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The Remote Food Photography Method Accurately Estimates Dry Powdered Foods—The Source of Calories for Many Infants

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ABSTRACT

Background Infant formula is a major source of nutrition for infants, with more than half of all infants in the United States consuming infant formula exclusively or in combination with breast milk. The energy in infant powdered formula is derived from the powder and not the water, making it necessary to develop methods that can accurately estimate the amount of powder used before reconstitution.

Objective Our aim was to assess the use of the Remote Food Photography Method to accurately estimate the weight of infant powdered formula before reconstitution among the standard serving sizes.

Methods For each serving size (1 scoop, 2 scoops, 3 scoops, and 4 scoops), a set of seven test bottles and photographs were prepared as follow: recommended gram weight of powdered formula of the respective serving size by the manufacturer; three bottles and photographs containing 15%, 10%, and 5% less powdered formula than recommended; and three bottles and photographs containing 5%, 10%, and 15% more powdered formula than recommended (n=28). Ratio estimates of the test photographs as compared to standard photographs were obtained using standard Remote Food Photography Method analysis procedures. The ratio estimates and the US Department of Agriculture data tables were used to generate food and nutrient information to provide the Remote Food Photography Method estimates.

Statistical analyses performed Equivalence testing using the two one-sided *t* tests approach was used to determine equivalence between the actual gram weights and the Remote Food Photography Method estimated weights for all samples, within each serving size, and within underprepared and overprepared bottles.

Results For all bottles, the gram weights estimated by the Remote Food Photography Method were within 5% equivalence bounds with a slight underestimation of 0.05 g (90% CI −0.49 to 0.40; $P<0.001$) and mean percent error ranging between 0.32% and 1.58% among the four serving sizes.

Conclusions The maximum observed mean error was an overestimation of 1.58% of powdered formula by the Remote Food Photography Method under controlled laboratory conditions, indicating that the Remote Food Photography Method accurately estimated infant powdered formula.
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FOOD INTAKE AND PROPER NUTRIENT INTAKE ARE important for maintaining adequate growth and development, maintaining a healthy weight, and preventing chronic diseases, yet accurate measurement of food intake to help inform consumers, clinicians, and researchers is challenging. Objective assessment methods have a high degree of accuracy, but considerably high burden and cost for most settings,[1-3] particularly when implementation is required on a large scale, such as in clinical practice. On the other hand, methods that are subjective are relatively simple to execute, but are less accurate because estimation is reliant on the individual for identification of foods and portion estimation.[4-6] The Remote Food Photography Method (copyright held by the Board of Supervisors of Louisiana State University and Agricultural and Mechanical College, Baton Rouge) is a validated method for assessing food intake that allows individuals or caregivers to utilize the SmartIntake smartphone application (a trademark of the Board of Supervisors of Louisiana State University and Agricultural and Mechanical College, Baton Rouge) to capture photographs of food provision and plate waste and to describe the food contained in the photographs within the application. Then, the photographs and descriptions are transmitted automatically to the Food Photography Application analysis program for energy and nutrient intake estimation. Portion estimation of foods contained in the photographs is completed by trained raters with the estimations expressed as ratios to food standard photographs.

The Food Photography Application uses US Department of Agriculture data tables and manufacturers' instructions to generate food and nutrient intake.[4,7] In comparison to doubly labeled water, the Remote Food Photography Method was found to underestimate energy intake by only 3.7% (−152±694 kcal/day; P=0.16) in free-living adults and by 1.2% in a buffet meal setting.[7]

Traditionally, compared with conventional foods, food intake assessment methods are less successful at estimating energy intake from condiments and beverages, leading to the potential for inaccurate estimation.[8,9] Indeed, Williamson and colleagues[2] found that digital photography was highly correlated with directly weighed foods for intake of various foods, except for condiment intake, which was overestimated by 16.6% (P<0.05; intra-class correlation coefficient [ICC]= 0.60).[2,8] The ability to measure calories in small quantities (eg, infant powdered formula) is becoming increasingly important because, according to the most recent Centers for Disease Control and Prevention Breastfeeding Report Card, more than half of all infants in the United States consume infant formula exclusively or in combination with breast milk.[10] Infant powdered formula is not only packaged in single-use servings, but also in larger containers that require the caregiver to portion the recommended amount of powder to mix. An additional nuance of reporting infant formula intake is that the caloric density of the reconstituted product is likely to vary between each preparation, as this is dependent on the exact measurement of the powder and liquid (eg, milk or water) that is placed into the serving container[9] and the amount of the prepared formula that is consumed. Egemen and colleagues[11] showed that 50% of mothers in their study sample added 10% more or 10% less water to a second formula bottle as compared to a first formula bottle that was prepared, illustrating that caregivers may not precisely measure powdered infant formula and water before infant feeding. Therefore, infant formula has potential for a large degree of misreporting, which presents a need for methodology to assess the caloric density in prepared formula and to provide measurement of infant formula intake from free-living infants.

Because the source of energy or kilocalories is derived from the powdered formula and not the water, which is typically used as the mixer with powdered formula, it is vital to develop methods that can accurately estimate the amount of powdered formula in bottles being prepared for infants. The aim of this proof-of-concept study was to assess the use of the Remote Food Photography Method in estimating powdered formula using standard infant formula photographs and the variability in accuracy of the Remote Food Photography Method among different serving sizes of powdered formula. If successful, the Remote Food Photography Method could be applied to the measurement of infant formula intake.

METHODS

Study Design

This was a laboratory-based, proof-of-concept study that was designed to evaluate the feasibility of applying the Remote Food Photography Method in the estimation of powdered formula. The Pennington Biomedical Research Center's Institutional Research Board considered this study, with no human subjects, a proof of concept and, therefore, exempt from human subjects research approval. The study was designed to determine whether the Remote Food Photography Method could be used to accurately estimate powdered formula before reconstitution using established standard photographs and US Department of Agriculture database food codes among standard formula serving sizes.

Development of Standard Photographs. Standard procedures of the Remote Food Photography Method require that photographs of foods be compared to a standard photograph showing the standard serving size of the food being analyzed. To prepare standard photographs of powdered formula, exact gram weight of powdered formula in each of the four recommended standard serving sizes (1 scoop [8.7 g], 2 scoops [17.4 g], 3 scoops [26.1 g], and 4 scoops [34.8 g]) was measured into a clear, generic infant bottle (Figure, panel A). A digital photograph of each bottle containing the specific serving size of the powdered formula was captured with the Remote Food Photography Method reference card, which is used for food sizing according to standard Remote Food Photography Method practices.[7] The gram weight for each serving size was determined from the nutrient label recommendation provided on the commercial packaging. All standard photographs were stored in the Remote Food Photography Method analysis database, the Food Photography Application. The standard photographs were used by trained raters as a reference standard to estimate the ratio of powdered formula present in the test photographs as compared to the standard photographs (Figure, panel B) using visual comparison methods described previously.[2,4,7]

Preparation of Test Photographs. To test the accuracy of the Remote Food Photography Method gram estimates as compared to actual gram weight in unknown bottles, and to assess the lower limit of estimation for each serving size, an individual impartial to the study (laboratory manager) prepared bottles and captured test photographs of powdered formula used in the study. The bottles were prepared with powdered formula that was fresh and stored according to the package instructions. For each serving size (1-scoop, 2-scoop, 3-scoop, and 4-scoop bottles), a set of seven test bottles were prepared and photographs were immediately captured. Each set of test bottles and photographs contained the recommended amount of powdered formula specified for the individual serving size by the manufacturer (100%), as well as three bottles and photographs containing 15%, 10%, and 5% less powdered formula than recommended and three bottles and photographs containing 5%, 10%, and 15% more powdered formula than recommended. The seven different conditions allowed for the investigation of the use of the Remote Food Photography Method to estimate differing gram weights for each scoop size, and it provided translation to real-world settings, as individuals are unlikely to scoop the recommended gram weight every scoop. For each serving size, the test photographs were randomly assigned labels A through G. In order to objectively test inter-rater reliability in estimating the amount of powdered formula in the bottles, the test photographs were then analyzed using the Food Photography Application by a trained rater. Using the Food Photography Application, the rater compared each test photograph to the