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Can children and adolescents use photographs of food to estimate portion sizes?

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Objective: The goals of this study were to investigate whether children and adolescents can accurately estimate portion sizes of preweighed food by viewing photographs of food, and whether age influences the ability to estimate food portion sizes.
Subjects: A total of 63 male and female volunteers aged 9–19 y participated in the study.
Design: Each participant received a photographic booklet with photograph series of 13 food items. Participants over 10 y of age were asked to estimate portion sizes of food on 34 plates placed in front of them by comparing the different portions to corresponding photographs of food. Younger participants were asked to estimate portion sizes of food on 17 plates by comparing the portions to photographs.
Results: Participants made 2019 comparisons between actual food portion sizes and photographs of food portion sizes. On average, 60% of the comparisons were made correctly. A photograph directly adjacent to the photograph depicting the correct portion size was chosen in 35% of the comparisons and 5% of the comparisons were made incorrectly. Portion sizes were estimated more accurately when the actual served portions of food had exactly the same appearance as the foods portrayed in the photographic booklet. No differences existed between children's and adolescents' abilities to estimate portion sizes using photographs.
Conclusions: Large variability may exist in an individual's capability of choosing a photograph that correctly depicts food portion sizes, but the error at the group level is quite small. These data indicate that a photographic booklet of foods can be a useful tool for portion size estimates in these age groups.
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Introduction

Estimation of portion sizes has always been a challenge in dietary studies among free-living subjects. Methods used to quantify food intakes may be divided into two broad categories: those in which foods are weighed directly and those in which food quantities are estimated. Use of scales may minimise the problem of portion size estimation. However, weighing each food item can introduce changes in eating habits, and there are circumstances where weighing are not suitable, for example, in large epidemiologic studies (Nelson *et al*, 1996; Nelson & Bingham, 1997). Several widely used dietary survey methods, such as food frequency questionnaires and food diaries, rely upon the ability of subjects to accurately describe food portion sizes in household measures.

Visual aids, such as food photographs, may help to improve participants' accuracy in reporting food quantification. Photographs of foods have been used to help subjects estimate portion size in several large epidemiological studies (Hankin *et al*, 1983; Pietinen *et al*, 1988; Slimani *et al*, 1999). Some studies have evaluated the use of photographs in portion size assessment (Faggiano *et al*, 1992; Tjønneland *et al*, 1992; Haraldsdottir *et al*, 1994; Nelson *et al*, 1994, 1996; Håglin *et al*, 1995; Lucas *et al*, 1995; Robinson *et al*, 1997; Robson & Livingstone, 2000; Frobisher & Maxwell, 2003) by illustrating up to eight portion sizes for one food item (Nelson *et al*, 1994, 1996; Frobisher & Maxwell, 2003).

Participants in prior evaluation studies of photographic booklets have typically been between the ages of 18 and 90 y

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(Pietinen *et al*, 1988; Faggiano *et al*, 1992; Haraldsdottir *et al*, 1994; Nelson *et al*, 1994, 1996; Lucas *et al*, 1995; Robinson *et al*, 1997). To our knowledge, only one previously published evaluation study used photographs in portion size estimation among children (Frobisher & Maxwell, 2003).

The present study assessed whether children and adolescents could accurately estimate portion sizes of preweighed food by viewing photographs of food, and whether age influenced their abilities to estimate food portion sizes.

Methods

Photographic booklet

The photographic booklet of foods used in the present study was developed for use in a nationwide dietary survey among Norwegian children and adolescents (UNGKOST-2000) (Øverby *et al*, 2004). The photographic booklet embodies 13 colour photograph series. The selection of food items for the photographic booklet was based on several considerations. In focus group interviews among children, we found that voluminous foods were difficult to estimate in household measures like decilitre or spoonfuls. Therefore, several of these food items were included (eg meat sauce, cornflakes and porridge). Moreover, experiences from earlier dietary studies have shown that for example a slice of pizza vary both in size and shape (ie triangular and square) and it is thereby difficult to estimate the portion size correctly.

The portion sizes presented in the photographic booklet range from small (A) to large (D) portion sizes. Since Norwegian standard portion sizes are not available for children, the different portion sizes are based on earlier experiences and each photographic series ranges from a spoonful to a full plate (see Appendix A). Four photographs, an even number, were chosen to avoid the middle option being chosen out of convenience.

The photographs were taken from an angle of 42°, which was considered to provide the best compromise between showing both the depth and height of the foods (Nelson *et al*, 1994; Robson & Livingstone, 2000). One page in the photographic booklet presented two photographic series of four photographs, and each photograph was 50×65 mm in size.

Subjects

Participants were between 9 and 19 y of age. Of the 63 participants (41 female and 22 male), 11 were 9–10-y-olds, 20 were 13–15-y-olds and 32 were 16–19-y-olds. One primary school class and two secondary school classes were invited to take part, along with students from a college. All pupils and students who had the opportunity to attend during the data collecting period were included. Information letters were sent to the parents of those younger than 16 y of age.

Design

To compare estimates of food portion sizes, participants were presented with actual plates of food and asked to compare portion sizes to foods depicted in photographs. The participants were instructed to write down which photograph in their view most closely corresponded to the portion on the plate. The foods presented on the plates were prepared using the same recipes as the foods presented in the photographic booklet. Data were collected during 3 days and the food was continuously made to look fresh. All foods were presented cold and the participants did not consume any of the food.

Participants were presented with 17 different food items in two different portion sizes. Of the 17 food items, 12 were similar to food items depicted in the photographic booklet. Five of the 17 food items were not depicted in the booklet, but participants used photographs of other food items to estimate portion size (ie, photographs of spaghetti were used for estimating portion sizes of spaghetti with tomato sauce and portion sizes of rice; photographs of ice cream were used for estimating portion sizes of chocolate pudding; photographs of cornflakes were used for estimating portion sizes of other breakfast cereals, and photographs of french-fried potatoes were used for estimating fried potatoes). In total, 34 comparisons were made per participant, except for the 9–10-y-olds who only made 17 comparisons each. This was done to ensure that the attention was kept high during the whole session among the youngest age group.

Half of the portion sizes shown to participants (17 of 34 portions) had the same portion size as those depicted in one of the photographs, and 17 of the portion sizes were either 1/3 above or 1/3 below a portion size shown on a photograph (Table 1).

Analysis

The agreement between the photograph chosen by the participants and the photograph that depicted the correct portion size are presented in two ways:

(1) As the percentages of participants choosing the correct photograph, the photograph adjacent to the correct photograph or a distant photograph when comparing food items presented on plates with photographs in the photographic booklet (Table 1).
(2) As the mean difference between the portion size on the photograph chosen by the participants and the portion size on the correct photograph (Table 2). These differences express the error at group level. The percentage presented in Table 2 was calculated for food items and portion sizes using this formula:

$$[(\text{mean portion size on the photographs chosen by the participants (g)} - \text{portion size on the correct photograph (g)})/\text{portion size on the correct photograph (g)} \times 100]$$

χ^2-test for independence (or Fisher's exact probability test if one or more cells had expected counts less than five) was

Table 1 Percentages of participants choosing correct photograph, adjacent photograph or distant photograph when comparing food items presented on plates with photographs of food

		Adjacent photograph (%)		*Distant photograph (%)*	
Food items on the plates[a,b,c,d]	*Correct photograph (%)*	*−1*	*+1*	*>−1*	*>+1*
Fat-spread on bread 1 ($n=63$)[c]	35		52		13
Fat-spread on bread 2 ($n=52$)	14		87		
Cornflakes 1 ($n=63$)[c]	78	16	6		
Cornflakes 2 ($n=52$)	67	14	19		
Porridge 1 ($n=63$)	29		71		
Porridge 2 ($n=52$)[c]	85		14	2	
French-fries 1 ($n=62$)	2	52		45	
French-fries 2 ($n=52$)[c]	96		4		
Spaghetti 1 ($n=63$)[c]	79	19	2		
Spaghetti 2 ($n=52$)	29	69		2	
Pizza triangle 1 ($n=63$)	89	11			
Pizza triangle 2 ($n=52$)[c]	100				
Pizza square 1 ($n=63$)	22		78		
Pizza square 2 ($n=51$)[c]	96	2	2		
Breakfast cereals 1 ($n=63$)[b]	78		18		5
Breakfast cereals 2 ($n=51$)[b]	43		51		6
Chocolate pudding 1 ($n=63$)	57		41		2
Chocolate pudding 2 ($n=52$)	19		56		25
Fried potatoes 1 ($n=63$)[b]	5	75	2	19	
Fried potatoes 2 ($n=52$)	39	56	6		
Spaghetti & tomato sauce 1 ($n=63$)	97		3		
Spaghetti & tomato sauce 2 ($n=52$)[b]	31	67		2	
Rice 1 ($n=63$)[b]	22	75		3	
Rice 2 ($n=52$)	87		14		
Mashed potatoes 1 ($n=63$)	64		35		2
Mashed potatoes 2 ($n=52$)[c]	98	2			
Salad 1 ($n=63$)	87	6	6		
Salad 2 ($n=52$)[c]	65	25	10		
Mixed vegetables 1 ($n=63$)[c]	98		2		
Mixed vegetables 2 ($n=52$)	2		46		52
Meat sauce 1 ($n=62$)[c]	95		2		2
Meat sauce 2 ($n=52$)	92	2	6		
Fish 1 ($n=63$)[c]	56		44		
Fish 2 ($n=52$)	71	19	10		

[a]Food items marked with 1 and 2 are different portion sizes for the same food item.
[b]Food items with the same portion size but not the same type of food as in the photographic booklet.
[c]Food items with the same appearance, both in type of food and portion size, as in the photographic booklet.
[d]n = the number of participants making that specific comparison.

used to test whether the percentages of correctly chosen photographs differed with age (three age groups), and whether appearance of portion size and food item influenced the percentages of correctly chosen photographs. SPSS (version 11.0) was used for analyses. The cutoff level for statistical significance was $P<0.05$. Many variables were analysed and concern with multiple comparisons must be kept in mind when drawing conclusions.

Results

The distribution of gender was not equally distributed, with more girls than boys participating in the study.

Of the 52 participants aged 13–19 y, 50 completed all 34 assessments of portion sizes, two participants missed two assessments each and completed 32 assessments, and the 9–10-y-olds evaluated 17 portion sizes. A total of 2019 comparisons were made between actual food portion sizes and photographs of foods. Table 1 shows the percentages of comparisons in which the photograph that actually depicted the portion size was chosen as matching the food item on a plate, as well as the percentages of comparisons in which an adjacent or distant photograph was chosen as matching. On average, 60% of the comparisons were made correctly; that is, participants chose photographs that correctly depicted portion sizes of food on a plate. A photograph directly adjacent to the photograph depicting the correct portion size was chosen for 35% of the comparisons and 5% of the comparisons were incorrect by more than one photograph. The percentages of correct comparisons varied between 2 and 100%, depending on the food item and the portion size

Table 2 Difference between the portion sizes on the photograph chosen by the participants and the portion size on the correct photograph

Food items on the plates[a,b,c]	*Served portion size gram (g)*	*Difference between served portion size and correct photograph (g)*	*Difference between the portion sizes on the photograph chosen by the participants and the portion size on the correct photograph*[d] *% (g)*
Fat-spread on bread 1 ($n=63$)[b]	3	0	67% (2)
Fat-spread on bread 2 ($n=52$)	10	+1	33% (3)
Cornflakes 1 ($n=63$)[b]	30	0	−3% (−1)
Cornflakes 2 ($n=52$)	50	−7	4% (2)
Porridge 1 ($n=63$)	100	+50	142% (71)
Porridge 2 ($n=52$)[b]	350	0	4% (14)
French-fries 1 ($n=62$)	110	−10	−3% (−44)
French-fries 2 ($n=52$)[b]	30	0	3% (1)
Spaghetti 1 ($n=63$)[b]	160	0	−10% (−16)
Spaghetti 2 ($n=52$)	220	−30	−26% (−66)
Pizza triangle 1 ($n=63$)	150	−15	−4% (−6)
Pizza triangle 2 ($n=52$)[b]	270	0	0% (0)
Pizza square 1 ($n=63$)	70	+18	94% (49)
Pizza square 2 ($n=51$)[b]	165	0	1% (1)
Breakfast cereals 1 ($n=63$)	46	0	57% (26)
Breakfast cereals 2 ($n=51$)	138	0	57% (78)
Chocolate pudding 1 ($n=63$)	55	−21	30% (23)
Chocolate pudding 2 ($n=52$)	139	+11	58% (74)
Fried potatoes 1 ($n=63$)	120	0	−28% (−34)
Fried potatoes 2 ($n=52$)	139	+19	−17% (−20)
Spaghetti & tomato sauce 1 ($n=63$)	45	+11	3% (1)
Spaghetti & tomato sauce 2 ($n=52$)	160	0	−40% (−64)
Rice 1 ($n=63$)	208	0	−46% (−95)
Rice 2 ($n=52$)	74	−14	18% (16)
Mashed potatoes 1 ($n=63$)	255	+50	28% (57)
Mashed potatoes 2 ($n=52$)[b]	500	0	−1% (−3)
Salad 1 ($n=63$)	125	+25	2% (2)
Salad 2 ($n=52$)[b]	52	0	0% (0)
Mixed vegetables 1 ($n=63$)[b]	40	0	3% (1)
Mixed vegetables 2 ($n=52$)	145	−15	−36% (−58)
Meat sauce 1 ($n=62$)[b]	50	0	14% (7)
Meat sauce 2 ($n=52$)	150	−50	3% (6)
Fish 1 ($n=63$)[b]	27	0	93% (25)
Fish 2 ($n=52$)	65	−19	−7% (−6)

[a]Food items marked with 1 and 2 are different portion sizes for the same food item.
[b]Food items with the same appearance, both in type of food and portion size, as in the photographic booklet.
[c]n = the number of participants making that specific comparison.
[d]The mean percentage difference was calculated as

$$[(\text{mean portion size on the photographs chosen by the participants (g)} - \text{portion size on the correct photograph (g)}) / \text{portion size on the correct photograph (g)} \times 100]$$

The mean difference expressed as gram is presented in the parenthesis.

on the plate, but for most food items, 95% of the comparisons were within an error of ±1 photograph (Table 1).

The highest percentages of correctly made portion size comparisons were observed for mashed potatoes, pizza, meat sauce, salad and cornflakes. For both the served portion sizes of fat-spread on bread and fried potatoes, less than 40% of the comparisons were made correctly. For the other food items presented in Table 1, one of the two portion sizes served often had low percentages of correct comparisons.

At the individual level, variations were seen in the number of incorrect (adjacent or distant) photographs selected by the participants (data not shown). Among the 50 participants who estimated 34 portion sizes, an incorrect photograph was chosen for, on average, 14 of the 34 comparisons, with a range of 9–19. Three participants chose an incorrect photograph for more than 17 comparisons. Moreover, three other participants had four or five comparisons in which they chose a photograph that was two or three away from the correct photograph.

When a food item served on the plates appeared in exactly the same way as it appeared in the photographic booklet (12 of the served portion sizes), participants chose the correct photograph 82% of the time. Served portions that differed from photographs in the photographic booklet—either in portion size, type of food or both (22 of the served portion

sizes—were estimated correctly in 48% of the comparisons (Table 1).

For most food items, no significant differences existed between the 9–10-, 13–15- and 16–19-y-olds' abilities to choose the correct photograph in the photographic booklet. Only for one portion size of chocolate pudding, fried potatoes, pasta with tomato sauce and fish were there significant differences in percentages of correct photographs between the three age groups.

Table 2 shows the mean percentage difference between the portion sizes on the photograph chosen by the participants and the portion sizes on the correct photograph for all food items and portion sizes served. The percentage difference ranged from 0 to 142%. For 19 of the served food items, participants chose photographs with portion sizes that, on average, deviated less than 20% from the portion size on the correct photograph, while for seven food items, participants chose photographs with portion sizes that deviated more than 50% from the portion size on the correct photograph.

Discussion

Overall, 60% of the 2019 comparisons conducted in the present study were made correctly. Others have found correct portion size estimations in the range from 40 to 70%, but the study designs differ notably between the studies (Haraldsdottir *et al*, 1994; Nelson *et al*, 1994; Lucas *et al*, 1995).

Frobisher and Maxwell (2003) studied both children's and adults' abilities to estimate portion sizes with help of a photographic atlas. Errors in portion size estimates were observed for most foods, regardless of age, but errors were greater for children than for adults; median difference ranged from −33 to 79% for children and from 5 to 73% for adults. In the present study, the differences in the participants' abilities to choose the correct photograph in the photographic booklet were not related to age.

The participants' ability to choose the correct photograph differed according to photographic series. The photographic series for meat sauce, mashed potatoes, pizza and salad had the highest degree (about 85%) of correct comparisons. One explanation of why participants more successfully matched these food items to photographs as compared to other food items may be that three of these food items have a defined surface. Pizza is, in this context, the most defined food item, and meat sauce and mashed potatoes were served in stiff mounds. Salad did not have a defined surface, but kept a shape similar to the salad depicted in the photograph. Other food items, however, like porridge and fish, which also had defined surfaces and clear edges, had smaller percentages of correct comparisons.

The fact that portion sizes of some foods appeared to be more difficult to estimate accurately than others is a common finding (Nelson *et al*, 1994), although different studies show different rankings of food items. In one study (Nelson *et al*, 1994), the largest error in rates of portion size estimation occurred for mashed potatoes and the smallest error occurred for cornflakes. In the present study, however, portion sizes of both mashed potatoes and cornflakes were largely estimated correctly.

Findings from this study suggest that assessing a photograph that depicts the actual portion size of food is easier when the served food and the photograph of the food appear to be exactly the same (Tables 1 and 2). For french-fried potatoes and mixed vegetables, a large difference existed in the percentages of correct comparisons between the two served portion sizes. One of the two portions of french-fried potatoes was correctly estimated in 96% of the comparisons (Table 1), while only 2% of the comparisons for the other portion sizes were correct. An explanation for this difference could be that the largest portion of french-fried potatoes was scattered around the plate while handed from participant to participant, thus the food was not arranged on one side of the plate like in the photograph; the same situation occurred with the large portion of mixed vegetables. In fact, several participants pointed out that the differences in the appearance of foods made assessing the correct photograph difficult. For example, with the first portion of served pizza, one side of the pizza square was slightly curved, whereas in the photograph all sides of the pizza were straight, and as we can see from the score (Table 1), only 22% of the participants chose the correct photograph. For the other three pizza portions, almost all comparisons were made correctly. Others have also looked into this phenomenon. Lucas *et al* (1995) found that if the real food differed from the photograph in number of food items (eg, crackers, potatoes) or thickness of slices or distribution on the plate, participants had difficulties estimating the correct portion sizes. Robson and Livingstone (2000) contradicts this finding and states that, overall, little evidence indicated that any particular food shape or other visual characteristics influenced the extent of over- or underestimation of portion sizes.

We observed low percentages of correct comparisons for both portion sizes of fat-spread on bread and fried potatoes (Table 1). However, the average percentage difference between portion size on the chosen photographs and portion size on the correct photograph for fried potatoes was only −23%, while it was somewhat higher (50%) for fat-spread on bread (Table 2). It seems as if these two food items showed poor estimates at the individual level, but showed fewer differences at the group level.

In general, the mean difference between the portion sizes on the photograph chosen by the participants and the portion size on the correct photograph was less than one photograph away from the correct photograph for all but three food portions. This indicates that even if large variability exists in the error at the individual level, the error at the group level was less than one photograph away from the correct photograph.

The consequences both for energy and nutrient intake for misclassifying portion sizes vary between different types of

food. For example, the energy intake from fat-spread on bread in photograph A is 90 kJ (3 g), B is 180 kJ (6 g), C is 270 kJ (9 g) and D is 360 kJ (12 g). If a participant who ate 5 slices of bread per day chose the photograph adjacent to the correct photograph, the difference in reported energy intake per day would be 450 kJ. If the participant chose two photographs away from the correct photograph, the difference in reported energy intake would be 900 kJ per day. On average, we found that fat-spread was overestimated by 67 and 33%, respectively (2 and 3 g) (Table 2), and thereby was not more than one photograph away from the correct photograph. However, with one of the served portion sizes, 13% of the participants (Table 1) chose a photograph two photographs removed from the correct photograph, and on a daily basis at the individual level, the fat-spread on bread question could add up to $\pm 10\%$, depending on the participant's total energy intake. For another example, if a participant ate mixed vegetables portion size B and chose an adjacent photograph as being the correct portion size, the reported energy intake difference would be small (81 kJ), but the β-carotene difference between the portion sizes would be more substantial (1073 μg). During a food registration period, it is likely that food items eaten frequently would contribute more to the total amount of energy or nutrient intake than food items eaten seldom; thus, correctly estimating portion sizes of food items eaten frequently is important.

Estimating food quantity with the aid of food photographs is a highly complex and multifaceted task. The process of using a photograph to identify portion size has three main elements: perception, conceptualisation and memory. In this study, conceptualisation and memory were eliminated because the estimates were made with no time delay between seeing the food and using the photographic booklet (Nelson *et al*, 1996). The study was conducted under highly controlled conditions where the participants neither served themselves nor ate the food afterwards. If estimation of the portion sizes was not successful in these ideal surroundings, one should assume that a photographic booklet is not a feasible method to use in real-life conditions.

In food surveys, all kinds of food is both served and ate, and most likely not in the shape and portion sizes as shown in the photographic booklet. The present study shows both 'the best case' scenario when the food on the plate and in the photograph was exactly the same, and 'the next best case' when food and portion size differ from the photograph in some way. When 'the best cases' were presented for the subjects 82% chose the correct photograph, while when 'the next best cases' were presented, 48% chose the correct photograph. This difference in accuracy seems to illustrate that it is the divergence from the photograph in size or food item that make the portion size more difficult to assess, and not so much the photograph or the assessment situation in it self. However, nearly all food items were estimated within ± 1 photograph from the correct photograph independent of the foods appearance on the plate.

The photographic booklet used in this study was developed for use among 9- and 13-y-olds in the national survey UNGKOST. The participants included were selected to represent the age groups included in UNGKOST. The sample was a convenience sample and relatively small, which is a limitation of the study and reduces the generalisablity of the results. In the national survey, parents were asked to help the 9-y-olds to estimate portion sizes; however, knowing the extent to which the children themselves are able to estimate portion sizes is important.

In conclusion, results indicate that, even with large variability in the capability for choosing a photograph depicting actual food portion sizes at the individual level, the error at the group level is small. We observed that portion sizes with exactly the same appearance as in the photographic booklet were more correctly estimated than portion sizes which differed in food type and size. However, nearly all food items were estimated within ± 1 photograph from the correct photograph independent of the foods appearance on the plate. Thus, a photographic booklet of foods appears to be a valuable tool for estimating portion sizes among children and adolescents.

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Appendix A

Weights of the foods represented in the photographic booklet are given in Table A1.

Table A1 Weights (g) of the foods represented in the photographic booklet (photographs A–D)

	Photograph A (g)	*Photograph B (g)*	*Photograph C (g)*	*Photograph D (g)*
Fat-spread on bread	3	6	9	12
Cornflakes	10	30	57	86
Porridge	50	200	350	500
Spaghetti	34	68	160	250
Mashed potatoes	60	205	355	500
French fries	30	60	90	120
Mixed vegetables	40	80	120	160
Salad	33	52	100	175
Meat sauce	50	200	350	500
Pizza, triangular	56	114	165	270
Pizza, square	52	112	165	270
Fish	27	84	134	166
Ice cream	38	64	97	139