American Dietetic Association

RESEARCH

Research and Practice Innovations

Convergent Validity of a Digital Image-Based Food Record to Assess Food Group Intake in Youth

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ABSTRACT

Current methods to assess the dietary behavior of youth have many limitations that reduce accuracy. Previous research has examined use of food images to assess nutrient intake. The objectives for this study are to validate the use of a novel digital image-based food record (DIFR) method to assess food group intake in youth and examine inter-analyst reliability. In 2009, a convenience sample of youth aged 9 to 12 years were recruited in Davis, CA, and asked to take images of the food they ate between 5 PM and bedtime for 7 days. To examine convergent validity, 1-day and average weekly food group intakes assessed by DIFR were compared to food group estimates derived from 24-hour dietary recalls. To examine interanalyst reliability, estimates of food group intakes made by two independent nutrition students were compared, using Spearman correlation coefficients. Data from 26 youth showed that each participant's 1-day food group intakes assessed by the DIFR and recall methods were significantly correlated ($P<0.001$) for both analysts for all food groups. Estimated average daily intake amounts determined by the DIFR method and recall methods were also significantly correlated for all food groups except grains (n=28). Interanalyst reliability was very good; estimates of food group intakes, provided by the two students, were significantly correlated (n=28, $P<0.001$). These results show great potential for use of DIFR to assess 1 day's intake of food groups, but more research is needed to determine how well the method performs in capturing usual intake and changes in intake.

J Am Diet Assoc. 2011;111:756-761.

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Manuscript accepted: November 29, 2010.

0002-8223/$36.00

doi: 10.1016/j.jada.2011.02.004

Childhood obesity rates continue to be a concern. An estimated 35.5% of US children aged 6 to 11 years are overweight or obese, with 19.6% being obese (1). In its May 2010 report to the president (2), the White House Task Force of Childhood Obesity gave recommendations on how to solve the problem of childhood obesity and stressed the importance of monitoring dietary patterns as well as obesity trends.

However, assessing dietary intake in children and adolescents poses several problems. Livingstone and colleagues (3) reviewed these problems, highlighting cognitive ability, age, and body weight as key factors affecting accuracy and validity of assessment. Both under- and over-reporting of foods are seen in dietary assessment methods, including food frequency questionnaires, 24-hour dietary recalls, written food records, and diet histories, mainly stemming from the subject's inability to correctly quantify the foods eaten (3). The weighed food record method has been shown to be very accurate in assessing intake but imposes subject burden and leads to changes in subject behavior (4). The direct visual observation method is also accurate, using weighed food records as the gold standard, but it relies on a trained observer to be present during the meal (5). Therefore, this method is costly and may not be feasible for larger studies. Methods that reduce the burden and improve accuracy for both respondents and dietetics practitioners are needed (6). The combination of digital image-based food records and a trained expert to analyze food images may minimize errors associated with estimating food intake and possibly reduce respondent burden.

PREVIOUS WORK

Many research groups have reported being successful in developing and/or validating the use of food images to assess different measures of dietary intake (5,7-24). Bird and Elwood (7,8) were the first to do this and found very high correlations when they assessed free-living subjects' energy and macronutrient intake across 4 days by weighed records and the photographic method. More recently, Boushey and colleagues (21,24) described the development of a method using a camera-equipped, mobile computing device that works in conjunction with a remote server to automatically identify and quantify foods. Higgins and colleagues (22) validated the use of an image-based food record in free-living adolescents (aged 10 to 16 years) by comparing analyses of food images recorded by adolescent participants to records of preweighed foods prepared in a research laboratory.

Although many have looked at the validity of an image-based food record to measure the intake of energy and certain macro- and micronutrients, only one study has used the method to assess intake of the US Department of Agriculture MyPyramid food groups (25). Humphries and colleagues (personal communication, April 2010) found that registered dietitians were able to correctly identify foods in images from test meals and quantify them into MyPyramid food group equivalents, using weighed records as the gold standard. Digital images were also used successfully to capture differences in preference and intake of whole vs sliced fruit in a school cafeteria (26).

In a pilot study of a nutrition education curriculum targeting youth aged 9 to 12 years, the authors examined changes in vegetable intake at the evening meal using disposable cameras (27). Due to low subject compliance, poor picture quality, and lack of instruction about how to photograph foods, the evaluation method did not yield conclusive data. To resolve these issues and improve data quality, we conducted this validation study with clearer instructions on how to capture images of food for research purposes using digital cameras and materials. This article describes the validation of a novel digital image-based food record (DIFR) method for assessing food group intake in youth aged 9 to 12 years. Specifically, convergent validity was determined by comparing intakes of the MyPyramid food groups assessed by the DIFR method with intakes assessed by 24-hour dietary recalls. Although not a gold standard, the recall method was chosen because it is less burdensome than weighed food records. Interanalyst reliability is also examined by comparing estimates of food group intakes made by two independent analysts.

METHODS

Study Design and Population

The Institutional Review Board at the University of California at Davis approved the study protocol. The parents and youth signed informed consent and assent forms, respectively. The authors enrolled children aged 9 to 12 years in Davis, CA. Using a digital camera, the participants were instructed to take images of the foods eaten between 5 PM and bedtime for 7 days. If a participant did not have his or her own camera, the study provided a digital camera. Eligibility requirements included: residence in Davis, CA; ages between 9 and 12 years; and willingness to take images of foods and beverages consumed for 1 week. A convenience sample was chosen using E-mail and word of mouth, targeting community organizations, making sure to get an equal numbers of each sex. If two eligible children in one household wanted to participate, they had to do so during separate weeks, with the older child participating first.

Data Collection

During an initial meeting with each participant and the parent(s), a nutrition graduate student (T.B.M.) conducted a 24-hour dietary recall and used two- and three-dimensional food models to help the participant quantify intake more accurately. Each participant, along with his or her respective parent(s), was given instructions on proper techniques for taking images of foods before and after a meal. These included using the placemat, provided by the study, as a backdrop for the foods eaten; holding the camera at 90° above the placemat; making sure the flash is on; making sure all foods being eaten are visible in the image (with special attention given to sandwiches and burritos to view contents); making sure the image is clear and taking another if not; and taking images before and after having additional servings. The youth were also instructed to fill out a simple food log to identify the foods in the images, which was important to help the analysts identify the foods later. The Figure shows an example of before and after images of a meal, along with the food log that identifies the items in the image. To help reinforce these instructions, the graduate student simulated a meal with food models and had the participant practice using the camera to capture an image and write in the food log. Parents were present throughout the meeting and were asked to verify and ensure adequate detail for the recall. During the 7 days of capturing the evening foods, the graduate student performed two more 24-hour recalls (either in person or by telephone), again with both the participant and parent(s). In most cases, the second recall was conducted by telephone and the final recall, in person. One of the recalled days was a weekend day, whereas the other two were weekdays. Weight and height were collected using a scale and stadiometer during the initial meeting with the participant.

Outcome Variables

The 24-hour recall data were entered into Food Processor SQL (version 10.5.0, 2009, ESHA Research, Salem, OR) by a different graduate student researcher and analyzed by food group (grains, vegetables, fruits, milk, and meats and beans) according to MyPyramid classifications (25). Separate values were calculated for the entire day and intakes after 5 PM. For each day, digital images were independently analyzed by a graduate student and a nutrition undergraduate student to estimate MyPyramid food group intakes. To do this, analysts viewed the images of a meal alongside the food log to identify the foods. To calculate how much of each food was eaten, they looked at the before and after images and, using three-dimensional food models and measuring cups as visual aids, estimated the difference. Inch marks, drawn onto the placemats that the participants used in the study, helped the analysts estimate the relative size of foods. The analysts used the following rules for coding: any food that could not be seen was not coded; if there was no after-meal image, assume all foods were eaten; if multiple images were taken within 5 minutes and look the same, assume it was the same serving; and if images were taken more than 5 minutes apart and it was not clear whether or not it is the same food as in the before image, assume it is a separate serving. Training of the analysts consisted of doing a run-through on a meal that was not part of the study and assessing agreement between the two analysts' estimates.

Food groups were used instead of nutrient-level data for two reasons. First, using nutrient-level data requires certain assumptions about food composition that may be questionable based on images and a brief log. Second, nutritional education messages generally encourage eat-