

Reliability and Validity of Digital Imagery Methodology for Measuring Starting Portions and Plate Waste from School Salad Bars

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ABSTRACT

Background Scientifically sound methods for investigating dietary consumption patterns from self-serve salad bars are needed to inform school policies and programs.

Objective To examine the reliability and validity of digital imagery for determining starting portions and plate waste of self-serve salad bar vegetables (which have variable starting portions) compared with manual weights.

Design/methods In a laboratory setting, 30 mock salads with 73 vegetables were made, and consumption was simulated. Each component (initial and removed portion) was weighed; photographs of weighed reference portions and pre- and post-consumption mock salads were taken. Seven trained independent raters visually assessed images to estimate starting portions to the nearest $\frac{1}{4}$ cup and percentage consumed in 20% increments. These values were converted to grams for comparison with weighed values.

Statistical analyses Intraclass correlations between weighed and digital imagery–assessed portions and plate waste were used to assess interrater reliability and validity. Pearson's correlations between weights and digital imagery assessments were also examined. Paired samples *t* tests were used to evaluate mean differences (in grams) between digital imagery–assessed portions and measured weights.

Results Interrater reliabilities were excellent for starting portions and plate waste with digital imagery. For accuracy, intraclass correlations were moderate, with lower accuracy for determining starting portions of leafy greens compared with other vegetables. However, accuracy of digital imagery–assessed plate waste was excellent. Digital imagery assessments were not significantly different from measured weights for estimating overall vegetable starting portions or waste; however, digital imagery assessments slightly underestimated starting portions (by 3.5 g) and waste (by 2.1 g) of leafy greens.

Conclusions This investigation provides preliminary support for use of digital imagery in estimating starting portions and plate waste from school salad bars. Results might inform methods used in empirical investigations of dietary intake in schools with self-serve salad bars.

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THERE IS GREAT NATIONAL SUPPORT FOR SCHOOL salad bars as a means to increase fruit and vegetable intake within the National School Lunch Program.¹ Despite the increasing prevalence of salad bars in schools,¹ few studies have investigated their impact on fruit and vegetable intake, and even fewer have investigated their effectiveness under the new meal standards set forth by the 2010 Healthy Hunger-Free Kids Act.²⁻⁵ When such investigations are conducted, methodologically sound procedures for estimating intake from salad bars are needed to inform policies and programs designed to enhance fruit and vegetable consumption in schools.

In a recent review of methods to assess children's dietary consumption in schools, investigators reported varied

outcomes, with meal observations (on-site or digital images) offering the highest interrater reliabilities (IRRs).⁶ However, there are few reports of the accuracy of dietary assessment methods in the school context. Furthermore, few studies have included school salad bars. Obtaining weights of food waste has been considered the gold standard; however, this method is time-, cost-, and labor-intensive and not conducive to large-scale data acquisition.⁷ Visual estimation on site and digital photography overcome many of these challenges.⁷⁻¹¹ For example, a recent study demonstrated that on-site visual estimation is a valid and reliable method for measuring plate waste in a cafeteria setting.¹¹ However, this method can only be used when the starting portion is standard, and it is not feasible for use with self-serve items of

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various portion sizes, such as those obtained from salad bars. Digital imagery has the potential to address this challenge.

Digital imagery plate waste assessment methods^{9,12,13} include labeling trays and taking a photograph from a standard angle before and after consumption; each pair of images is then viewed in the laboratory, and plate waste is visually estimated. The primary benefit of digital imagery is the ability to obtain a large amount of data in a faster and less disruptive way compared with manual weighing; it also has the benefit of allowing researchers to view and rate the photographs in an unhurried laboratory setting, in sharp contrast to the noisy, hectic cafeteria environment. The variety of foods selected can also be easily recorded when this method is used. Although results of some studies have supported the reliability and validity of digital imagery for determining plate waste with school lunches,^{9,12,13} its use to estimate variable starting portions, in addition to consumption, from self-serve salad bars has not been empirically supported. Taylor and colleagues⁹ reported that foods served in varying portions (eg, leafy greens) are more challenging to assess by means of digital imagery. Given the variable starting portions of salad bar items (because students self-serve their plates), determining the starting portion is essential, particularly if assessment of energy intake (or other nutrition information) is desired. Prior investigations in which digital imagery was used to determine plate waste^{7,14} might not translate to salad bars, given the potential for self-serve salad to contain overlapping vegetables, be obscured by salad dressing, or vary widely in composition and portion size. Thus in the present study, digital imagery assessments (ie, laboratory-based coding of digital images before and after consumption) were compared with measured weights in an attempt to determine whether digital imagery can accurately and reliably determine starting portions and plate waste from self-serve salad bars.

METHODS

This study was conducted by trained research staff at Virginia Commonwealth University in preparation for a larger investigation of the impact of school salad bars on dietary consumption patterns among Title I elementary school students. The current validation study was conducted in the laboratory setting and did not involve human subjects; thus it was not subject to institutional review board approval.

Preparation of Weighed Reference Portions and Test Salads

Salad bar menus were obtained from School Nutrition Services in the school district in which the trial was going to occur to identify all vegetables offered on the salad bars, including recipes for mixed items (eg, corn and black bean salsa). Only fruits and vegetables are served on the salad bar (no meats or grains). Because fruit on the salad bars is served cupped in a standard 4-oz serving, only vegetables were used in this investigation. Study staff re-created salad bar vegetables using preparation methods identical to those used in the target schools (eg, diced, sliced, or whole). In the schools, students use a $\frac{1}{4}$ -cup spoodle (serving spoon) and are allowed up to three spoodles (6 oz) of vegetables. For this study, two trained research staff members independently served three portions ($\frac{1}{4}$ cup, $\frac{1}{2}$ cup, and $\frac{3}{4}$ cup) of each vegetable into paper boats (identical to those used in the

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Research Question: Psychometrically sound methods are needed for assessment of dietary intake from salad bars, given their increasing prevalence in schools. In a laboratory setting, researchers attempted to determine whether digital imagery can be used to reliably and accurately measure starting portions and plate waste from self-serve salad bars.

Key Findings: Results support the interrater reliability and accuracy of digital imagery for estimating starting portions and waste from salad bars. Although the nutritional impact is negligible, assessment with digital imagery underestimated starting portions and waste of leafy greens. Results provide preliminary support for use of digital imagery in investigations of dietary consumption in schools with salad bars.

schools) to maintain consistency with school presentation and portion parameters. Each portion was labeled and photographed to serve as a reference (Figure 1). Portions were weighed in triplicate to the nearest gram, and the average was used as the measured weight of each vegetable.

Study staff viewed 44 pairs of images (“pre-” and “post-consumption”) of students’ salads from a prior school lunch investigation to observe typical portion and consumption patterns. Investigators trained study staff to generally adhere to student portion guidelines (1 to 3 spoodles), and staff then made 30 mock salads in paper boats using various portions of the 16 vegetables (up to three vegetables per salad) that would be served on the salad bar. Each ingredient ($n=73$ across the 30 salads) was weighed in triplicate to the nearest gram, and an average was calculated to determine the reference weight. This weight was then converted to cups. Researchers then simulated consumption by removing variable amounts of vegetables from the salads, weighed these “consumed” amounts in triplicate, and calculated waste (average grams remaining for each ingredient). Weighed percentage waste was determined for each salad ingredient as follows: Starting portion (g)–Portion consumed (g)/Starting portion (g) $\times 100$.

Photographs of each salad were taken before and after “consumption” (Figure 1). To simulate presentation at school, which might include salad dressing (each student is permitted up to two 1.5-oz low-fat ranch salad dressing packets, which would only be applied in the “post-consumption” image), dressing was then added, and a second photograph was taken. All photographs were taken from an angle of approximately 45 degrees by using iPads, which is consistent with methods used in prior studies.¹⁵ Photographers were instructed to ensure all four corners of the salad boat were in the image before taking the photograph to maintain size consistency. All weights were taken in triplicate to the nearest gram and averaged by using the Ozeri Pronto Digital Food Scale (Model ZK14-S; Ozeri Kitchen). Scales were tared before each use to exclude the weight of the salad boat.

Digital Imagery Assessment of Portion Sizes and Waste

Seven undergraduate students, who received research credit for participating, were trained in digital imagery methods by

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