

# An evaluation of portion size estimation aids: precision, ease of use and likelihood of future use

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## Abstract

**Objective:** The present study aimed to evaluate the precision, ease of use and likelihood of future use of portion size estimation aids (PSEA).

**Design:** A range of PSEA were used to estimate the serving sizes of a range of commonly eaten foods and rated for ease of use and likelihood of future usage.

**Setting:** For each food, participants selected their preferred PSEA from a range of options including: quantities and measures; reference objects; measuring; and indicators on food packets. These PSEA were used to serve out various foods (e.g. liquid, amorphous, and composite dishes). Ease of use and likelihood of future use were noted. The foods were weighed to determine the precision of each PSEA.

**Subjects:** Males and females aged 18–64 years ( $n$  120).

**Results:** The quantities and measures were the most precise PSEA (lowest range of weights for estimated portion sizes). However, participants preferred household measures (e.g. 200 ml disposable cup) – deemed easy to use (median rating of 5), likely to use again in future (all scored either 4 or 5 on a scale from 1 = 'not very likely' to 5 = 'very likely to use again') and precise (narrow range of weights for estimated portion sizes). The majority indicated they would most likely use the PSEA preparing a meal (94%), particularly dinner (86%) in the home (89%; all  $P < 0.001$ ) for amorphous grain foods.

**Conclusions:** Household measures may be precise, easy to use and acceptable aids for estimating the appropriate portion size of amorphous grain foods.

**Keywords**  
Portion size  
Obesity  
Consumer  
Energy intake

The wider availability of larger portion sizes (PS) outside the home has contributed to consumers' distorted perceptions of appropriate PS<sup>(1)</sup>, leading them to over-estimate their PS in the home<sup>(2)</sup>. PS management is often considered irrelevant by consumers on a personal level and is deemed necessary only for those on a special diet (e.g. for weight loss)<sup>(3–6)</sup>. Some of the key challenges for consumers with regard to PS management include irregular eating patterns, food serving size (SS; or pack sizes), poor nutrition knowledge, avoiding food waste, lack of cooking skills and availability of leftovers. There is also the tendency to consume larger PS when eating outside the home<sup>(5)</sup>. However, recent research found that almost half of consumers in the UK find it most difficult to achieve appropriate PS when preparing and eating foods in the home<sup>(7)</sup>. Furthermore, consumers generally distrust

the SS on food labels as they believe the food industry manipulates them in order to make the nutrient levels seem more favourable<sup>(8)</sup>. Consumers often buy in excess of the SS stated on the food labels as they perceive them to be insufficient<sup>(5)</sup>.

A major obstacle in providing consumer education on appropriate PS is the current absence of national quantitative dietary guidance in the UK. Consumers receive conflicting messages from various sources with different objectives (e.g. weight loss *v.* weight maintenance advice). Changes in dietary messages over time have also contributed to consumer confusion; for example, study participants questioned whether the recommendation for milk was a pint or a glass of milk per day<sup>(9)</sup>. The 'Eatwell Plate' advises on the proportion (but not the specific amount or SS) of each food group to consume<sup>(10)</sup>.

Therefore, health professionals have called for the introduction of national SS guidance as consumers are confused about what constitutes an appropriate PS for many foods<sup>(3,9–12)</sup>. On the other hand, in the Republic of Ireland, the national dietary guidelines include information on SS for different age, gender and activity levels. However, measuring specific weights and volumes tends to be laborious and time consuming<sup>(12)</sup> while traditional SS guidance such as ‘small, medium or large’ may be too ambiguous for consumers<sup>(12,13)</sup>. As a result, the Irish dietary guidelines have recently incorporated more convenient and approximate tools to aid PS estimation (i.e. household measures and reference objects including a 200 ml plastic cup, a teaspoon, the palm of the hand and a matchbox)<sup>(14)</sup>. However, no evaluation of the efficacy, likely uptake or practical application of these aids has been conducted to date. Research elsewhere that has assessed the usefulness of other aids such as food photographs for PS estimation has found equivocal results<sup>(12,15–17)</sup>. Furthermore, the accuracy (measured *v.* putative PS) of PS estimation aids (PSEA) is questionable<sup>(18)</sup> and the size of some PSEA such as a cup or spoon can be open to interpretation<sup>(12)</sup>. In essence, there is a lack of comprehensive data on consumer understanding of SS guidance<sup>(19)</sup>. In general, consumer estimations of PS, particularly of breakfast cereals<sup>(8)</sup>, tend to deviate from the suggested or recommended SS<sup>(5,20–23)</sup>. The 5-a-day message is widely recognised guidance for fruit and vegetables<sup>(24)</sup> yet consumers have expressed their uncertainty as to what equates to a SS<sup>(9)</sup>.

There is a paucity of both quantitative and qualitative research evaluating the use of appropriate aids to facilitate the estimation of appropriate PS before consumption, despite considerable investigation into their use in dietary assessment after consumption. There is currently a lack of consistent evidence about which, if any, PSEA appear to be most effective in helping consumers to determine appropriate food PS prior to consumption. The main objectives of the present study were to evaluate (in practice) the precision, ease of use and likelihood of future use of a range of PSEA for various foods with diverse characteristics.

Note that, for the purposes of the present study, the term ‘PS’ refers to the amount of food intended to be consumed whereas ‘SS’ refers to the amount of food recommended to be consumed. However, it was apparent that the aids selected for the study were inconsistently used to either estimate PS or SS. Therefore, all aids are referred to as ‘PSEA’ herein.

## Experimental methods

The study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving human subjects were approved by the University of Ulster, University College Dublin and

Queen’s University Belfast Research Ethics Filter Committees. Written informed consent was obtained from all participants before commencing the study protocol.

## Participants

Adults (aged 18–64 years) living on the island of Ireland were recruited to take part in the study via email distribution lists, social media, local advertisements or word of mouth. The study was conducted at three centres including the University of Ulster Coleraine, University College Dublin and Queen’s University Belfast. Forty individuals were recruited at each centre over a period of approximately 6 weeks during January and February 2013.

## Portion size estimation aids

A range of PSEA were selected that could be used to aid the estimation of PS of a range of commonly eaten foods of diverse visual and physical properties. These included PSEA for amorphous (i.e. foods without a definite shape such as rice), liquid, solid, cooked and dried foods. The PSEA chosen included: quantities and measures (e.g. SS on food labels); reference objects (e.g. a small matchbox for a SS of cheese); household measures and utensils (e.g. 200 ml disposable cup or coloured portion pots from Rosemary Conley™ which included a guide detailing the colour of pot that corresponded with certain foods); and indicators on food packets (e.g. SS demarcations on the packaging of a block of cheddar cheese). Only PSEA that were relevant and available to Irish and UK consumers were chosen; others such as the baseball, which originates from the USA, were not included. A full list of the PSEA and their corresponding foods are presented in Table 1.

## Study foods

Sixteen foods in total were selected to pilot the PSEA (Table 1). Foods included were either major contributors to energy intakes on the island of Ireland<sup>(25)</sup> or were previously identified as challenging in terms of measuring/quantifying PS<sup>(26)</sup>. As previously outlined, these foods represented a diversity of shapes and visual characteristics. Pre-defined amounts of the foods were displayed in their original packaging where possible, or otherwise cooked foods were presented in suitable serving dishes (Table 1). Common crockery and utensils were provided for serving out the foods; the sizes of these were kept uniform throughout the study. The relevant PSEA were displayed beside each food with a card detailing the SS recommended by the source of the aid. For example, for mayonnaise, participants could choose to serve out either one level tablespoon using either a typical tablespoon or a measuring spoon with a sliding cover that could adjust from the size of a teaspoon to the size of a tablespoon (household items), 15 g (using the weighing scales) or an amount the size of the tip of their thumb (reference object).

**Table 1** Foods and portion size estimation aids considered in the present study

Food group	Foods	Portion size estimation aids				Indicators on food packets
		Amount displayed	Quantities and measures	Reference objects	Household measures and utensils	
Dairy	Cheddar cheese (grated)	250 g bag	SS (food scales)	Small matchbox	Tablespoon	Demarcations Demarcations
	Cheddar cheese (block)	250 g block	SS (food scales)		Portion pot	
Grains	White rice (uncooked)	500 g box	SS (food scales)		200 ml disposable cup	Demarcations
	White penne pasta (cooked)	920 g serving dish	SS (food scales)		Portion pot	
	Cornflakes	500 g box	SS (food scales)		Portion pot	
Fruit and vegetables	Rice Krispies	510 g box	SS (food scales)		200 ml disposable cup	Demarcations
	Carrots	240 g dish	SS (food scales)		Portion pot	
	Orange juice	1 litre carton	SS (measuring jug)		200 ml disposable cup	
Meat dishes	Lasagne	1500 g dish	SS (food scales)	Food photo Palm of hand Food photo Food photo Portion pack	Teaspoon	Fraction
	Chicken pieces (cooked)	520 g dish	SS (food scales)			
	Beet curry	1040 g dish	SS (food scales)			
High fat/sugar	Victoria sponge	228 g cake	SS (food scales)			
	Spread	500 g tub	SS (food scales)			
	Crisps	150 g share bag	SS (food scales)			
	White wine	750 ml bottle	SS (food scales)			
	Mayonnaise	400 g jar	SS (food scales)		Portion pot Tablespoon	Average wine glass Measuring spoon Tip of thumb

**Study protocol**

For each food in turn, participants were shown the PSEA that could potentially be used with that food and its respective SS. They were then asked to select the aid they considered to be most appropriate for that food and use it to serve out the indicated SS of that food. Participants were then required to rate each of the PSEA they used in terms of its ease of use (from 1 = ‘not very easy’ to 5 = ‘very easy’) and the likelihood of using it in future (from 1 = ‘not likely’ to 5 = ‘very likely’). Any problems or difficulties encountered while using the PSEA were indicated orally by the participants and noted by the researcher. Participants were then asked to specify foods they thought the PSEA would be most and least useful for, before finally choosing the contexts from a list provided in which they would be most likely to use the PSEA (e.g. eating at work/ breakfast). The weight (in grams) of each food served out was covertly recorded by the researchers.

**Analysis**

Statistical analysis was carried out using the statistical software package IBM SPSS Statistics for Windows Version 20.0. Statistical significance was set at  $P < 0.05$ . To overcome non-normal distributions, non-parametric testing was used throughout. Descriptive statistics were used to derive median ratings for ease of use and likelihood of using the PSEA again. The precision of the PSEA was assessed based on the range (minimum and maximum values) in grams of the estimated SS for each food (i.e. a wider range of weights was indicative of a less precise aid). The  $\chi^2$  goodness-of-fit test was used to determine which PSEA participants selected most frequently and to assess the context participants would be most likely to use the PSEA. Open-ended questions were analysed similar to focus group transcripts by using a thematic framework approach, grouping similar problems with the PSEA together to establish themes, and identifying common foods for which the PSEA would be most and least useful.

**Results**

**Participants**

A total of 120 adults (sixty-one males and fifty-nine females) completed the study protocol, including the demographics questionnaire and the PSEA evaluation. The majority of participants were aged 18–25 years (50%); of normal weight (self-reported median BMI = 23.4 kg/m<sup>2</sup>); single (63%) postgraduate/undergraduate students (51%); following no special diet (88%); and either independently or jointly responsible for preparing and cooking meals (87%).

**Portion size estimation aids selected by participants**

The direct quantification and measuring aids (e.g. using food scales to weigh out the SS on the food label) were the

least frequently selected PSEA by participants for use during the study protocol, aside from crisps, but no alternative PSEA were available for that particular food. Demarcations on food packaging were the most frequently selected PSEA for foods that need to be sliced (block of cheese, 72%; cake, 69%), while cutlery was the most frequently selected PSEA for condiments (spread, 72%; mayonnaise, 59%) and grated cheddar (61%). For the grains, the majority of participants selected the portion pots for the cooked pasta (74%) and the breakfast cereals (Rice Krispies, 76%; Cornflakes, 78%); however, the disposable cup was the most frequently selected PSEA for the dried rice (44%; all  $P < 0.001$ ; Table 2).

### ***Ease of use***

After using the PSEA, participants unanimously rated all PSEA used as being either 'easy to use' (median rating of 4) or 'very easy to use' (median rating of 5). In particular, the quantities and measures and the household measures were given an overall median rating of 5 (i.e. 'very easy to use'; Table 3).

### ***Likelihood of using selected portion size estimation aids in future***

When asked if they would be likely to use the selected PSEA in future, participants indicated that they would be 'likely' or 'very likely' to use the household measures and food packaging again (median ratings overall of 4 and 5, respectively; Table 4). However, while participants were of the opinion that quantities and household measures were easy to use, they were not as likely to use these (median rating overall of 3) particularly not for foods like the grated cheese, lasagne (composite food), crisps or white wine (median ratings of 2). In terms of the reference objects, participants indicated that they would be likely to use the food photos again (median rating of 4), but for all other PSEA in that group they said that they 'might' use them in future (median ratings of 3).

### ***Precision of portion size estimation aids***

The weighing scales and measuring jug (quantities and measures) were consistently the most precise PSEA for all foods: precision (denoted by the range of weights of the foods served out using these PSEA) ranged from 0 g for spread to 60 g for orange juice and was narrower than for all other PSEA (Table 5). Food photos were the least precise, with a range of 336 g and 391 g in the amounts estimated by participants for beef curry and lasagne, respectively. Aside from the quantities and measures, the next most precise set of PSEA overall were the household measures; they had a narrower range of estimated weights in comparison with the reference objects and food packaging, with the exceptions of the average glass for the wine (range 190 g), the tablespoon for the mayonnaise (range 28 g) and the matchbox for the block of cheddar (range 48 g; Table 5).

### ***Context participants would use portion size estimation aids***

The majority of participants indicated they would be most likely to use the PSEA when preparing a meal (94%), particularly dinner (86%) in the home (89%; all  $P < 0.001$ ). There were no differences in the number of participants who indicated they would or would not use the PSEA for breakfast ( $P = 0.10$ ) and lunch ( $P = 0.715$ ). However, the majority of participants indicated they would not use PSEA at any other eating situation, including eating out (93%) and special occasions (72%; all  $P < 0.001$ ). Males in particular indicated they would not use PSEA at special occasions (80%;  $P = 0.032$ ; Table 6), and there was no difference in the number of underweight ( $BMI < 18.5 \text{ kg/m}^2$ ) participants who indicated they would or would not use the PSEA at special occasions compared with the other BMI categories, where the majority indicated they would not use the PSEA at special occasions ( $P = 0.024$ ; Table 7). Older participants (aged 56–64 years) indicated they would be likely to use the PSEA when eating in the company of friends (75%;  $P = 0.004$ ) and at supper time (75%;  $P = 0.005$ ). There were no other differences according to age, gender (Table 6), BMI or occupation status (Table 7; all  $P > 0.05$ ).

### ***Importance of portion size estimation aids for particular foods***

When participants were asked to list foods for which PSEA would be most useful, the vast majority indicated amorphous grain foods particularly rice, breakfast cereals and pasta. Some participants also noted that PSEA would be useful for potatoes. On the other hand, PSEA were thought to be least useful for fruit and vegetables. The results for other foods were less clear-cut. For example, some participants specified the need for PSEA for specific foods/food groups while others were of the opposite opinion. These foods included: fats and oils (e.g. spreads and mayonnaise); cheese; alcohol; high-fat/sugar snacks (e.g. crisps and cake); meat; chicken; and composite dishes (e.g. curry and lasagne).

### ***Perceived problems encountered when using the portion size estimation aids***

When participants were given the opportunity to note any problems with using the PSEA, some common themes emerged. Overall, using PSEA was considered to be time consuming and inconvenient (particularly the weighing scales), involved more washing up, and was necessary only for those on weight-loss diets. It was also pointed out that using PSEA to estimate PS of hot foods such as cooked pasta before transferring it to a plate could reduce the temperature of the food. For the weighing scales, participants were concerned about getting the exact weight in grams and suggested it may affect the appearance of composite foods like lasagne as it would require adding/removing smaller amounts until the suggested amount was

**Table 2** Portion size estimation aids selected for each food (%) by adults (aged 18–64 years) living on the island of Ireland, January–February 2013

Food group	Food	Quantities and measures	Reference objects				Household measures					Food packaging	
		Scales/jug	Food photos	Hand physiology	Portion pack	Matchbox	200 ml disposable cup	Portion pots	Cutlery	Glass	Measuring spoon	Pack markings	Fractions
Dairy	Cheddar (grated)	14						25					
	Cheddar (block)	9				19				61**			
Grains	White rice (uncooked)	8					44**	40				72**	
	Pasta (cooked)	5					21	74**				8	
	Cornflakes	3					19	78**					
Fruit and vegetables	Rice Krispies	2					22	76**					
	Carrots	10					90**						
Meat dishes	Orange juice	34					29					37	
	Lasagne	18	82**										
High fat/sugar	Chicken pieces	35		65*									
	Beef curry	18	82**										
	Cake	2	28										69**
	Spread	2			26					72**			
	Crisps	100											
	White wine	3						23		73**			
	Mayonnaise			5						59**		36	

Significant differences in percentage of participants selecting portion size estimation aids ( $\chi^2$  goodness-of-fit test): \* $P < 0.01$ , \*\* $P < 0.001$ .

**Table 3** Ratings of ease of use† for the portion size estimation aids by adults (aged 18–64 years) living on the island of Ireland, January–February 2013

Food group	Food	Quantities and measures	Reference objects				Household measures					Food packaging		
		Scales/jug	Food photos	Hand physiology	Portion pack	Matchbox	200 ml disposable cup	Portion pots	Cutlery	Glass	Measuring spoon	Pack markings	Fractions	
Dairy	Cheddar (grated)	4						5		5				
	Cheddar (block)	5				4						4		
Grains	White rice (uncooked)	5					5	5				4		
	Pasta (cooked)	4					5	4						
	Cornflakes	5					4	5						
Fruit and vegetables	Rice Krispies	5					4	5						
	Carrots	4					5							
Meat dishes	Orange juice	5					5					4		
	Lasagne	4	4											
High fat/sugar	Chicken pieces	4		4										
	Beef curry	4	4											
	Cake	4	5										5	
	Spread	4			4				5					
	Crisps	5												
	White wine	5						5		5				
	Mayonnaise			5					5		5			
Median rating overall		5	4	4	4	4	5	5	5	5	5	5	4	5

Values are presented as medians.

†Ease of use ratings range from 1 = 'not very easy' to 5 = 'very easy'.

**Table 4** Ratings of likelihood of future use for the portion size estimation aids by adults (aged 18–64 years) living on the island of Ireland, January–February 2013

Food group	Food	Quantities and measures			Reference objects			Household measures				Food packaging	
		Scales/jug	Food photos	Hand physiology	Portion pack	Matchbox	200 ml disposable cup	Portion pots	Cutlery	Glass	Measuring spoon	Pack markings	Fractions
Dairy	Cheddar (grated)	2						4					
	Cheddar (block)	5				3	5				4		
	White rice	5									4		
Grains	(uncooked)												
	Pasta (cooked)	4											
	Cornflakes	5					4						
	Rice Krispies	5					5						
	Carrots	3					3						
Fruit and vegetables	Orange juice	5											
	Lasagne	2	4										
Meat dishes	Chicken pieces	3	4		3								
	Beef curry	3	4										
	Cake	4	3										5
High fat/sugar	Spread	3									5		
	Crisps	2											
	White wine	2											
Median rating overall	Mayonnaise	3	4		3	3	4	4	5	5	4	4	5

Values are presented as medians.

†Likelihood of future use ratings range from 1 = 'not likely' to 5 = 'very likely'.

achieved. The main concerns with the portion pots were: they were 'messy' for foods like cooked pasta; difficult to use for liquids without spilling; they are not widely available; and some were unsuitable for left-handed people. Participants who poured cereals into the pots found them 'messy' whereas those who dipped the pot into the cereal box avoided this issue; this was similar for the disposable cup. In addition, some participants thought it was hard to estimate fractions of the cup (e.g. half a cup).

A large proportion of participants had difficulty using the demarcations on the packet of cheese as some chose to try and cut the serving of cheese while it was still in the packet; however, the demarcations did not run to the edge of the packet which made it awkward to use. Others cut through the packet or took the cheese out of the packet and lined it up with the demarcations to overcome this problem. Difficulty was noted in levelling the rice inside the box in order to use the demarcations effectively.

For the visually impaired, there was concern that markings, fractions and other PS or SS estimation aids displayed on food packaging would be too small for them to see. Participants also indicated that it was difficult to judge the size of the visual PSEA (i.e. the objects, hand physiology, fractions and food photos). With regard to food photos, participants also noted that it was difficult to judge the perspective of the photograph, size of the plate and depth of the food.

Finally, participants specified that detailed instructions would be needed for some PSEA (e.g. whether to use a heaped/level tablespoon) and difficulty in differentiating between the sizes of spoons (e.g. tablespoon *v.* dessert-spoon) was also noted. Spoons and the graduated spoon were deemed inappropriate for 'sticky' foods like spreads and mayonnaise as there tended to be residue left on the PSEA.

## Discussion

In the present study, the precision, ease of use and likelihood of future use of a range of PSEA were examined in practice. Overall, the household measures (e.g. portion pots and 200 ml disposable cup) were the preferred PSEA. They were deemed easy to use, acceptable for future usage and relatively precise, and would most likely be used when preparing the main meal in the home.

The findings of the present study indicate that although the weighing scales and measuring jug were deemed to be the most precise PSEA, consumers would not be very likely to use them on a regular basis. This is not surprising as consumers generally have little or no concept of weight or volume whether expressed in metric units or the imperial system<sup>(5)</sup>. Furthermore, the weighing scales and measuring jug were seen to be more burdensome. Instead, the household measures appear to be the most user-friendly and relatively precise aids. These findings support



**Table 6** Likelihood (indicated by yes/no responses) of using the portion size estimation aids at particular eating occasions and situations, by gender and age group, among adults (aged 18–64 years) living on the island of Ireland, January–February 2013

Eating occasion/situation	Participants' response	Gender								Age group										
		Total (n 120)			Male		Female			18–25 years		26–35 years		36–45 years		46–55 years		56–64 years		P value
		n	%	P value	n	%	n	%	P value	n	%	n	%	n	%	n	%	n	%	
Eating in	Yes	107	89	<b>&lt;0.001</b>	55	90	52	88	0.721	52	87	25	89	13	93	10	100	7	88	0.768
	No	13	11		6	10	7	12		8	13	3	11	1	7	0	0	1	13	
Eating out	Yes	9	8	<b>&lt;0.001</b>	4	7	5	8	0.690	3	5	3	11	0	0	1	10	2	25	0.222
	No	111	93		57	93	54	92		57	95	25	89	14	100	9	90	6	75	
At work	Yes	41	34	<b>0.001</b>	16	26	25	42	0.062	16	27	14	50	3	21	3	30	5	63	0.073
	No	79	66		45	74	34	58		44	73	14	50	11	79	7	70	3	38	
Eating with friends	Yes	32	27	<b>&lt;0.001</b>	15	25	17	29	0.601	15	25	9	32	0	0	2	20	6	75	<b>0.004</b>
	No	88	73		46	75	42	71		45	75	19	68	14	100	8	80	2	25	
In stressful situations	Yes	14	12	<b>&lt;0.001</b>	7	11	7	12	0.947	4	7	5	18	1	7	1	10	3	38	0.092
	No	106	88		54	89	52	88		56	93	23	82	13	93	9	90	5	63	
Lack of time	Yes	24	20	<b>&lt;0.001</b>	14	23	10	17	0.411	11	18	6	21	3	21	2	20	2	25	0.991
	No	96	80		47	77	49	83		49	82	22	79	11	79	8	80	6	75	
Special occasions	Yes	34	28	<b>&lt;0.001</b>	12	20	22	37	<b>0.032</b>	17	28	8	29	3	21	2	20	4	50	0.641
	No	86	72		49	80	37	63		43	72	20	71	11	79	8	80	4	50	
Eating late or after a night out	Yes	16	13	<b>&lt;0.001</b>	8	13	8	14	0.943	6	10	3	11	1	7	3	30	3	38	0.105
	No	104	87		53	87	51	86		54	90	25	89	13	93	7	70	5	63	
Watching television	Yes	31	26	<b>&lt;0.001</b>	16	26	15	25	0.929	16	27	8	29	2	14	2	20	3	38	0.763
	No	89	74		45	74	44	75		44	73	20	71	12	86	8	80	5	63	
Preparing a meal	Yes	113	94	<b>&lt;0.001</b>	56	92	57	97	0.261	56	93	27	96	14	100	9	90	7	88	0.705
	No	7	6		5	8	2	3		4	7	1	4	0	0	1	10	1	13	
Shopping for food	Yes	36	30	<b>&lt;0.001</b>	16	26	20	34	0.359	13	22	12	43	7	50	3	30	1	13	0.091
	No	84	70		45	74	39	66		47	78	16	57	7	50	7	70	7	88	
Breakfast	Yes	69	58	0.100	33	54	36	61	0.443	33	55	17	61	7	50	5	50	7	88	0.438
	No	51	43		28	46	23	39		27	45	11	39	7	50	5	50	1	13	
Lunch	Yes	62	52	0.715	27	44	35	59	0.099	30	50	16	57	5	36	5	50	6	75	0.465
	No	58	48		34	56	24	41		30	50	12	43	9	64	5	50	2	25	
Dinner	Yes	103	86	<b>&lt;0.001</b>	50	82	53	90	0.217	48	80	26	93	13	93	9	90	7	88	0.471
	No	17	14		11	18	6	10		12	20	2	7	1	7	1	10	1	13	
Supper	Yes	39	33	<b>&lt;0.001</b>	21	34	18	31	0.647	12	20	14	50	4	29	3	30	6	75	<b>0.005</b>
	No	81	68		40	66	41	69		48	80	14	50	10	71	7	70	2	25	
Snacks	Yes	39	33	<b>&lt;0.001</b>	19	31	20	34	0.748	14	23	15	54	4	29	3	30	3	38	0.085
	No	81	68		42	69	39	66		46	77	13	46	10	71	7	70	5	63	
Drinks	Yes	35	29	<b>&lt;0.001</b>	17	28	18	31	0.750	13	22	9	32	6	43	4	40	3	38	0.425
	No	85	71		44	72	41	69		47	78	19	68	8	57	6	60	5	63	
Other	Yes	6	5	<b>&lt;0.001</b>	3	5	3	5	0.967	1	2	2	7	0	0	2	20	1	13	0.088
	No	114	95		58	95	56	95		59	98	26	93	14	100	8	80	7	88	

Significant *P* values ( $\chi^2$  goodness-of-fit test) are indicated in bold font.



**Table 7** Likelihood (indicated by yes/no responses) of using the portion size estimation aids at particular eating occasions and situations, by BMI category and occupational status, among adults (aged 18–64 years) living on the island of Ireland, January–February 2013

Eating occasion/ situation	Participants' response	BMI category†										Current occupational status													
		Underweight		Normal weight		Overweight		Obese		P value	Employed full-time		Employed part-time		Full-time home maker		Unemployed		Student		Never worked		Retired		P value
		n	%	n	%	n	%	n	%		n	%	n	%	n	%	n	%	n	%	n	%	n	%	
Eating in	Yes	5	83	63	88	23	100	11	85	0.312	43	88	6	100	2	100	2	100	54	89	0	0	0	0	0.854
	No	1	17	9	13	0	0	2	15	6	12	0	0	0	0	0	0	7	11	0	0	0	0		
Eating out	Yes	1	17	2	3	3	13	2	15	0.138	3	6	2	33	0	0	0	0	4	7	0	0	0	0	0.177
	No	5	83	70	97	20	87	11	85	46	94	4	67	2	100	2	100	57	93	0	0	0	0		
At work	Yes	2	33	22	31	9	39	6	46	0.682	21	43	3	50	0	0	0	0	17	28	0	0	0	0	0.243
	No	4	67	50	69	14	61	7	54	28	57	3	50	2	100	2	100	44	72	0	0	0	0		
Eating with friends	Yes	2	33	17	24	9	39	4	31	0.526	14	29	2	33	1	50	0	0	15	25	0	0	0	0	0.801
	No	4	67	55	76	14	61	9	69	35	71	4	67	1	50	2	100	46	75	0	0	0	0		
In stressful situations	Yes	1	17	7	10	4	17	1	8	0.715	7	14	1	17	0	0	1	50	5	8	0	0	0	0	0.367
	No	5	83	65	90	19	83	12	92	42	86	5	83	2	100	1	50	56	92	0	0	0	0		
Lack of time	Yes	0	0	17	24	5	22	1	8	0.343	11	22	2	33	1	50	0	0	10	16	0	0	0	0	0.563
	No	6	100	55	76	18	78	12	92	38	78	4	67	1	50	2	100	51	84	0	0	0	0		
Special occasions	Yes	3	50	27	38	2	9	2	15	<b>0.024</b>	14	29	4	67	0	0	0	0	16	26	0	0	0	0	0.195
	No	3	50	45	63	21	91	11	85	35	71	2	33	2	100	2	100	45	74	0	0	0	0		
Eating late or after a night out	Yes	2	33	9	13	1	4	2	15	0.269	7	14	3	50	0	0	0	0	6	10	0	0	0	0	0.082
	No	4	67	63	88	22	96	11	85	42	86	3	50	2	100	2	100	55	90	0	0	0	0		
Watching television	Yes	2	33	17	24	7	30	3	23	0.881	12	24	3	50	1	50	1	50	14	23	0	0	0	0	0.500
	No	4	67	55	76	16	70	10	77	37	76	3	50	1	50	1	50	47	77	0	0	0	0		
Preparing a meal	Yes	6	100	65	90	23	100	13	100	0.226	46	94	6	100	2	100	2	100	57	93	0	0	0	0	0.953
	No	0	0	7	10	0	0	0	0	3	6	0	0	0	0	0	0	4	7	0	0	0	0		
Shopping for food	Yes	1	17	20	28	9	39	3	23	0.601	18	37	1	17	0	0	2	100	15	25	0	0	0	0	0.094
	No	5	83	52	72	14	61	10	77	31	63	5	83	2	100	0	0	46	75	0	0	0	0		
Breakfast	Yes	4	67	40	56	14	61	8	62	0.918	29	59	6	100	0	0	1	50	33	54	0	0	0	0	0.110
	No	2	33	32	44	9	39	5	38	20	41	0	0	2	100	1	50	28	46	0	0	0	0		
Lunch	Yes	4	67	31	43	14	61	9	69	0.169	26	53	5	83	1	50	1	50	29	48	0	0	0	0	0.580
	No	2	33	41	57	9	39	4	31	23	47	1	17	1	50	1	50	32	52	0	0	0	0		
Dinner	Yes	6	100	59	82	20	87	12	92	0.530	44	90	5	83	2	100	2	100	50	82	0	0	0	0	0.722
	No	0	0	13	18	3	13	1	8	5	10	1	17	0	0	0	0	11	18	0	0	0	0		
Supper	Yes	3	50	23	32	8	35	5	38	0.817	20	41	2	33	0	0	1	50	16	26	0	0	0	0	0.422
	No	3	50	49	68	15	65	8	62	29	59	4	67	2	100	1	50	45	74	0	0	0	0		
Snacks	Yes	3	50	21	29	8	35	5	38	0.690	19	39	2	33	2	100	0	0	16	26	0	0	0	0	0.131
	No	3	50	51	71	15	65	8	62	30	61	4	67	0	0	2	100	45	74	0	0	0	0		
Drinks	Yes	2	33	25	35	5	22	2	15	0.411	15	31	2	33	0	0	0	0	18	30	0	0	0	0	0.782
	No	4	67	47	65	18	78	11	85	34	69	4	67	2	100	2	100	43	70	0	0	0	0		
Other	Yes	0	0	4	6	2	9	0	0	0.657	5	10	0	0	0	0	0	0	1	2	0	0	0	0	0.312
	No	6	100	68	94	21	91	13	100	44	90	6	100	2	100	2	100	60	98	0	0	0	0		

Significant *P* values ( $\chi^2$  goodness-of-fit test) are indicated in bold font.†Underweight, BMI < 18.5 kg/m<sup>2</sup>; normal weight, BMI = 18.5–24.9 kg/m<sup>2</sup>; overweight, BMI = 25.0–29.9 kg/m<sup>2</sup>; obese, BMI ≥ 30.0 kg/m<sup>2</sup>.

they aimed to serve out with each PSEA). This was because, for many of the PSEA, there was no indication as to the basis of its SS or the weight of the SS in grams that it aimed to represent. Indeed, as the putative SS for some PSEA were either unknown or inconsistent due to different aims (e.g. weight loss or weight maintenance), it was not appropriate to compare their median estimated weights as a means of assessing their accuracy. However, the ranges of the estimated weights served out of each food were compared to examine the precision of the PSEA.

The relative imprecision of SS estimated with the aid of reference objects, particularly food photographs, is an issue that needs to be addressed. A previous report recommended a combination of PSEA that included visual images<sup>(9)</sup>. However, in the present study, a wide range of SS were estimated with food photographs which suggests they may not be an accurate guide to their intended SS. Participants highlighted the fact that it was difficult to judge the size of the plate, depth of the food and perspective of the food photograph. In addition, it has been found that consumers can be sceptical of food photographs when displayed on food packaging with the belief that they are for marketing purposes only<sup>(5)</sup>. In contrast, food photographs were found to be relatively accurate PSEA for use with children<sup>(28–30)</sup>. Nevertheless, there are no validated alternative PSEA for composite foods. Therefore, further development is needed to establish effective PSEA for home-cooked and amorphous composite dishes<sup>(9)</sup>. Three-dimensional food models have previously been effective in the classroom setting<sup>(31)</sup>, yet other aids such as adjustable wedges and rulers have resulted in some error<sup>(32)</sup>. Alternatively, perhaps the application of demarcations and fractions could be extended to packaged composite foods that require slicing such as pies and lasagne. In addition, a recent Canadian study advised caution with the use of reference objects as an evaluation of a range of household- and sports-related objects revealed that they did not always reflect the true weight or volume of food as intended<sup>(18)</sup>. This highlights the need to have a sound and consistent basis for the putative weights and volumes of PSEA, and to provide clear indication as to whether they are aimed at optimising health or aiding weight loss in order to resonate with consumers and portray realistic SS.

## Conclusion

In terms of precision, ease of use and likelihood of future use, household measures should be promoted to consumers as effective aids for the estimation of appropriate PS of amorphous grains such as rice. Food packaging (i.e. demarcations and fractions) may be an effective aid for foods that require slicing such as cheese; however, they should be accompanied by clear instructions in order to improve precision. Further research is needed to establish

more precise PSEA for composite foods. In conclusion, the provision of 'fit-for-purpose' PSEA and guidance is vital to empower consumers with the ability and motivation to select more appropriate PS.

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