

Validity of a Digital Diet Estimation Method for Use with Preschool Children

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ARTICLE INFORMATION

Article history:

Submitted 9 June 2016

Accepted 4 May 2017

Keywords:

Validation study
 Dietary assessment
 Young children
 Toddlers
 Smart Intake

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<http://dx.doi.org/10.1016/j.jand.2017.05.005>

ABSTRACT

Background The validity of using the Remote Food Photography Method (RFPM) for measuring food intake of minority preschool children's intake is not well documented.

Objective Our aim was to determine the validity of intake estimations made by human raters using the RFPM compared with those obtained by weighing all foods and beverages consumed by 3- to 5-year-old children (weighed method).

Design We conducted a cross-sectional observational study.

Participants/settings A convenience sample of 54 3- to 5-year-old Hispanic and African-American children were observed during a 12-hour period at Baylor Metabolic Research Unit between June 2013 and January 2014.

Main outcome measures All foods/beverages consumed by the children were provided by Baylor research coordinators who took and wirelessly transmitted before-and-after pictures of the trays to trained human raters at the Pennington Biomedical Research Center who estimated grams consumed. Energy and macronutrients were calculated using the Food and Nutrient Database for Dietary Studies or food facts data provided by manufacturers.

Statistical analyses Paired *t* test, mean differences, and Bland-Altman limits of agreement were performed.

Results Compared to the weighed method, the rater method significantly overestimated total intake by 34 ± 71 g ($P < 0.0001$), with a mean percent error of 2.9% (root mean square error = 7.1%), and total energy intake by 75 ± 102 kcal ($P < 0.0001$), with a mean percent error of 7.5% (root mean square error = 12.3%). The standard error for the macronutrient intakes ranged from 11.0% to 20.2%. The Bland-Altman approach demonstrated a positive slope for the rater method relative to the weighed method for total intake in grams ($P = 0.006$), carbohydrate ($P = 0.01$), and protein ($P = 0.01$) (ie, magnitude of the bias increased with increasing intakes).

Conclusions The rater method overestimated total intake in grams and energy in kilocalories in minority preschool children in a well-controlled condition and needs to be further tested in a free-living environment.

J Acad Nutr Diet. 2017; ■:■-■.

ACCURATE METHODS OF DIETARY ASSESSMENT IN young children are needed to determine whether their diets are adequate for normal growth and development. Despite the importance of understanding the diets of preschool children, collecting accurate and reliable intake information from this population poses multiple challenges^{1,2}; preschool children consume small amounts of food at frequent intervals, have a limited cognitive ability to recall foods and estimate amounts, are not able to complete questionnaires on their own and adult proxies are often used to collect their diet information, and they often spend time under the care of several individuals where meals are consumed outside the home.

Dietary assessment methods typically used among preschool children include direct observation or food weighing by trained researchers or caregivers, dietary recalls or food diaries from an adult proxy, or food frequency questionnaires completed by caregivers. Each of these methods has

well-known limitations. Direct observation may result in accurate estimates of food intake, but can disrupt the eating environment. Dietary recalls and food questionnaires can overestimate or underestimate energy intake because memory and portion-size estimation are a major source of inaccuracy.³ Food diaries are also subject to portion-size estimation inaccuracies, pose a significant caregiver burden, and can be reactive, as they could change dietary intake. In children 6 months to 4 years of age, food weighing by parents/caregivers has been shown to be the most accurate method of dietary assessment⁴; however, it entails a high participant response burden and may be impractical for preschool children with multiple caregivers in multiple care venues.

A digital diet-estimation method, which relies on images captured by the camera in hand-held devices, such as smart phones or tablets, has recently been shown to be an effective method that can improve the accuracy of assessing the

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dietary intakes of preschool children, elementary school children, adolescents, and adults.^{5,6} However, studies conducted with preschool children^{5,7} have focused on single meals rather than total daily intake. Photographic methods employ procedures similar to the direct visual estimation method, but instead of having an observer hand-record food consumed, food selections and plate waste are captured using a digital camera to be used later on by trained human raters to estimate consumption. These digitally aided methods offer lower respondent (caregiver) burden compared to other methods, and might produce more reliable and valid estimates among preschool children with multiple caretakers and/or feeding venues. Although the Remote Food Photography Method (RFPM) has been validated for measuring food intake of preschool children, elementary school children, adolescents, and adults, its accuracy in assessing young minority children's intake is not well documented.⁷ The feasibility of using this method with preschool children has been used to assess single meals using trained human raters to do the photographic estimations.^{8,9} The method has not been used to assess total daily intake. A more detailed description of the RFPM and the use of a hand-held device (in this case an iPhone, Apple Inc) for capturing and transmitting food images is available elsewhere.^{10,11}

Before conducting a validation study in a free-living environment, it was necessary to establish feasibility and criterion validity in a controlled environment with established and well-tested protocols. The primary goal of this study was to compare the RFPM and use of a human rater method against the criterion measure (weighed method) where gram weights were obtained in a controlled environment. A secondary goal was to compare the rater method and weighed method for total energy and macronutrient estimations after transforming grams consumed into nutrients using the Food and Nutrient Database of Dietary Studies (FNDDS 5.0)¹² or manufacturer's Nutrition Facts label information, when available.

MATERIALS AND METHODS

Design

In this study, the weighed method was the criterion and the rater method was the RFPM. Fifty-four 3- to 5-year-old Hispanic and African-American children participated in this study, which was conducted for 12 hours in a metabolic research unit (MRU) of the Baylor College of Medicine Children's Nutrition Research Center in Houston, TX, between June 2013 and January 2014. Convenience sampling was used to contact and screen potential candidates from two sources: the Baylor's Children Nutrition Research Center volunteers' research database and onsite recruitment at participating Head Start centers in Houston, TX. The sample size was calculated using the results of a previously completed pilot study⁵ and was considered to have 90% power to ensure detection of a nonequivalent difference of 10%. The study received the approval of the Institutional Review Boards of Baylor College of Medicine and the Pennington Biomedical Research Center, Baton Rouge, LA.

Procedures

To be eligible for participation, children had to satisfy the following eligibility criteria: Hispanic or African American; no

food-related allergies (eg, lactose intolerance, peanut allergy), diet modification (eg, vegetarian), or medical condition (eg, type I diabetes) that could impair or limit their ability to consume a regular diet; and have a caregiver who agreed to transport and/or accompany the child to meet with research staff on two occasions. During the first encounter, research staff obtained the required written consent from children's caregivers and verbal assent from children. The second encounter happened on the observation day at the MRU of the Children's Nutrition Research Center. Children were observed for a 12-hour period and received a total of five meals: breakfast, morning snack, lunch, afternoon snack, and dinner. For the first four eating occasions, children were offered meals prepared at the MRU, but for the last one (dinner), they were given a child-sized meal purchased at a nearby fast-food location. All menus were standardized and represented the types of foods/beverages most frequently consumed by this age group, according to national surveillance. The last two available reports of the What We Eat in America National Health and Nutrition Examination Surveys (2007-2008 and 2009-2010)^{13,14} were used as a reference when creating the menus.

Weighed Method (Criterion Measure)

At the MRU, a total of four research coordinators weighed and recorded all food served to and discarded by the children, and captured before and after images of the food that were used by the human raters at Pennington Biomedical Research Center to assess intake. In addition to the food photography, the Smart Intake application offered the ability to collect and transmit food descriptions (text or audio recordings) and other food identifiers. All of these were transmitted wirelessly and in real time to an offsite server at Pennington Biomedical Research Center. All menu specifications and gram weights of every item served to the children were documented on the meal observation form after being assessed by the research coordinators who used a calibrated food scale (Sartorius Corporation) with a precision of 0.1 g. Plate waste was also weighed and documented by the research coordinators on the meal observation form to allow total intake estimations by difference (amount served or offered minus leftovers or plate waste). FNDDS 5.0¹² and energy and macronutrients information from Nutrition Facts labels were used to compute intake estimates.

RFPM (Rater Method)

The method that was validated was the RFPM (copyright held by the Board of Supervisors of Louisiana State University and Agricultural and Mechanical College, Baton Rouge), and the instrument used to capture and transmit digital images was the camera of a smart phone (iPhone 4) loaded with the Smart Intake application (a trademark of the Board of Supervisors of Louisiana State University and Agricultural and Mechanical College, Baton Rouge). The server for the Automated Data Management Utility was housed within the Food Photography Application and was the control center for Ecological Momentary Assessment and photo organization. Ecological Momentary Assessment delivered text messages to the designated cell phone as a reminder to take and send photos of the meal around

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