



Accuracy of food photographs for quantifying food servings in a lunch meal setting among Danish children and adults

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21 **Abstract**

22 Background: Visual aids, such as food photographs, are widely used in estimating food quantities in
23 dietary surveys. The purpose of the present study was to assess how accurately Danish adults and
24 children can estimate food portion sizes using 37 series of photographs illustrating 4-6 different
25 portion sizes under real-life conditions, whether adults were more accurate than children, and to
26 estimate the error caused by using portion-size photos to estimate weights of foods consumed in
27 macronutrient calculation.

28 Methodology: 622 adults and 109 children were recruited in three workplace canteens and in two
29 schools, respectively, to estimate their lunchtime portions based on photos. Participants were told to
30 keep the foods separated on their plate when taking lunch. Participants thereafter estimated their
31 own portions by looking at the relevant photo series. Then the actual food portions were weighed.

32 Results: The proportion of correct estimations was 42% overall (range; 19%-77%). The mean
33 difference (%) between estimated and actual weight was 17% (range; 1%-111%). Small portion size
34 photographs were more often used correctly compared with larger portion photographs. Children
35 had as many correct estimations as adults, but overestimated portions more. Participants using
36 fractions of, or more than, one photo to estimate the portion of a food had significantly larger errors.
37 When calculating the macronutrient content of a weekly menu using the estimated portion sizes,
38 protein had the largest error (29%).

39 Conclusion: When used in a real-life situation the portion size photos validated in the present study
40 showed a certain inaccuracy compared with the actual weights.

41

42 **Introduction:**

43 Quantification of consumed portions is associated with large measurement errors in most dietary
44 assessment methods but food weighing (1).

45 In epidemiologic studies including dietary data collection and food surveillance and national dietary
46 surveys, weighing of food portions is often not feasible. Standard portions, household-measures,
47 food models and food photos have therefore been used as aids for quantitative estimation of the
48 eaten food items (2-5). The use of standard portions assigns the same portions to all participants and
49 thereby underestimates the true variation in eaten portion sizes and compromises the ability to rank
50 participants according to true intake. The use of household measures to estimate intake may be
51 particularly difficult for individuals who are not accustomed to using household measures in food
52 preparation. Therefore, visual aids, such as photos of different portion sizes, have been widely used
53 to improve participants' accuracy in reporting food quantities (6-9). Portion size photos are practical
54 to distribute to participants in a dietary survey either in a booklet using paper or via the internet.
55 Portion size photos are also used in the Danish National Survey of Diet and Physical Activity 2011-
56 13 (DANSDA 2011-13) by participants to estimate portion size for a large number of foods (10).

57 Several authors have validated the accuracy of using portion size photos to estimate portion size
58 (8,11-14). However, many studies have been conducted in controlled settings. In these studies,
59 participants are invited to the investigating unit and are presented with a number of single pre-
60 weighed foods on standard plates. Often the same foods weights and plates as presented on the food
61 photographs are used as reference measures. Participants are asked to compare the portions
62 presented on the plates to the portion sizes depicted in the photographs and to write down which
63 photograph most closely corresponds to the portion on the plate (8,11,12,15). This procedure has
64 the advantage that the same participant can compare all of the different depicted food portions in a
65 short time period. In the above-mentioned studies, between 15 to 52 servings were evaluated by the
66 same participant in one setting. This sort of evaluation gives little information about the success of
67 the use of portion size photos to estimate food portion sizes in a real dietary assessment. It tests
68 participants' ability to compare a serving size of a single food to a photo of the exact same food.
69 Foods eaten by individuals are often eaten as meals with several other food items on the plate, often
70 overlapping and most likely appearing differently than the foods presented in the food photographs
71 or in the pre-weighed foods participants were asked to compare with the photographs. In a real life
72 situation, people serve themselves and eat what they give themselves, but in the studies, described

73 participants are comparing foods and portion sizes that may not be relevant and familiar to
74 participants, which may introduce errors. Furthermore, this “laboratory” validation technique does
75 not allow for calculating how errors in portion size estimation by photos may influence the
76 following nutrient calculation, because single food items are evaluated and not meals that allow for
77 meaningful nutrient calculation.

78 The purpose of the present study was to assess how accurately Danish adults and children can
79 estimate food portion sizes under realistic eating situation using photographs of foods, whether
80 adults were more accurate than children, whether the option to specify fractions of a portion size
81 image or to choose from two or more images to describe the portion were just as accurate as
82 choosing the image that came closest to the portion size, and the influence of estimating portion
83 sizes by photos or by weight on the calculation of macronutrient intake from a weekly lunch menu.

84

85 **Method**

86 *Food photographs*

87 The food photographs used in the present study were developed for use in the DANSDA 2011-13
88 among 4-75 year olds. The DANSDA 2011-13 uses a 7-day pre-coded food record where
89 participants continuously record what they have eaten, and the portion sizes are given in predefined
90 household measures (e.g. cups, glasses and spoons) or estimated from 41 series of photos of
91 different portion sizes.

92 In the present study, 37 color portion size photo series were included. Each photo series included up
93 to six photos of increasing and for fat spread decreasing portion sizes. The selection of food items
94 for the food photographs was based on food items that both contribute significantly to energy and/or
95 nutrient intake, and food items that would be difficult to estimate by household measures (as meat,
96 fish, chicken cuts, vegetables, casseroles, filling on bread, rice, pasta, potatoes and other
97 voluminous foods). The foods depicted in the photo series represented the most commonly eaten
98 foods and dishes in Denmark.

99 As suggested by Nelson et al., the optimal number of photos in each series is between 4 and 8, and
100 6 (9 x 6 cm) were chosen as optimal for the DANSDA (16). For two of the photo series, fat spread
101 on rye bread and fat spread on wheat bread, only four photos were chosen. Due to the small

102 increment in grams between the small and large portion of fat spread, it would be difficult to see the
103 difference among portions with more photos within the weight range. Nelson also recommends an
104 equal number of photos in a photo series to avoid that participants always choose the middle photo
105 (16). The two smallest portions represented on photos A and B were considered “Small”. The two
106 middle size portions represented on photos C and D were considered “Medium”. The two largest
107 portions represented on photos E and F were considered “Large”. For fat spread on bread with only
108 four portion size photos, the smallest was considered “Small”, the two middle were considered
109 “Medium” and the largest “Large”.

110 The weights depicted on the photos were based on a survey investigating common food portion
111 weights in Denmark among 258 children and adults (17). The weight intervals were equal
112 increments between the 5th and 95th percentile, and slightly adjusted to represent a clear visual
113 progression among photos. Furthermore, a suitable camera angle of 52 degrees for casseroles, meat,
114 vegetables, potatoes/rice and pasta, and confectionary, 25 degrees for fat spread and filling on bread
115 and 35 degrees for cake was applied to clearly demonstrate the volume of the foods (height and/or
116 circumference), and based on a typical eating situation applying to the specific foods. Finally, the
117 same size-relationship between the different photo-series was ensured. Most food photographs
118 displayed the foods on a white plate measuring 27/22 cm (outer/inner diameter) which is the most
119 commonly bought plate size in Denmark, including cutlery as a reference measure and using a light
120 grey color as background. Chicken pieces and fat spread were displayed on a large cutting board
121 containing all portion sizes, with one image size of 16 x 19 cm. Candy and chocolate were
122 displayed directly on the background.

123 *Subjects*

124 622 adults (19-68 years) and 109 children (8-12 years) participated in the validation study. The
125 adults were recruited from three companies and the children through recruiting whole school classes
126 from two different schools in the Copenhagen area. In one of the schools, the children brought
127 packed lunches from home while the other had a school lunch buffet programme. All of children in
128 school on the days of measuring participated in the study. All the companies had canteens with
129 lunch buffets. Two of the companies employed office workers and one was a defense college. The
130 heads of the companies and schools were approached by telephone followed by written information
131 material. After approval, contact was made with the canteen leaders or teachers for further
132 arrangements.

133 *Design*

134 In all companies and schools, the relevant lunch portion sizes were estimated using the portion size
135 photos and weighed over 3-5 days. The menu plans were given to the research team beforehand, so
136 it was possible to plan the testing of the different photo series. It was the intention to get ≥ 50
137 observations for each photo series. This goal was used to guide the number of days spent at each
138 company canteen and to negotiate with the canteen leader about the menus. Occasionally cakes and
139 sweets were on the lunch buffets and in the children's lunch boxes. These items were included in
140 the photos, weighed and estimated in the same way as other foods.

141 Adult participants were recruited in the company canteen directly by the research team before or
142 while standing in lunch queue. Participants were instructed to separate foods on the plate (e.g. gravy
143 on the side, butter on the side, etc.). After participants had taken their food, photos were taken of the
144 plates using a Nikon COOLPIX S700 digital camera (12.1-Megapixel) and a cubelite (Lastolite
145 Cubelite 58 cm). These photos were used as documentation. Thereafter, participants estimated their
146 own portions by looking at the relevant photo series. Participants were asked to determine which
147 photo in the series corresponded best to the portion on their plate. They were allowed to choose
148 fractions of a photo portion or more than one photo within a photo series to describe the served
149 portion size of one food, e.g. a small portion could be $\frac{1}{2}$ B rather than one portion A. Afterwards,
150 the different types of food on the plate were weighed (Soehnle; Vera 67002, with a precision of ± 1
151 g) by carefully transferring the food, item-by-item, to another plate standing on the scale. Finally,
152 the participants were asked to state their age and education (adults) before eating their meal.

153 In the school where the children brought packed lunch from home, the classes received a short
154 instruction in the classroom. Solid white polystyrene plates (Model LINPAC; Size 26 cm) marked
155 with class, date, ID numbers were distributed to all children in the classroom, and the children were
156 asked to unpack their lunch and place the different meal elements separately on the plate. All
157 children went through the same procedure as the adults with photographing, portion size estimation
158 using photos, and weighing their lunch. In the school with the lunch buffet, the same procedure was
159 conducted.

160 This study was conducted according to the guidelines laid down in the Declaration of Helsinki.
161 Information to the parents was sent through the schools electronic communication system, and
162 informed consent was provided to the teacher using this system.

163 *Data analysis*

164 The agreement between the photograph chosen by the participants and the actual weight of the food
165 portions was calculated and illustrated in several ways:

- 166 • As a percentage of estimations choosing the correct photo, the photo adjacent to the correct
167 photo or a distant photo when comparing food portions on the plate to portion size photos. If
168 actual weight was within half of the increment between photo weights (on both sides of photo
169 weights) in a photo series it was considered a correct estimation.
- 170 • As an error in relation to actual weight: photo weight (g) – actual weight (g), and as mean
171 percent: mean photo weight (g) – mean actual weight (g)/mean actual weight (g) x100. Negative
172 error/error rates indicate underestimation and a positive error/error rate indicates overestimation.
- 173 • Wilcoxon's test was used to test for the differences between the photo and actual weights.
- 174 • Spearman correlations between the estimated portion (by photo) and the actual portion (by
175 weight) within a photo series were used to test the correlation between the portion sizes chosen
176 and the actual weights.
- 177 • Mann-Whitney test was used to test if using a fraction of, or more than, one photo to estimate
178 portion size gave different errors than when using one photo for the estimation, and to test the
179 difference between children and adults.
- 180 • Chi² was used to test if the percent correct estimations and direction of errors were the same
181 when using the small, medium and large portion size photos for the estimation.

182

183 The statistical analysis was carried out with the SPSS statistical package (SPSS, version 23, 2015).

184 Finally, to estimate the magnitude of error introduced in the nutrition calculation when using photo
185 weights, the macronutrient intake was calculated for a weekly lunch menu estimated by portion size
186 photos and the actual weights. The weekly menu was composed from all the different workplaces
187 and schools and was constructed to include most of the portion size photos (95%). Only food items
188 with a corresponding portion size photo were estimated and weighed. Since there was no portion
189 size photos for bread, bread was not weighed. Bread is therefore not included in the nutrition
190 calculation. Nutrient calculations were performed using the General Intake Estimation System
191 (Version 1.000i6) developed at the National Food Institute, Technical University of Denmark, and
192 the Danish Food Composition Databank (version 7, Søborg, Denmark, 2009).

193

194 **Results**

195 *Characteristics of participants*

196 The characteristics of participants are shown in Table 1. The presented characteristics are weighted
197 according to the number of portion size estimations done by each participant since this differed
198 from participant to participant. The mean (range) number of portion estimations from each
199 participant was 3 (1-9). The mean (SD) age of adults was 40 (12) years and of children 9 (1) years.
200 Males/boys did a little more than half of the portion size estimations. Among the adults, two-thirds
201 of the portion size estimations were done by those having a medium level or long education.

202 *Precision of portion size estimations*

203 The mean of percent correct estimations in all categories was 42% (Table 2); 17% of the food,
204 portions were estimated smaller than the actual portion and 41% were estimated larger. The
205 proportion of correct estimations was below 50% for 70% of the photo series. The proportion of
206 correct estimations was lowest for mayonnaise-based salads (11%) and highest for rice (77%) and
207 tomato slices (73%) (Results not shown).

208 Correlation coefficients between the estimated portions and actual portions ranged between 0.18
209 (meat sauce) and 0.89 (chocolate). Three photo series (mayonnaise-based salads, fish fillet, and
210 meat sauce) had non-significant correlations (results not shown). The mean estimation error
211 percentages for all food servings were 17% (Table 2) ranging from -1% (liver paste) to 111%
212 (cooked/baked potatoes) (results not shown). Only for vegetables were there no significant
213 differences between photo weight and actual weight.

214 The positive direction of the errors for most photo series indicates a trend to estimate servings larger
215 than the actual weight. Filling on bread, vegetables and pasta were more likely to be underreported
216 than the rest of the photo series.

217 In the present study, 12% of the participants chose to use a fraction of one photo or two photos
218 within the same photo series to describe their portion size. The results showed that using a fraction
219 of one photo or two photos compared with one photo gave significantly larger estimation errors
220 ($P=0.006$) (Table 3).

221 The results presented in Table 4 show that portions estimated by the small portion size photos were
222 more likely to be correct than portions estimated by medium and large portion size photos (Percent

223 error: small -4 vs. medium/large 22/23). When using the large portion size photos, 59% of the
224 estimations resulted in overestimation.

225 Figure 1 illustrates the ability of adults to choose the correct photo compared with the ability of
226 children. The result shows that children, in just as many cases as adults, choose the correct photo.
227 However, when children are making estimation errors, they are more likely to be positive compared
228 with adults who have larger negative estimation errors compared with children. This also results in
229 a significant larger positive estimation error in grams and percentages in children (21.4 g; SE: 1.2;
230 40%) than for adults (12.2 g; SE: 2.3; 15%) ($P < .001$) (Results not shown).

231 The influence of using estimated weight vs. actual weight on macronutrient calculation for a weekly
232 lunch menu showed overall error estimation percentage (min-max) of 21% (5% - 38%) for energy,
233 29% (8%-44%) for protein, 21% (4%-33%) for total fat, 26% (15%-42%) for saturated fat, 16%
234 (4%-35%) for carbohydrate, 20% (8%-36%) for added sugar and 9% (-17%-19%) for dietary fiber
235 depending on the menu type. The macronutrient content based on the children's lunch showed
236 much larger overestimations than for adults (Table 5).

237

238 **Discussion**

239 In the present study, portion size photos were validated in a real-life setting for both adults and
240 children. Furthermore, the macronutrient content was calculated and compared when using portion
241 size photos to estimate intake and using the actual weight of foods. This study showed that overall
242 only 42% of the study population was able to pick the correct photo, and that this was not different
243 for children (Adults: 44% vs. children: 41%). However, children's mean estimation error was larger
244 because they tended to overestimate more than adults did. In other studies, it was also found that
245 when using age-appropriate portion size photos, children (4-11 years) were just as accurate as adults
246 (8,13). The study of Foster et al. (2006) also found that children were more likely to overestimate
247 the portion size of foods and dishes compared with adults (13).

248 The use of the photos illustrating the larger portion sizes lead to larger positive estimation errors in
249 grams and percentages. This was also seen in a Finnish study with adults validating food servings
250 against portion size photos (12). This could be because of the difficulties in noticing the difference
251 between large portions if the increment size is relatively small. Most studies have used an equal

252 increment between portions from the 5th and 95th percentile based on data from national dietary
253 surveys (6,14,18-21). In some studies, they made increments on a log scale between the portion
254 sizes to overcome the difficulties distinguishing between larger portions (11,18). Using a log scale
255 might also lead to greater errors when choosing large portions because of greater portion
256 differences. In the present study, equal increments were chosen, but small adjustments were made
257 to ensure visual increment difference between photos.

258 The errors related to the choice of large portion photos could also be due to the perception of size
259 and depth of the two dimensional portion size photos, and the photo angle used when taking the
260 photos. Food portions taken from an angle, as in the present study, seem smaller than photos taken
261 from above as the angle visually shrinks the plate, and it becomes more oval in shape. However,
262 Subar et al. (2010) studied the importance of the angle of the pictures taken from above and with an
263 angle of 45 degrees for 27 portion size images of foods (21). The only food where there was
264 significant difference between estimation errors at the two angles was for potato chips, which were
265 determined best by photos obtained at 45 degrees. The study also illustrated that participants
266 preferred the photos taken from above, but the preference is not reflected in smaller estimation
267 errors. Few other studies have used photos taken from above. Thoradeniya et al. (2012) was the
268 only study that exclusively used photos that were taken from above (19).

269 The present study also illustrated that using fractions of, or more than, one photo portion to estimate
270 the portion size of the food served introduced larger errors than choosing the photo closest to the
271 portion size served. This has, to the authors' knowledge, not been reported before in the scientific
272 literature. Nelson et al. (1994) showed that a series of eight photos provided more accurate
273 estimates than just one photo where the participants should indicate the percentage or fraction of the
274 displayed portion corresponding to the served portion (6). In other studies, participants had the
275 opportunity to indicate that the portion was "smaller than the smallest portion" or "larger than the
276 largest portion" in a photo series, but the results were not reported according to use of these options
277 (14,22).

278 Finally, we estimated the size of error on the estimated intake of macronutrients from a weekly
279 lunch menu using the portion size photos compared with the real weight. This showed total
280 estimation error percentages from 9% for dietary fiber to 29% for protein. Energy was
281 overestimated by 21%, so it is likely that other macronutrients were overestimated to the same
282 degree. This was not the case for carbohydrates and dietary fiber. However, bread was not included

283 in the calculations, and pasta and rice had fairly high percentages of correct estimations (57% and
284 77%, respectively). On the other hand, meat and casserole portions were frequently overestimated,
285 and overall meat portions were overestimated by 51% and casserole portions by 55%. This can
286 explain the larger difference in protein (29%) and saturated fat (26%) between estimated and actual
287 food portions.

288 Several of the photo series in the present study (casseroles, meat and fish, rice and pasta, vegetables,
289 cake) were also included in another validation study, only moderated slightly to reflect the portion
290 sizes for children 3-10 years (11), but using the same plates, the same foods, the same angels,
291 photographer etc. These photo series were validated in a “laboratory” condition where parents of 3-
292 10 year olds evaluated predefined servings of single foods across three European countries. For
293 most of the photos, but not all, there were more correct estimations. This could be due to the
294 validation method where the vast majority of the predefined servings validated were exactly similar
295 foods as the ones on the portion size photos. This might not represent a realistic use of the portion
296 size photos in, e.g., a national dietary survey. Therefore, the validation method may also produce a
297 better result than can be expected in real life.

298 Turconi et al. (2005) also validated 434 portion size photo series, with each series illustrating three
299 portions among 448 volunteers in a real-life setting, similar to the present study. They, however,
300 reported the errors of the 9075 assessments in five broad food groups, and because of the large
301 number of observations, the mean differences were small (3%-11%) (7). In the present study, there
302 were 2202 observations, and the overall difference in percent was 17%, and the mean difference in
303 the 7 food groups ranged from -7% to 44%.

304 Subar et al. (2010) also mimicked real-life in their validation of digital portion size photos. They
305 found that 14% of all the foods they included were estimated within $\pm 10\%$ of the actual weight, in
306 the present study it was 18%. The study of Subar et al. (2010) also found that drawings of generic
307 mounds or household measures (cups, glasses, bowls) were as accurate as photos of food portions
308 and therefore are cost-effective alternatives to photos of foods (14). In the study of Frobisher and
309 Maxwell (2003), it was also found that standard descriptions of portion sizes performed no worse or
310 better than photographs of portion sizes (23). In an Irish study by Faulkner et al. (2016), they
311 evaluated the precision and ease of use of different portion size estimation aids and they found that
312 food photos were the least precise and that household measures (portion pots and cups) were easy to

313 use and relatively precise. However, the study focused on an aid's ability to help participants to
314 choose an appropriate serving size (24).

315 Even if participants choose the correct photo, the mean difference between actual weight and photo
316 weight can be relatively high if the weight span within a photo series is large. If in a wide weight
317 span only a few photo portions are available to choose among, a high percentage of correctly
318 estimated portion sizes is more likely, but because the weight distance between the photos is large,
319 there could be large differences between estimated and actual weight.

320 Small portions of foods such as cold cuts of meat and fat spread get high error percentages very
321 easily for a small overestimation of e.g. 2 g, because all photos show small amounts with small
322 weight increments between. Several studies have showed large overestimations of fat spread on
323 bread (8,25,26). The major estimation error of fat can be problematic for the calculation of fat and
324 energy intake. Therefore, having an optimal number of photos and an appropriate weight range for
325 the target group is important. Studies suggest that photo series with more photos provide higher
326 accuracy than photo series with fewer photos (eight vs. four; five vs. three; eight vs. one photo). But
327 in these studies, photo series with fewer photos seemed to be easier for participants to grasp
328 (6,12,14,19,27).

329 The strength of the present study is that it was conducted in a real-life setting closer to the use of the
330 food portion photographs in the DANSDA where the food intake is to be recorded on a continuous
331 basis. The validation technique used also allowed for performing nutrient calculation on a weekly
332 menu to get an idea of the error size introduced in macronutrient calculations when using the photo
333 weights compared with the actual weight. A weakness was that participants estimated their portions
334 before eating and not after eating as would probably be the procedure in a dietary
335 assessment/survey. In the present study, participants did not have to take memory and waste into
336 account, which could have introduced even larger errors. Therefore, the present study qualifies as a
337 perception study according to the psychological constructs involved in portion size estimation using
338 food photographs proposed by Nelson & Darbyshire in 1994 (6). Furthermore, participants were
339 asked to separate the food on the plate when taking a portion. Serving, e.g., the meat sauce on top of
340 the rice would have made estimations more difficult.

341

342

343 **Conclusion**

344 Photos of different food portion sizes are cost-effective compared with actual weights as a portion
345 estimation tool and widely used in dietary surveys. However, the photos validated in the present
346 study were not very accurate when used in a realistic situation compared to actual weights. This has
347 substantial influence on estimated food intake and nutrient calculations.

348 **Acknowledgement**

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350 companies for taking part in this study and for helping with the planning of relevant menus,
351 estimating their portion sizes using photos and letting us weigh their lunch meals in portions of
352 food. The study was internally funded. The authors declare no conflict of interest.

353

354 **Transparency Declaration**

355 The lead author affirms that this manuscript is an honest, accurate, and transparent account of the
356 study being reported, that no important aspects of the study have been omitted and that any
357 discrepancies from the study as planned (and registered with) have been explained. The reporting of
358 this work is compliant with STROBE guidelines. The lead author affirms that no important aspects
359 of the study have been omitted and that any discrepancies from the study as planned have been
360 explained. The study has not been registered in any trials registry.

361

362 **Author contributions:**

363 The authors' contributions are as follows: APBJ, KHYG, TRHNI, SFA, TUCHR designed the study
364 and formulated the research questions; ABJ, TRHNI and KHYG collected the dietary intake data.
365 APBJ drafted the manuscript. All authors took part in a critical revision of the manuscript and
366 approved the final version of the paper.

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438 Table 1. Characteristics of children and adults who took part in the study.

Characteristics*	Adults (n= 622, 1840 estimations)	Children (n=109, 362 estimations)
Age, mean (sd)	40 (12)	9 (1)
Males (%)	59	53
Education (%)		
No/vocational/short (below 13 years)	33	-
Medium/long (13 years or above)	64	-
Missing	3	

439 * Numbers are weighed by number of estimations

440

Accuracy of food photographs for estimating intake

Table 2. Percentages of participants choosing the correct, adjacent or distant photo when comparing photo weight to actual weight. Difference and standard error (SE) of the difference between the photo weight and actual weight in grams. The mean difference as a percentage of the actual weight. Spearman correlation between the photo weight and the actual weight.

Food items	Photo series	Observations N	Correct photo ^l (%)	Adjacent photo (%)		Distant photo (%)		Mean photo weight g \pm (SE [¶])	Mean actual weight g \pm (SE [¶])	Mean difference: Photo weight - actual weight g \pm (SE [¶]) ^l	Mean difference %	Spearman Correlation [§]
				-1	+1	> -1	> +1					
Fat spread on bread	2	121	28	13	31	2	26	10.7 (0.6)	8.8 (0.5)	1.9 (0.4)**	22	0.69**
Filling on bread	7	370	35	15	20	11	19	41.3 (1.5)	38.2 (1.3)	3.1 (1.4)*	8	0.67**
Meat/fish	7	403	33	7	33	1	26	115.3 (3.1)	80.0 (1.8)	35.3 (2.4)**	44	0.69**
Casseroles	3	105	30	8	42	3	17	200.7 (7.0)	146.0 (6.1)	55.2 (7.4)**	38	0.37**
Potatoes/rice/pasta	5	363	54	11	23	2	10	127.8 (4.3)	109.3 (3.4)	18.5 (3.7)**	17	0.69**
Vegetables	9	571	49	16	19	11	5	79.1 (2.6)	85.2 (3.3)	-6.1 (1.9)	-7	0.76**
Cake and confectionary	4	269	45	6	36	1	12	105.1 (3.5)	84.4 (3.0)	20.6 (2.0)**	24	0.83**
Total	37	2202	42	11	26	6	15	92.6 (1.6)	78.9 (1.4)	13.7 (1.1)**	17	0.83**

*= <0.05; **<0.001

[§]Spearman correlation between estimated portion (by photo) size and actual portion size (by weight).

[¶]As the number of estimations for each photo series was different, the standard error was chosen as a measure of the precision of the sample mean since the standard error depends on both the standard deviation and the sample size.

^l To test whether the estimation method significantly overestimated or underestimated, the consumed portion was tested with Wilcoxon's Signed Rank test.

^lIf actual weight was within half of the increment between photo weights (on both sides of photo weights) in a photo series it was considered a correct estimation.

Accuracy of food photographs for estimating intake

Table 3. Mean difference percentage when using one or fractions of or more than one photo for estimating portion size.

Number of photos used to assess portion size	One photo (n=1928)	Fractions of or more than one photo (n=274)	P-value*
Mean difference g±SE (%)	12±1.0 (15)	29±4.8 (40)	
Median difference g, P25;P75 (%)	0 (0;35) (0)	10 (-3;38) (18)	.006

*Mann Whitney test

Accuracy of food photographs for estimating intake

Table 4. Percent correct estimations and direction of errors and error size in g and percent when using the small, medium and large portion size photos.

Portion size photos [§]	Photo portion letter [§]	Number of observations	Correct estimation (%)	Smaller estimation (%)	Larger estimation (%)	Mean difference: Photo weight - actual weight g ± (SE)	Mean difference %
Small	A, B	774	65	20	15	-2.6 (1.0)	-4
Medium	C, D	809	30	14	56	19.2 (1.6)	22
Large	E, F	345	22	19	59	25.7(3.2)	23
All		1928*	43	17	40	12.6 (1)	15

Distributions of correct-, under- and overestimation are significantly different between small, medium and large portion size photos P-value <0.001. Analyzed by chi2 test

*Only those estimations which included portion size estimation by one photo

§. The two smallest portions represented on photos A and B were considered “Small”. The two middle size portions represented on photos C and D were considered “Medium”. The two largest portions represented on photos E and F were considered “Large”. For fat spread on bread with only four portion size photos, the smallest was considered “Small”, the two middle were considered “Medium” and the largest “Large”.

Accuracy of food photographs for estimating intake

Table 5: Mean daily macronutrient content for a weekly lunch menu estimated by photo weight and actual weights. Mean differences in kilojoule and grams and in percent.

Lunch menu including occasional cakes and sweets for one week (mean estimated vs. mean weighed grams)	Macronutrients	Photo weight (mean)	Actual weight (mean)	Difference: Photo weight - actual weight (mean)	Difference in percent (mean)	Min-max %
Children, n=109						
	Energi (Kj)	2486	1652	833	50	28-66
	Protein (g)	29,4	19,4	9,9	51	27-79
	Total fat (g)	32,8	19,9	12,9	65	49-77
	Saturated fat (g)	12,2	7,4	4,8	66	50-80
	Carbohydrate (g)	47,3	35,9	11,5	32	1-65
	Sugar (g)	10,5	6,3	4,2	66	50-133
	Dietary fiber (g)	3,6	2,7	1,0	38	18-65
Adults, n=622						
	Energi (Kj)	3636	3091	544	18	1-40
	Protein (g)	42,8	34,1	8,7	26	1-45
	Total fat (g)	47,1	40,2	7,0	17	3-38
	Saturated fat (g)	19,0	15,6	3,4	22	4-43
	Carbohydrate (g)	71,2	62,9	8,3	13	-3-29
	Sugar (g)	25,7	21,9	3,8	17	8-32
	Dietary fiber (g)	5,2	4,8	0,4	8	-19 -15
All, n=731						
	Energy (KJ)	3448	2855	593	21	5-38
	Protein (g)	41,2	31,9	9,3	29	8-44
	Total fat (g)	44,0	36,4	7,6	21	4-33
	Saturated fat (g)	17,8	14,1	3,7	26	15-42
	Carbohydrates (g)	68,6	59,2	9,4	16	4-35
	Sugar (g)	24,1	20,1	4	20	8-36
	Dietary fiber (g)	4,8	4,4	0,4	9	-17- -19