more food than when given a single size portion.

Supporting

- Give children smaller portions of food to start and if they want more food then give it to them, allow them to eat to appetite
- Don't pressure children to eat all the food on their plate
- Use dishes and cutlery that match a child's size – big plates and bowls are for bigger people
- Avoid having fatty and sugary snack foods freely available between and after main meals. Children will eat these even if they aren't hungry or at the expense of nutritious foods they need
- When eating out, ask for child size portions

2 Summary of evidence

The international increase in food portion sizes that has occurred in line with increasing obesity rates in developed countries has led to the suggestion that food portion sizes may be a 'possible' risk factor for obesity (World Health Organisation [WHO], 2003⁽¹⁾). Data that has been collected since the 1970s from the United States of America (USA) has shown strong trends in the upward direction for portions sizes. Data from the Republic of Ireland (ROI) and the United Kingdom (UK) is less consistent, but it should be noted that data is available over much shorter timeframes. What is apparent from this data is that people eat many sugary and fatty-snack-foods and drinks in unit sizes. These unit sizes have increased and therefore people eat larger sizes.

A recent systematic review⁽²⁾ identified six good quality experimental studies that investigated the effect of portion size on children's food intake. They showed consistently that children aged four years consumed more calories when presented with large portions. Most of the studies recognised that young children have very good appetite control and aren't influenced by portion sizes in the same way as adults and children aged four years or more. However, the age at which this strong appetite control begins to become influenced by portion sizes and other environmental cues is unclear from the evidence.

Encouraging children to self-serve food from shared dishes is regarded as best practice from the perspective of them learning about appropriate portions sizes and also developing motor and social skills. However, emerging evidence is indicating that overweight children are likely to serve larger portions than those who have a healthy body weight. This indicates that in children above the age of four that self-serving may support overeating in those that are overweight and obese. There is some evidence to suggest that children using bigger plates, bowls and spoons are also more likely to serve themselves larger portions.

One USA experimental study has found that providing free access to highly palatable (i.e. top shelf) foods in large portions to young girls in the absence of hunger resulted in larger amounts being chosen by those who were overweight/ obese.

3 Literature

Trends in portion sizes

According to Nestle 2003⁽³⁾, the expansion of portions in the USA started as early as the 1970s, increased sharply in the 1980s and has continued to rise. Data indicate that between 1977 and 2002, major contributors of energy to the US diet (e.g. salty snacks, chocolate bars, muffins, soft drinks and ready-to-eat breakfast cereals) showed significant increases in portion size .^{(3); (4); (5); (6); (7)}.

Overall, trend data does exist in ROI and UK although on a limited scale. In Northern Ireland (NI) the only trend data is from the 1997 Northern Ireland Young Hearts Study. Data from ROI and UK has not been as consistent as data generated in the US (Table 1). This may be due to the fact that both countries haven't been collection dietary intake data for as long as the US. Therefore when looking at trends the timeframe for investigation is shorter. Despite this, there is some evidence to suggest that there are trends for increases in some more energy dense foods than others. Interestingly trends in both directions have been observed in the beverage, snack and confectionary food groups that reflect changes in package sizes. This indicates that the pack size of these foods is a very stronger indicator of portion sizes consumed.

Table 1: Summary of data available on portion size trends

Date published:	Type of study	Main aim/ objective	Main Findings/ Conclusions
2015	Almiron-Roig E et al. Large portion sizes increase bite size and eating rate in overweight women. <i>Physiology & Behaviour</i> 139 (2015) 297–302	Larger food portions lead to increased intake but the mechanism behind this effect is unclear. The effect of portion size on bite size, eating rate, deceleration rate, and meal duration.	Exposure to larger portion sizes has been linked with increased intake both in children and adults, and across a variety of foods and settings although, the mechanisms underpinning this effect are unclear. Secular increases in portion sizes of many foods mean that individuals may need to develop personal coping strategies to avoid overeating.
2015	Robinson T N., Matheson D. M. Environmental strategies for portion control in children. <i>Appetite</i> 88 (2015) 33–38	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	This study provides evidence to support some of the strategies that we suggest that parents use to control their children's intake. It looks into five potential environmental strategies that 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 (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.
2014	Mack, I et al, Obese children and adolescents need increased gastric volumes in order to perceive satiety. <i>Obesity</i> 2014 Volume 22, Issue 10, 2123–2125	In order to develop effective weight management strategies, it is important to identify factors that influence energy intake. Portion size has been discussed as one such factor. To date, most studies focusing on the relationship between portion size, energy intake, and weight have analyzed questionnaire data and 24-h records. In this study, we assessed the onset of satiety using the water-load test in normal-weight and obese children and adolescents.	Obese children and adolescents need to ingest greater volumes to feel full which may predispose toward the consumption of larger portion sizes. This may easily lead to overeating if predominantly energy-dense foods are consumed. A reduction in energy-dense foods in the diet of obese children and adolescents appears to be a necessary strategy for managing body weight.
2014	Johnson, S L, Portion sizes for children are predicted by parental characteristics and the amounts parents serve themselves. <i>Am J Clin Nutr</i> 2014;99:763–70	In this repeated-measures, cross-sectional observational study,	The amounts that parents served themselves were significantly associated with the amounts that they served to their children. This study identifies strong relation between portions offered by caregivers and the amounts children consume at a meal and suggest that factors

		145 parents and their pre-schoolers were recruited from Head Start settings in Houston, TX. The amounts served to and consumed by children and parents during three at-home evening meals were measured and analysed.	unrelated to the child (such as the amount a parent serves himself or herself) are important predictors of children's consumption. Efforts aimed at improving parents' recognition of developmentally appropriate portions for young children could be useful for future obesity-prevention efforts.
2013	Development of an online database of typical food portion sizes in Irish population groups. Lyons J, Walton J, Flynn A. Journal of Nutritional Science, 2013,3:1-6 (8)	Derived from three large cross-sectional food consumption surveys carried out in Ireland; NCF5('03-04), NTF5('05-06), NANS ('08-10) Median portion weights are described spilt by age group or gender as appropriate. It aims to serve as a useful reference against which to compare future portion size data.	Older-aged children (9-12 years) reported larger median portion weights for most foods than younger children (5-8years), in the Irish Food Portion Sizes Database. However, identical portion weights were reported by children for a range of packaged food items that tend to be consumed in unit amounts (for example yoghurt, crisps).
2012	<i>ADULTS ONLY</i> Changes in reported portion size of food and beverages consumed by Irish adults over a ten year period (2001-2011) in ROI O'Brien S, Livingstone MBE, M ^c Nulty BA, Lyons J, Walton J, Flynn A, Dean M, Spence M, McCrorie T, Nugent AP and Gibney ER (safe food funded - unpublished – in press)	Comparisons of portion size consumption in Ireland from nationally representative dietary surveys. Investigated the changes in the median reported portion size of all commonly consumed foods and beverages in Irish adults aged 18 to 64 years in 2001 to 2011.	Overall, with the exception of 'meat and meat products', 'breads, rice, pasta and cereals', and 'beverages' where there have generally been significant increases in the portion sizes consumed, the trends are largely inconsistent in direction. Within breads and cereals - an increase in the portion size eaten of white bread and bread products and ready to eat breakfast cereal. In contrast the portion size of wholemeal and brown bread remained static. Within meat and meat products portion sizes of all meats except sliced ham went up The increase in portion size of beverages (including alcohol) is attributed to increases in package sizes. The portion sizes of cakes, buns, pastries and biscuits also increased

			<p>A decrease in the portion size of fruit overall was seen (27g difference).</p> <p>A 2g increase was seen in vegetable portion size and for potatoes (boiled, chips/wedges) they decreased.</p>
2012	<p>What's in a bun?</p> <p>safefood funded research (9)</p>	<p>Provide a snap shot of the nutritional content and portion size of burgers, including kids' burgers</p>	<p>Found that one third of takeaway burgers marketed as 'kids' size are actually larger than a 'regular' size burger</p>
2009	<p><i>Adolescents</i></p> <p>Snacking patterns among adolescents: a comparison of type, frequency and portion size in Britain between 1997 and Northern Ireland in 2005.</p> <p>Kerr MA, Rennie KL, McCaffrey TA, Wallace JMW, Hannon-Fletcher MP & Livingstone MBE <i>British Journal of Nutrition</i> 101, 122-131.(10)</p>	<p>To compare type, frequency and portion size in Britain between 1997 and Northern Ireland in 2005</p>	<p>Found the portion size of many snack foods consumed by adolescents in the UK and Northern Ireland to have increased significantly between 1997 and 2005.</p> <p>This study used data from adolescents aged 13-16 years who took part in the 1997 National Diet and Nutrition Survey (NDNS) and that from a Northern Irish (NI) cohort of adolescents collected 8 years later, in 2005.</p> <p>The portion size of all carbonated and soft drinks were found to be significantly higher in the 2005 group than in 1997 group. The same was found for milks, crisps and savoury snacks and breakfast cereals, with no change in number of snacking occasions observed.</p>
2008	<p>Estimation of typical food portion sizes for children of different ages in Great Britain.</p> <p>Wrieden WL, Longbottom PJ, Adamson AJ, Ogston SA, Payne A, Haleem MA & Barton KL <i>British Journal of Nutrition</i> 99, 1344-1353. (11)</p>	<p>To estimate typical food portion weights for children of different ages</p>	<p>Some evidence for increasing food portion sizes being served in UK fast-food outlets.</p> <p>All portion sizes increased with age with the exception of milk in tea or coffee.</p> <p>These food groups included pizza, biscuits, cakes, crisps, savoury snacks, chocolate, sugar, confectionery and beverages.</p>
2008	<p>Trends in portion sizes in the UK – A preliminary review of published information.</p> <p>Report to the Food Standards Agency.</p>	<p>To review evidence on trends in portion sizes in UK</p>	<p>Data on trends in food portion sizes in the UK, indicate that the portion sizes of many standard and traditional products, such as cakes and biscuits, have remained fairly constant over the last 15 to 20 years</p>

	Church S Access online at www.food.gov.uk (12)		Identified a clear increase in the range of available portion sizes for many foods and beverages, particularly for some energy-dense foods like ready meals and white bread, as well as American muffins, chocolate confectionary, ice cream and crisps. Smaller packs sizes were found to be available for many products although these tended to be available in multipacks.
2002	The contribution of expanding portion sizes to the US obesity epidemic. Young LR, Nestle M. Am J Public Health. 92:246-249.(7)	Designed to weigh samples of marketplace foods, identify historical changes in the sizes of those foods, and compare current portions with federal standards.	With the single exception of sliced white bread, all of the commonly available food portions measured from restaurant foods, grocery products, and recipes in cookbooks, exceeded—sometimes greatly—USDA and FDA standard portions.
2003	Size makes a difference. Matthiessen J, Fagt S, Biloft-Jensen A, Beck AM & Ovesen L <i>Public Health Nutrition</i> 6(1), 65-72.(13)	To elucidate status and trends in PS of foods rich in fat and/or added sugars during the past decades, and to bring PS into perspective in its role in obesity and dietary guidelines in Denmark.	Found that portion sizes of energy-dense foods, caloric beverages and fast-food meals appear to have increased in Denmark since the mid-1980s
2003	Foods commonly eaten in the United States, 1989-1991 and 1994-1996: Are portion sizes changing? Smiciklas-Wright H, Mitchell DC, Mickle SJ, Goldman JD & Cook A Journal of the American Dietetic Association 103(1), 41-47.(6)	To compare quantities consumed per eating occasion in 1989-1991 and 1994-1996 was the objective of this study.	Considering amounts of commonly eaten foods consumed per eating occasion, larger amounts were reported in 1994-1996 for several foods including soft drinks, coffee, tea, and ready-to-eat cereal.

The effects of increasing portion sizes on amount eaten

It is well established in adults that when portion size is increased the amount of food eaten and calories consumed also increase for both adult men and women ⁽¹⁴⁻²⁰⁾ (see appendix 1 for key studies). The impact of varying portion sizes on children's food intake has been less well studied.

The evidence has consistently shown that infants and toddlers up to the age of 24 months, when assessed in controlled environments, self-regulate their energy intake ^{(21), (22); (23, 24); (25); (26)}. This indicates that children are born with good satiety cues that help them regulate their food intake.

A recent systematic review investigated the evidence available on the effect of varying portion size of young children ⁽²⁾. Six experimental studies were suitable for inclusion. These data showed in children aged four years and older food and calorie intake increased when larger portions were provided. The data available for younger children was more limited and findings more variable. It has been therefore suggested that at some point between the ages of two and four years children's satiety cues become less effective in counteracting increased portion sizes. This was also confirmed by a recent study by Fisher et al. 2013 ⁽²⁷⁾ where four to six years olds served themselves 40 percent more entrée when the amount available was doubled.

Small et al. ⁽²⁾ also investigated how effective portion size education was on knowledge among adults. Of the three eligible studies ⁽²⁸⁻³⁰⁾ they all demonstrated an increased knowledge through a range of educational tools including web based versions on adult's accuracy at estimating recommended portion sizes. However, none of the studies specially focused on children's portion sizes.

Additional strategies

Size of utensils and cutlery

Di Santas et al. ⁽³¹⁾ found that if African American children used bigger plates and bowls they consumed larger portions. This indicates that parents should serve food on smaller plates and bowls. Other research also showed that if children used bigger serving spoons to serve themselves they served 13 percent bigger portions ⁽²⁷⁾.

Encouraging children to serve themselves

Family-meal style service where children are encouraged to serve themselves is often promoted as best practice ^{(32), (31)} and HIP project (unpublished).

The rationale behind this approach is to promote self-autonomy and self-regulation through making food choices while providing them with opportunities for them to develop motor and social skills. The impact of allowing children to serve themselves on the portion of food they choose and ultimately eat is not very well understood. Studies that have investigated this have found mixed results ^{(33); (34); (22, 35, 36)}. In a recent study by Savage et al. 2012 ⁽³⁷⁾ that involved 63 three to five year old children found that those who served themselves larger portions tended to be overweight and more responsive to portion size (i.e. choose the largest amounts of food). This work is supportive of previous work showing relationships between body weights and eating behaviour ⁽³⁸⁻⁴⁰⁾.

Restrictive feeding versus providing structured choice

Orlet Fisher and Birch (2002) ⁽³⁵⁾ found that girls aged five to six years who had free access to highly palatable foods (e.g. popcorn, crisps, chocolate, biscuits and ice-cream) when not hungry (under experimental conditions) tended to be heavier. Girls were tested two years later and the same pattern was seen. Among these overweight girls it was also found that parents reported more restrictive feeding practices. The authors suggest that restricting unhealthy foods doesn't promote moderate intakes when they are available. They suggest having structure choice for children that provides access to a wide variety of healthy foods in appropriate portions. This approach reduces food neophobia and promotes acceptance of healthier choices.

Snack and treat foods and sugary drinks in most cases are energy dense. An independent but additive effect observed for PS and ED is apparent in the evidence ⁽⁴¹⁾ and reductions in both can lead to sustained decreases in energy intake for up to two days, without increased hunger⁽⁴²⁾. The WCRF also indicate that there is evidence that both portion size and energy density have an independent and cumulative effect on energy intake, but that modifying energy density could be a more effective way to control weight than reducing portion size ⁽⁴³⁾.

Using fruit and vegetables to lower energy portion

Reducing the energy density of meals has been shown to decrease the EI of young children ⁽⁴⁴⁾. Intervention studies have observed a reduction in children's EI (25%), when the ED of an entrée has been decreased in children as young as two years old ^{(45),(46)}. EI reductions (14%) were also observed with children, when the ED of multiple meals is reduced ⁽⁴⁴⁾.

Increasing the portion size of a vegetable served as a first course ⁽⁹⁾ can be an effective strategy for increasing vegetable consumption in preschool children. However, meal energy intake was not shown to be significantly affected by the amount of vegetables served in the first course.

Strategies such as encouraging children to eat more portions of low energy dense food (Fruit & veg, Low fat dairy) ⁽⁴⁷⁾ or covertly incorporating vegetables into meals, is an effective strategy to decrease children's EI ⁽⁴⁸⁾ and can help them to maintain a healthy weight. Reducing the energy density of foods in the diet has shown a marked positive change on the Body Mass Index (BMI) of children, for up to two years ⁽⁵⁾.

Table 2: Studies examining the effect of varying portion size on food and energy intake (EI) in children and adults

Author	Participants	Study	Type of food	Main outcomes
Studies included in systematic review Small <i>et al.</i> 2013				
Rolls <i>et al.</i> 2000 (49)	Pre-school children aged three to five years (n 32).	Serving portion size influences 5-year-old but not three-year-old children's food intakes.	University associated pre-school, child eating lab Within subjects design; at the usual lunch setting, small, medium and large portions of macaroni and cheese served on same day of the week for three weeks . Macaroni and cheese (varied portion sizes); fixed portions of apple sauce, carrot sticks and milk also provided .	Larger food portions resulted in increased energy intakes in 5-year-olds; PS did not affect EI in three to five year olds.
Fisher et al 2003(35)	Children aged three to five years (n 35).	Children's bite size and intake of an entrée are greater with large portions than with age-appropriate or self-selected portions.	One meal- University associated pre-school, child eating lab. Energy intake, bite size, and comments on portion size were evaluated at 2 series of lunches; age-appropriate or a large portion entrée served.	Two-fold increase PS *=15% total EI increase Although bite frequency did not change with the large PS, bite size significantly increased. The varying PS's of entrée served did not affect intake of non-entrée foods. Children consumed 25% less entrée when allowed to serve themselves than when served a large entrée portion. Children's bite size positively correlated with child weight .
Fisher et al 2007 AJCN(50)	Children aged five years (n 59).	Portion size effects on daily energy intake in low-income Hispanic and African American children and their mothers.	24-hrs- laboratory setting. Within-subjects experimental design with reference and large portion sizes used PS of 3 entrées (lunch, dinner, and breakfast) and an afternoon snack served in 24-h period were of a ref size in one condition and X2 in other condition.	The effect of large portions were demonstrated at the first meal and had a significant cumulative increased intake by lunch. Two-fold increase PS. 12% increase EI.

				Large portions may contribute to obesogenic dietary environments by promoting excess daily intakes among Hispanic and African American children.
Fisher et al 2007 Obesity (34)	Children aged two to nine years. (n 75)	Effects of Age on Children's Intake of Large and Self-selected Food Portions.	One-meal- Lab setting, group meal and eating arrangement. A dinner meal in reference, large, and self-selected portion size conditions, and entrée size was age-appropriate, doubled, and determined by the child.	Two-fold increase PS*, 13% increase EI. Serving large entrée portions promotes increased intake at meals among two to nine year-old children. Suggesting that any age-related differences in children's response to large portions are likely to be smaller than previously suspected. Increased ED of food alone did not have an effect on entrée intake but did have a positive effect on total EI. There was a significant effect for manipulation of PS and ED on entrée consumption.
Fisher <i>et al.</i> 2007 AJCN (51)	Children aged five to six years (<i>n</i> 53).	Effects of portion size and energy density on young children's intake at a meal.	Macaroni and cheese entrée (manipulated); fixed portions of apple sauce, milk, carrots, corn and cookies. A 2x2 within subjects design was used to manipulate entrée portion size (250g, 500g) and energy density (1.3kcal/g, 1.8kcal/g); fixed portions of other familiar foods provided.	Independent but additive effects observed for portion size and energy density; children consumed 76% more energy from the entrée and 34% more energy at the meal overall when served the larger, 'more energy dense' entrée .
Spill et al 2010 (52)	Eating vegetables first: the use of portion size to increase vegetable intake in preschool children.	Three to five year old children (n = 51).	Crossover design. Served a test lunch once a weekx4. First course of raw carrots varied in portion size (30, 60, or 90 g), and no first course was served in the control. Children consumed the first course ad libitum over 10 min and then served a main course of pasta, broccoli, applesauce, and milk.	Total vegetable consumption at the meal increased as the PS of carrots increased. X2 PS of the first course increased carrot intake (47%). X3 PS of carrots- no further increase in intake. Meal EI was not significantly affected by the amount of carrots served in the 1st course.

Other Studies

Savage et al 2012(53)	Children aged three to six years (n 17).	Serving smaller age-appropriate entree portions to children aged three to five years old increases fruit and vegetable intake and reduces energy density and energy intake at lunch.	Within-subject design used to examine the effect of varying entrée portions (i.e., 100, 160, 220, 280, 340, and 400 g) on children's ad libitum EI of macaroni and cheese and fixed portions of unsweetened applesauce, green beans, and whole-wheat roll served with the entree. Served a series of 6 lunches, which varied only in entrée PS, once per week. 1-meal.	Four-fold increase PS*. 61% increase EI. Increasing PS increased children's entrée intake & decreased intake of other foods served with the entrée, including fruit and vegetables. As a result, children consumed a more-energy-dense lunch as PS increased. Overweight children showed greater increases in entree intake with increasing entrée portion.
Savage JS, Haisfield L, Fisher JO, Marini M, Birch LL. 2012(37)	N=63 children aged three to five years.	Do children eat less at meals when allowed to serve themselves?	Two within-subjects experiments were used to examine ad libitum intake at meals when 400 g of a pasta entrée was either plated or available for children to self-serve.	Children's entrée and meal intakes did not differ between the self-served & plated. Children who served themselves larger portions tended to be overweight and more responsive to portion size.
Savage et al 2012(53)	N= 17 children aged three to six years.	Serving smaller age-appropriate entree portions to children aged three to five years old increases fruit and vegetable intake and reduces energy density and energy intake at lunch.	Within-subject design to examine the effect of varying entrée portions (i.e. 100, 160, 220, 280, 340, and 400 g) on children's ad libitum EI of macaroni and cheese and fixed portions of unsweetened applesauce, green beans, and whole-wheat roll served with the entree. Served 6 lunches, with varying entrée PS, once week.	Six weeks. Increasing PS increased children's entrée intake and decreased intake of other foods served with the entrée, including fruit and vegetables. Children consumed a more-energy-dense lunch as PS increased.

DiSantis et al 2013(31)	N= 42 predominantly African American elementary school-aged children	Plate Size and Children's Appetite: Effects of Larger Dishware on Self-Served Portions and Intake.	Within-subjects experimental design was used to test the effects of dishware size (i.e., plates and bowls with a 100% increase in the surface area of plates and volume of bowls) on children's self-served portion sizes and intakes in a naturalistic setting.	Observed on repeated occasions during school lunch. Children served themselves more with larger (adult-size) plates and bowls. Adult-size dishware also promoted EI indirectly - children consumed nearly 50% of the calories that they served themselves.
Smith et al 2013(54)	N= 173 children two age groups mean age 4.2 yrs & 6.1 yrs	Portion size variably affects food intake of six-year-old and four-year-old children in Kunming, China.	Within-subjects crossover. classroom setting, Served a predefined reference, small (-30%) and large (+30%) portion of rice, vegetables, and a protein source during lunchtime.	Three consecutive days. All children consumed less food when served smaller portions. 6-yr children consumed more food and 4-yr children consumed less when served a larger portion.
Fisher et al 2013(27)	60 ethnically diverse children aged four to six years and their mothers.	External influences on children's self-served portions at meals.	Within-subjects design two different serving sizes (275 vs 550 g), and the serving spoon size (teaspoon vs tablespoon) were systematically varied.	Children served themselves 40% more entree when the amount available was doubled and 13% more when the serving spoon size was tripled. Greater self-served portions and EI at the meal were seen among children whose mothers reported indulgent or authoritarian feeding styles.
Kling et al 2015	120 children aged three to five years (14% overweight or obese).	Double Trouble: Energy Density and Portion Size Combine to Increase Preschool Children's Lunch Intake.	In a crossover design, responses to meals that were varied in ED and portion size, using foods often served in preschools, were investigated. For 6 meals, all items were served at two levels of ED (100 or 142%) & three levels of portion size (100, 150, or 200%).	Large portions of high-ED foods are likely to contribute to childhood obesity by promoting the overconsumption of energy. Increasing meal ED by 42% led to a 40% increase in energy intake and doubling portions led to a 24% increase.
Krala et al 2015	Review of studies	Variability in children's eating response to portion size. A bio-behavioural perspective.	A review to present and discuss evidence that innate controls of appetite and eating, which involve genes that encode key hormones and	Children's response to portion size is shaped by the gene-environment interaction. Heritable eating traits increase the

			neuropeptides implicated in processes of satiety and satiation, may differentially affect meal size.	risk of overeating in children. Risk of obesity can be moderated by experience through the early home environment.
Lyons et al 2015	Nationally representative (ROI) samples of children aged five to 12 years (n 594) and adolescents aged 13–17 years (n 441).	Food portion sizes and dietary quality in Irish children and adolescents.	Cross-sectional data from the Irish National Children's Food Survey and National Teens' Food Survey were used to compare mean values for a number of dietary quality indicators across portion size tertiles for a range of foods, on the days the foods were consumed.	<p>Lower dietary energy density and saturated fat intakes, and higher dietary fibre intakes, were observed on the days larger portions of fruit and boiled potatoes were consumed.</p> <p>Higher dietary energy density and lower micronutrient intakes were observed on the days larger portions of sugar-sweetened beverages were consumed.</p> <p>Higher Na intakes were observed on the days larger portions of frying meats were consumed.</p>

Table 3: Additional strategies

Author	Study	Participants	Study Design	Main outcome
Spill et al 2011 (48)	Hiding vegetables to reduce energy density: an effective strategy to increase children's vegetable intake and reduce energy intake	N= 40 Preschool age children Three to five years	Crossover study, children were served all meals and snacks one day a week for three weeks. Entrées at breakfast, lunch, dinner, and evening snack were reduced in ED. 100% ED (standard), 85% ED (tripled vegetable content), and 75% ED. Entrées were served with un-manipulated side dishes and snacks, and children were instructed to eat as much as they liked.	A 25% ED reduction (incorporation of substantial amounts of puréed vegetables) resulted in a 12% EI reduction. Results persisted over 24 hours. Children did not compensate with increased amounts of snacks and side.
Leahy et al 2008 (44)	Reducing the energy density of multiple meals decreases the energy intake of preschool-age children	N = 26 (10 boys, 16 girls) Three to five years	Crossover study Manipulated breakfasts, lunches, and afternoon snacks two days per week for two wk. Foods and beverages served at these meals in one week were lower in ED than other week. ED altered by decreased fat and sugar and increased fruit and vegetables content.	Children consumed a consistent weight of foods and beverages over two days in both conditions, and therefore their energy consumption declined by (14%) in the lower-ED condition.
Epstein et al 2008 (47)	Increasing Healthy Eating vs. Reducing High Energy-dense Foods to Treat Paediatric Obesity	N=41 Eight to 12 years	>85th BMI percentile were randomly assigned to a 24-month family-based behavioural treatment that targeted increasing fruits and vegetables and low-fat dairy vs. reducing intake of high energy-dense foods.	Children in the 'increase healthy food' group showed greater reduction in BMI compared to children in the 'reduce high energy-dense' food group, at 12- and 24 month follow-up. Children in the 'reduce high ED' group showed larger sustained reductions in 'high ED Foods'.
Johnson et al 2014	Portion sizes for children are predicted by parental characteristics and the amounts parents serve themselves	N=145 Pre-school (Average 4.5 years of age)	A cross-sectional observational study of 145 parents and their preschool children found significant association between the amount of food parents served themselves and the amount they served to their children. When parents served more to themselves, they also served more to their children. The amounts served to children were also strongly associated with the amounts children consumed.	Findings suggest that factors unrelated to the child (such as the amount a parent served himself or herself) are important predictors of children's consumption. Authors suggest that efforts should be made to improve parents' recognition of appropriate portions for young children.

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5 Appendix

Author	Participants	Study	Type of food	Main outcomes
Levitsky & Youn, 2004 (14)	<i>Adults</i> University students; mean age 23 years (<i>n</i> 13)	The more food young adults are served, the more they overeat.	Within subjects design; individual portions of four foods (Soup, pasta, breadsticks, ice cream) consumed at a buffet meal a week previously were served on three different days at 100%, 125% and 150% of the portions consumed.	Increased food and energy intake with increasing portion size of each food .
Kral <i>et al.</i> 2004 (15)	Women aged 20-45 (<i>n</i> 39)	Combined effects of energy density and portion size on energy intake in women.	Within subjects cross over design; three different portion sizes of Italian pasta bake (100%, 140%, 180%) and three different energy densities.	Consuming the largest portion led to 20% more food been consumed versus the smallest; combined effect of portion size and energy density evident; EI increased by 56% (225kcal) when served largest, 'most energy dense' portion compared to smallest 'least energy dense' portion .
Diliberti <i>et al.</i> 2004 (16)	Adults aged 18 and upwards (<i>n</i> 180), mixed	Increased portion size leads to increased energy intake in a restaurant meal.	Between subjects parallel group design; restaurant provided two different entrée portion sizes of Baked pasta in	Those who purchased the larger entrée portion increased energy intake of their entrée by 43% (172kcal) and of the whole meal by 25% (159kcal)

	body weight categories		cheese sauce (100%, 152%) on different days at the same price.	
Wansink & Kim, 2005 (17)	Adult moviegoers (<i>n</i> 158)	Bad popcorn in big buckets: portion size can influence intake as much as taste.	Between subjects design; subjects randomly assigned medium (100%) or large (200%) portions of fresh or stale popcorn. Fresh and stale popcorn .	Increased food intake when served larger portions of either fresh (45%) or stale (34%) popcorn .
Rolls et al 2006(55)	young women (<i>n</i> =24)	Reductions in portion size and energy density of foods are additive and lead to sustained decreases in energy intake.	Crossover design, meals and snacks for two consecutive days per week for four weeks; all foods eaten ad libitum. At four sessions, subjects were served the same two daily menus, but all foods were varied in PS and ED between a standard (100%) and a reduced (75%).	Reducing PS and ED of all foods led to significant and independent decreases in EI over two days. 25% decrease in PS led to a 10% decrease in EI, and a 25% decrease in ED led to a 24% decrease in EI. The effects on EI were additive and sustained from meal to meal. Despite the large variation in EI, there were no significant differences in the ratings of hunger and fullness across conditions over the two days.
Flood <i>et al.</i> 2006 (18)	Adults aged 18-45 (<i>n</i> 33)	The effect of increased beverage portion size on energy intake at a meal.	Within subjects cross-over design; two different portion sizes (100%, 150%) and three different beverages (Regular cola, diet cola, water).	Increased beverage intake when served a larger portion (men, 26%; women, 10%); increased energy intake in the case of caloric beverage.

Rolls et al 2006 (19)	32 adults from a University community.	Larger portion sizes lead to a sustained increase in energy intake over two days.	Randomized crossover design. EI and ratings of hunger and satiety were measured.	Significant effect of PS on EI in both men and women. PS 50% increase = daily EI increase by 16%, PS increase by 100% increased intake by 26%. EI did not differ between the two days of each week. Increasing the PS of all foods resulted in a significant increase in EI that was sustained over two days. Large portions are associated with excess EI that could contribute to increased body weight.
Rolls <i>et al.</i> 2007 (20)	Adults aged 20-40 (<i>n</i> 23)	The effect of large portion sizes on energy intake is sustained for 11 Days.	<p>Within subjects cross-over design during two 11-day periods (home and laboratory setting); all foods/drinks served as standard PS (100%) in one period and 150% in other.</p> <p>Complete daily menu that varied each day; included a wide range of meals, beverages and snacks</p>	Increased energy intake when served larger portions of all food categories <i>except</i> fruit as a snack and vegetables; mean daily energy increase of 423kcal with larger food portions; no energy compensation over 11-day period.

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