Validity of Children’s Food Portion Estimates

A Comparison of 2 Measurement Aids

Donna M. Matheson, PhD; Kara A. Hanson, RD; Tiffany E. McDonald, MPH; Thomas N. Robinson, MD, MPH

Background: Policy and clinical decisions regarding children’s nutrition are often based on dietary intake estimates from self-reports. The accuracy of these estimates depends on memory of both the type of food eaten and the amount consumed. Although children’s self-reports of food intake are widely used, there is little research on their ability to estimate food portions.

Objective: To assess the validity of children’s estimates of the food portions they consume by means of 2 types of measurement aids: standard 2-dimensional food portion visuals and manipulative props.

Design: Randomized controlled trial.

Participants: Fifty-four African American girls aged 8 to 12 years.

Main Outcome Measures: Girls were served a standard meal and actual intake was assessed by weighing food portions before and after the meal. On completion of the meal, dietitians collected food recalls and portion size estimates from the girls by means of both manipulative props and 2-dimensional food portion visuals, administered in a randomized order.

Results: Absolute value percentage differences between actual and estimated grams of food consumed averaged 58.0% (SD, 102.7%) for manipulative props and 32.8% (SD, 72.8%) for 2-dimensional food portion visuals. Spearman correlations between actual and estimated intakes with both portion size measurement aids were high (range, r = 0.56 to 0.79; all P < .001), with the exception of bread intake (r = 0.16, P = .43). Correlations with actual intakes did not differ significantly between the 2 methods.

Conclusions: Children’s self-reported portion size estimates are appropriate for ranking children’s relative intakes, but they result in sizable errors in quantitative estimates of food and energy intakes. Caution should be used in interpreting quantitative dietary intake estimates derived from children’s self-reports.

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Many clinical and policy decisions and recommendations regarding childhood nutrition are based on dietary intake estimates derived from children’s self-reports, such as 24-hour recalls or food frequency questionnaires. Therefore, their usefulness depends, in part, on the validity of these estimates. There are 2 primary sources of potential errors in self-reports of dietary intake: remembering the types of foods eaten and the amounts of foods consumed. Previous research has focused more on memory of the types of foods eaten. This research has demonstrated that preadolescent children are able to remember between 50% and 84% of the types of foods that they consumed during the previous 24 hours. There has been less research on the accuracy of children’s recalls of the amount of food they consumed.

There is no research that validates children’s use of common food portion measurement aids. In adults, the validity of a variety of food portion measurement aids, including 2- and 3-dimensional models, has been tested, but this research has not produced conclusive results. There have been no consistent differences in the errors associated with any of the food portion measurement aids tested. Average errors in adults’ portion size estimates have ranged from 23% to 63%. In general, errors associated with overestimates of food portions are larger than errors in underestimation. Similar data do not exist for children. Therefore, to examine the validity of children’s self-reports of food portions, we compared children’s measurements of actual food consumption with estimates produced.
from self-reports by means of 2 types of food portion measurement aids: manipulative props and 2-dimensional food models.

**SUBJECTS AND METHODS**

**SUBJECTS**

This study was conducted as part of the formative research for the Stanford Girls Health Enrichment Multisite Study project, an obesity prevention study for African American girls. African American girls aged 8 to 12 years were recruited from 7 community centers and church groups in the San Francisco Bay area of California. Eight groups, of 4 to 11 girls each, participated in focus groups during which they were served a standard dinner. All procedures were explained to parents and their daughters before they participated in the project. The girls were told that they would be served weighed portions of food, that they did not need to consume all the food that was served to them, and they could ask for additional servings of any of the foods provided. They were also told that their plates and cups would be reweighed after they were finished eating and they would be asked to estimate how much food they had consumed. Parents provided signed written consent for their child's participation and the girls provided assent. All girls who attended the focus groups participated and completed the portion size experiment. The study was approved by the Panel on Human Subjects in Medical Research at Stanford University, Palo Alto, Calif.

**PROCEDURES**

An experiment was designed to compare children’s actual food intake with estimates derived from 2 portion-size measurement aids. The girls were offered standard portion sizes of 4 foods that represented all physical states of food: solid, liquid, and amorphous (Table 1). They were not served any foods that they did not want to eat. Before consumption, gram weights of all foods were obtained by means of a digital kitchen scale (test-retest reliability intraclass correlation, 0.99). Children were monitored as they ate to ensure they did not share food and that they returned their dishes, with all uneaten food, to the food preparation area.

Within 10 minutes of finishing their meals, the girls were interviewed by registered dietitians, who collected food recalls and portion size estimates. The registered dietitians were very experienced at obtaining food recalls from children and followed standard procedures. First, the girls were asked to recall the foods they consumed, and they were prompted for specific foods that they ate but did not volunteer. The dietitian recorded foods that were recalled with and without prompting. Because the focus of this study was on portion size estimation, the dietitians were aware of the foods that were served, but they were blinded to the amount of food the girls actually consumed. Next, the girls were asked to estimate the amount of foods they consumed by means of 2 portion-size measurement aids, the commonly used 2-dimensional food portion visual developed by Nutrition Consulting Enterprises, Framingham, Mass, and manipulative props that were craft materials including modeling clay, small plastic beads, paper strips, and water that girls used to demonstrate the amounts they consumed. The girls completed their estimates of the amount of all the foods they consumed by means of one of the aids before repeating their estimates with the other aid. The girls were randomly assigned to one of the dietitians, who collected portion size estimates with both measurement aids. The order in which the portion size methods were administered was also randomly assigned for each girl. Each method required approximately 5 minutes.

**PORTION-SIZE MEASUREMENT AIDS**

The 2-dimensional food portion visual developed by Nutrition Consulting Enterprises has been compared with similar 3-dimensional models in samples of adults. Correlations between the estimates produced by the 2-dimensional and 3-dimensional models were highly significant ($r=0.89$ and $r=1.00$ for men and women, respectively). Food portion estimates produced by these models have not been compared with actual intakes.

We developed the use of manipulative props as a food portion measurement aid. Therefore, this method has not previously been tested. The girls used craft materials as props to demonstrate to the dietitian how much food they consumed, and then the dietitian estimated or measured this amount in units that could be entered into the NDS-R (Nutrition Data System for Research), Version 4.02, dietary analysis program. Specifically, the girls placed paper strips onto plates or bowls to demonstrate the amount of spaghetti or salad they ate and the dietitian estimated this amount in cups. Modeling clay was molded into a replica of the bread sticks and the dietitian measured the dimensions. Water was poured from a 4-c (1-L) liquid measuring cup into 1 of 3 glasses to indicate the amount of beverage consumed. In comparison, the 2-dimensional food portion visuals are drawings of drinking glasses with lines corresponding to standard servings (eg, ½ c [125 mL]) or shapes (eg, mounds, rectangles, wedges) in graduated sizes that represent standard servings (eg, ½ c and 3 oz [84 g]). Respondents select the drawing that they believe best represents the amount of food they consumed. The food portion measurement aids used for each food, under both experimental conditions, are included in Table 1.

This method of food portion estimation in children was expected to have 4 advantages over other food portion measurement aids. First, recent research indicates that visualization is one of the primary strategies used to recall food intake. The manipulative props allowed children to visualize and physically alter the props to depict the amount of food that they consumed. For example, they were able to show the portion of food that was served to them and remove the amount that they ate. Second, with the manipulative props, children’s food portion estimates would not be biased by the amounts depicted in the models, or limited by the shape of food models that were made available. Third, a registered dietitian was responsible for choosing the unit of measurement for the food, so children were not required to describe food portions in ounces.
or by physical dimensions as is often the case in standard food recalls. Fourth, children enjoy working with the manipulative props and, therefore, their interest could be maintained throughout the recall.

**STATISTICAL ANALYSES**

Descriptive statistics of the girls' weighed intakes and their food portion estimates with the manipulative props and the 2-dimensional visuals were calculated by means of the NDS-R software. Wilcoxon sign rank tests were used to test the statistical significance of differences between actual intakes and the estimates produced by the manipulative props or 2-dimensional food portion visuals. Percentage errors were calculated by means of the absolute values of the differences between actual and estimated portion sizes. Spearman correlation coefficients were used to assess the level of association between actual and estimated intakes derived from each portion size measurement aid. A t test of the difference between dependent correlation coefficients was used to test whether the correlations between the actual intakes and manipulative prop estimates and the correlations between actual intakes and 2-dimensional food portion visual estimates differed significantly from each other.19

### RESULTS

A total of 54 girls completed the experiment. Their ages ranged from 8 to 12 years, with a mean±SD of 9.8±1.1 years. All of the girls who consumed spaghetti and salad recalled these foods. However, 14 (27%) of 51 girls needed prompting to recall drinking a beverage and 6 (15%) of 39 girls required prompting to recall eating bread. Three girls each reported eating one food (spaghetti, salad, or beverage) that they actually did not consume. These phantom estimates were excluded from the analyses since percentage error could not be calculated for actual intakes of zero. Actual food intake and portion size estimates produced by the manipulative props and 2-dimensional visuals and the differences between actual intake and the estimates are reported in Table 2. Not all girls consumed every food, and therefore the sample sizes differed slightly for each food. Standard deviations and ranges of actual intakes were large, indicating that the girls' abilities to accurately estimate food portions varied considerably. There were no statistically significant differences due to the order in which the girls completed the portion size estimates (P=.75) or due to the dietitian who conducted the recalls (P=.22). The overestimates or underestimates and percentage errors, based on the absolute value of the differences between the estimated and actual intakes, are reported in Table 3. Most children overestimated their spaghetti intake and underestimated their beverage intake. For other foods, there were no consistent patterns across both methods in the number of girls who overestimated or underestimated their intakes.

Spearman correlation coefficients between actual intakes and estimated intakes are presented in Table 4. With the exception of the correlation between actual intake of bread and the estimate produced with manipulative props, all correlations were large20 and statistically significant (P<.001). The 2 methods did not produce

### Table 2. Actual Intakes and Estimated Food Portions

<table>
<thead>
<tr>
<th>Food</th>
<th>No. of Subjects</th>
<th>Actual Intake</th>
<th>Estimates From Manipulative Props</th>
<th>Estimates From 2-Dimensional Food Portion Visuals</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Mean ± SD</td>
<td>Mean ± SD</td>
<td>Mean ± SD</td>
</tr>
<tr>
<td>Spaghetti, g</td>
<td>50</td>
<td>106.8 ± 83.8</td>
<td>272.2 ± 210.7*</td>
<td>211.9 ± 142.6*</td>
</tr>
<tr>
<td>Salad, g</td>
<td>42</td>
<td>55.5 ± 41.7</td>
<td>69.5 ± 48.6†</td>
<td>41.4 ± 31.7†</td>
</tr>
<tr>
<td>Bread, g</td>
<td>39</td>
<td>45.0 ± 25.2</td>
<td>22.5 ± 14.4*</td>
<td>78.5 ± 56.1†</td>
</tr>
<tr>
<td>Beverage, g</td>
<td>50</td>
<td>199.5 ± 116.7</td>
<td>169.8 ± 118.9†</td>
<td>160.2 ± 132.8†</td>
</tr>
<tr>
<td>Total amount of food, g</td>
<td>54</td>
<td>355 ± 164</td>
<td>487 ± 238*</td>
<td>418 ± 205*</td>
</tr>
<tr>
<td>Total energy intake, kcal‡</td>
<td>54</td>
<td>293 ± 135</td>
<td>449 ± 265*</td>
<td>417 ± 209*</td>
</tr>
</tbody>
</table>

*P<.001 vs actual intake by Wilcoxon sign rank test.
†P<.05 vs actual intake by Wilcoxon sign rank test.
‡To convert to kilojoules, multiply by 4.184.

### Table 3. Average Percentage Overestimated or Underestimated by Each Method and Average Percentage Error Based on the Absolute Value Difference Between Actual and Estimated Food Intakes

<table>
<thead>
<tr>
<th>Food</th>
<th>Manipulative Props</th>
<th>2-Dimensional Visuals</th>
<th>Absolute Value Error</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>% Overestimate</td>
<td>% Underestimate</td>
<td>% Error</td>
</tr>
<tr>
<td>Spaghetti, g</td>
<td>207.8 ± 223.7</td>
<td>187 ± 209 (n = 44)</td>
<td>71 ± 45 (n = 6)</td>
</tr>
<tr>
<td>Salad, g</td>
<td>199.9 ± 619.2</td>
<td>336 ± 982 (n = 15)</td>
<td>45 ± 22 (n = 27)</td>
</tr>
<tr>
<td>Bread, g</td>
<td>112.5 ± 304.6</td>
<td>284 ± 606 (n = 19)</td>
<td>60 ± 26 (n = 7)</td>
</tr>
<tr>
<td>Beverage, g</td>
<td>47.7 ± 89.6</td>
<td>32 ± 37 (n = 21)</td>
<td>54 ± 27 (n = 29)</td>
</tr>
<tr>
<td>Total amount of food, g</td>
<td>58.0 ± 102.7</td>
<td>60 ± 69 (n = 38)</td>
<td>33 ± 24 (n = 16)</td>
</tr>
<tr>
<td>Total energy intake, kcal‡</td>
<td>67.8 ± 109.1</td>
<td>83 ± 105 (n = 41)</td>
<td>26 ± 24 (n = 13)</td>
</tr>
</tbody>
</table>

*P<.001 vs actual intake by Wilcoxon sign rank test.
†P<.05 vs actual intake by Wilcoxon sign rank test.
‡To convert to kilojoules, multiply by 4.184.
In this study, we tested the validity of children’s reports of the amount of food they had just consumed. We also compared a novel portion-size measurement aid for children with standard 2-dimensional food portion visuals. Overall, the 2 estimates were of similar accuracy when compared with actual intakes. Correlations between actual and estimated intakes derived from both measurement aids were high, except for the bread estimates. This result indicates that both methods were generally effective at ranking girls’ relative intakes. Girls who consumed larger portions of foods also estimated larger portions of those foods. However, the correlations between actual bread intake and the estimated intake were lower, particularly for the manipulative props estimate. Modeling clay was the manipulative prop used to estimate bread intake. It is possible that some girls may have enjoyed playing with the modeling clay so much that they became less focused on the purpose of the activity (ie, estimating their actual consumption) while using this prop. Manipulative props are engaging for children and may be highly effective for children who are unmotivated to complete dietary recalls; however, manipulative props cannot be used over the telephone. Therefore, the data collection protocols must be considered in deciding whether to use manipulative props or 2-dimensional food portion visuals to collect portion size data from children.

Because the estimates produced with both portion-size measurement aids proved to be reasonably valid in ranking children’s relative food intakes, either of these methods may be used in large-scale correlational studies. However, the magnitudes of the errors in children’s quantitative estimates of food portions were large. These results bring into question the validity of the food and energy intakes derived from children’s self-reports of dietary intake. This is of concern especially since our study tested children’s food recalls and portion size estimates under operational conditions; girls were informed before eating that they would be asked to estimate their food intakes, and the data were collected within 10 minutes of consuming their meal. Estimates derived from a recall the next day, as standard 24-hour diet recalls are usually performed, would be expected to have even greater errors.21 Basiotis and associates21 defined a precise estimate of intake as being within 10% of the true intake for a sample of people 95% of the time. In our research, absolute value errors in overall energy intake averaged 54% for 2-dimensional visuals and 68% for the manipulative props, well beyond this range. These large errors do not appear to be unique to our sample. Other researchers also have reported errors well in excess of 10%. In a recent experimental study in which third- and fourth-grade children were asked to estimate known quantities of foods, percentage errors in absolute values ranged from 25% for a prepackaged beverage to 539% for applesauce.12 Likewise, Lytle and associates5 reported that with the aid of 3-dimensional food models and tableware, children were able to recall only 35% of foods within 10% of the observed portion sizes. In that study, the portion sizes of approximately 42% of the foods were overestimated and 23% were underestimated, and for many foods errors were in excess of 100%. As with other studies, we found that errors due to overestimating food intakes were larger than underestimates.

Previous validation research on children’s dietary recalls has focused on children’s ability to remember both which foods and the amounts of foods they consumed. In our research, we used an experimental design to isolate the errors in children’s ability to estimate the amount of food they ate from the errors associated with remembering which foods they ate. Although more than one quarter of the girls needed prompting to recall consuming beverages and/or bread, portion size estimates were collected from all foods actually consumed by the children. Therefore, the errors that we observed can be attributed to the girls’ inability to express accurate portion sizes, and not to their inability to remember consuming a food. Additional errors in remembering which foods were eaten and extending the time between consumption and the recall would be expected to further increase the errors observed.22

Our research used an experimental design. Unlike many experiments in which external validity is sacrificed, an attempt to maintain external validity was made in this research. The girls ate in a group, similar to a school lunch setting, and were able to refuse foods or ask for additional servings. The foods served to the girls included solid, liquid, and amorphous foods. However, with the exception of their beverage (milk, juice, or water), the girls did not have a choice in the foods or the amounts that were served to them. Furthermore, the amounts of spaghetti, salad, and beverage served to the girls were standard serving sizes that directly corresponded to the size of mounds or drinking glasses in the 2-dimensional food portion visuals. This would only be expected to improve the accuracy of the girls’ estimates with the 2-dimensional food portion visuals, especially if the girls consumed all of the food served to them. However, these estimates still averaged errors of greater than 100%.

The accuracy of the girls’ reports of their food portions was highly variable. Some girls were able to pre-
Despite widespread use of self-reported food intake data in child nutrition research and clinical practice, there is little research that examines the validity of these data. Our research describes the errors associated with children's portion size estimates by means of 2 food portion measurement aids: the standard 2-dimensional food portion visuals and manipulative props. Although both methods were generally effective at ranking girls' relative intakes, errors in quantitative estimates of gram weight of foods and energy intakes were large. Children's inability to accurately estimate the food quantities they consumed limits the usefulness of their self-reported food intake for developing food and nutrient intake recommendations for children. These inaccuracies are important to acknowledge when making clinical decisions and policy recommendations regarding children's nutrition.

Valid estimates of dietary intake are needed to inform clinical and policy decision making. Because dietary recalls are used so frequently in both clinical nutrition assessment and research on children's diets, additional research on alternative methods of obtaining portion size information from school-aged children is greatly needed. We have no reason to believe that our results are unique to African American girls, but similar research is also needed in boys and other ethnic and age groups. Furthermore, because dietary recalls are typically conducted on the foods consumed on the previous day, research that examines the accuracy of portion size estimates 24 hours after consumption, not within minutes as in this research, is needed. In addition, future research that examines how the type of food or children's preference for a food influences their ability to estimate portion sizes is needed. Pending the development of more accurate methods, our results suggest that children's dietary recall estimates are most accurate for ranking children's relative intakes, but caution should be used in interpreting quantitative food and energy estimates.

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Corresponding author and reprints: Donna M. Matheson, PhD, Stanford Center for Research in Disease Prevention, Stanford University School of Medicine, 1000 Welch Rd, Palo Alto, CA 94304-1825 (e-mail: matheson@stanford.edu).

REFERENCES


What This Study Adds

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