The Journal of Extension

Volume 45 | Number 6 Article 16

12-1-2007

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Recommended Citation

Jacko, C. C., Dellava, J., Ensle, K., & Hoffman, D. J. (2007). Use of the Plate-Waste Method to Measure Food Intake in Children. *The Journal of Extension, 45*(6), Article 16. https://tigerprints.clemson.edu/joe/vol45/iss6/16

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December 2007 // Volume 45 // Number 6 // Research in Brief // 6RIB7

Use of the Plate-Waste Method to Measure Food Intake in Children

Abstract
Childhood overweight is increasing in the U.S. and is often associated with excess food intake. Because children consume at least one meal in school approximately half the days each year, it is important to develop accurate and cost-effective methods to measure food intake in schools. We compared the aggregated plate waste method with actual weighed food measurements. The aggregated plate waste measurements were similar to the energy and macronutrient intake determined by weighed food measurements. The plate waste methodology is a simple and accurate method that can be implemented by Extension professionals and teachers to assess children's energy intake.

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Introduction

The prevalence of children who are overweight continues to increase, placing a greater than ever stress on understanding the dietary factors associated with weight gain and obesity. However, it is difficult to accurately measure food intake in children, especially in a school setting, because most methods to measure food intake require direct contact with the children, a factor that can change their eating behavior and bias measurements. We present the use of an established, but rarely or never validated, method to assess food intake in children and compare it to a more accurate method to determine its usefulness and effectiveness for Extension and educational use. This article presents both the methodology for plate-waste method and compares it to a more precise method, providing a direct comparison of the aggregate versus individual methods, a missing piece of information for both nutrition and Extension professionals working with food intake in children.

Topics that will be discussed are summarized as follows:

- Childhood overweight and factors that promote weight gain.
- Foods consumed in school are often criticized as part of the problem.
- Techniques to measure and estimate food consumption patterns in school.
- The plate-waste methodology and need for validation of the technique.

Childhood Overweight

The number of children who are now overweight is greater than at any time in our nation's history (Kaur, Hyder, & Poston, 2003). Approximately 17% children are considered overweight, and this is generally associated with racial (Whitaker & Orzol, 2006) as well as socioeconomic factors (Ogden, Carroll, Curtin, McDowell, Tabak, & Flegal, 2006). Many factors are thought to influence weight gain in children, such as excess television viewing, lack of physical activity at home and in schools, the consumption of processed and fast foods, and safety of neighborhoods (Burdette & Whitaker, 2005; Dehghan, Akhtar-Danesh, & Merchant; 2005, Lumeng, Appugliese, Cabral, Bradley, & Zuckerman, 2006). It is also believed that foods eaten at school are part of the obesity epidemic, but few tools exist, especially for Extension specialists, to measure what children eat at school.

School Foods and Childhood Overweight

Schools often unfairly receive criticisms regarding their food programs (Hayne, Moran, & Ford, 2004). Most of these criticisms stem from the use of commercially prepared foods that are contracted or sold through cost-saving or fundraising programs in the face of constant budget cuts. Still, it is important to note that no research has provided data implicating foods consumed at school as a cause of the rise in childhood overweight. In fact, professional organizations have come to support school food programs in the face of criticisms that such programs provide less than healthful diets and may promote obesity in lower income children (Pilant, 2006). Nonetheless, schools provide a key avenue to both preventing and reducing the prevalence of childhood overweight given the near universal attendance of school by children and the fact that they are captive for many hours a day (Dehghan, Akhtar-Danesh, & Merchant, 2005).

Techniques to Measure Food Consumption

A step towards understanding the relationship between food intake at school and overall energy intake is to determine the foods and food quantities typically consumed by children at school during a normal school day.

Methods used to measure food intake in school children include the following.

Dietary Recall

Dietary recalls are often used to assess a relatively large numbers of subjects to minimize the economic and logistical burden. However, since results are based on the child's ability to recall both the type and amount of food consumed, the accuracy of dietary recalls tends to be low in school children (Comstock Pierre, & Mackiernan, 1981).

Visual Estimation

Visual estimation is an unobtrusive measurement method, although it is less accurate than a weighted food record (Comstock, St Pierre, & Mackiernan, 1981). Using visual estimation, trained observers classify foods using a rating scale and estimate portion sizes on trays before and after consumption. The main disadvantage is that ratings are not made on exact proportions and can differ among observers (USDA, 2002).

Physical Measurements of Food Consumed

The most traditional method used to measure in-school caloric intake is the actual measurement of food consumed by children. This method is very accurate, but is full of bias as children tend to change food intake patterns when supervised and especially when they know their intake is being measured.

The Plate Waste Methodology

Aggregate measures of plate waste have been used extensively in studies of school food intake of children (Blakeway & Knickrehm, 1978; Carver & Patton, 1958; Guthrie, 1977, Lee, Lee, & Shanklin, 2001; Whatley, Donnelly, Jacobsen, Hill, & Carlson, 1996). Although physical measures of plate waste have been criticized, compared to other methods, they provide the most accurate data when assessing food intake (Comstock, St Pierre, & Mackiernan, 1981; Kirks & Wolff, 1985). The use of aggregated plate waste as a method to measure actual dietary intake has not been validated against more accurate methods. Therefore, the objective of this paper is to describe how the estimated energy intake and macronutrient composition of meals measured using individual plate waste with estimates derived from aggregate plate waste in two public elementary schools in

New Jersey.

Methods

Food intake was measured during school lunch periods in 50 third, fourth, and fifth-grade students from two urban elementary schools in Elizabeth, NJ during the same months of two consecutive years. Measurements of plate waste were conducted on 10 semi-randomly chosen and unannounced days. No changes in the menus, food vendors, or cafeteria environment occurred during between the two sets of measurements.

Nutritional information of the food items were obtained from the product vendors and analyzed using Nutritionist Pro® *network version* (FirstDataBank, San Bruno, CA, 2002) to obtain the energy and macronutrient information for the lunches served. The nutrient calculations of the lunches served were based on the National School Lunch Program (NSLP) menus and did not include a la carte items, such as condiments, or extra-purchase snacks, such as cookies, candy, or various types of chips unless selected by a student studied.

The protocol for assessing food intake in the children using the plate-waste method was as follows. A menu of food items offered was obtained from dining services, and each item was measured to determine the mass being served. Second, a station was established near the garbage cans that had 6 large (2 gallon) pre-weighed plastic tubs. Students were asked to discard individual food items into each tub (e.g., french fries into tub #1, milk into tub #2, green beans into tub #4, and so on). When the set number of students for the lunch period had discarded their food, the tubs were weighed to record the total weight, and the difference between the tub weight and the tub + food weight was calculated and recorded as the mass of food "wasted."

Thus, for the total number of children who discarded food, we obtained the total amount of food wasted. The actual value of "food intake" came from the pre-measured amount of each food item offered at lunchtime. So we were able to calculate the total mass of each item offered for all children studied and subtract the total mass of each item discarded by these very students and estimate the mass of food consumed.

For individual food intake, we measured the mass of each food item served prior to the children entering the lunchroom. At the end of lunch, children selected on a random basis were asked to leave their trays at the station. When all students had exited the lunchroom, the research assistant weighed the items left on each student's tray to measure the mass of food "wasted." The estimated food intake was determined as the difference between the mass of each item served and the mass of each item wasted.

The individual sets of data on lunches served and consumed were averaged and compared against the results of the earlier study that used the aggregate selective plate waste method. The earlier aggregate selective plate waste study used an identical methodology, with the only exception being that leftover food items were weighed together for all children instead of separately for each child.

Means for all variables studies were compared using student's t-test, repeated measures, and independent measures because one could potentially consider the schools as one unit of study or the students as units of study. Statistical significance was set as $p < 0.05$, and all statistical analyses were done using SPSS for Windows, Version 12.0 (SPSS, Inc. Chicago, IL).

Results and Discussion

The difference in estimated energy intake was not statistically different between the two methods studied (Table 1). Moreover, there was no difference in the macronutrient intake of the groups studied using the different techniques.

Table 1.
Energy and Macronutrients of Served and Consumed Lunches

	Aggregate Method Year 1 (n = 455)		**Individual Method Year 2 (n = 50)**	
	Served	**Consumed**	**Served**	**Consumed**
Total energy (Kcal)	722 ± 167	479 ± 147	627 ± 93	476 ± 92
Protein (g)	31.9 ± 7.1	21.4 ± 4.5	26.1 ± 5.3	20.3 ± 4.1
Protein (%)	18.0 ± 4.2	18.6 ± 4.6	16.7 ± 3.1	17.3 ± 3.8
CHO (g)	99.6 ± 26.5	59.1 ± 19.2	81.3 ± 16.8	56.4 ± 13.5
CHO (%)	54.6 ± 4.5	49.0 ± 3.9	51.3 ± 4.3	47.2 ± 4.1

Fat (g)	22.2 ± 6.2	17.6 ± 7.5	22.2 ± 3.9	18.7 ± 4.3
Fat (%)	27.5 ± 4.4	32.4 ± 5.4	32.0 ± 5.1	35.5 ± 4.4

In terms of the number of servings of fruits and vegetables as suggested by the USDA food pyramid, there were no differences in the amount of servings consumed as estimated by either method (Table 2).

Table 2.
Average Daily Food Guide Pyramid Servings

	Aggregate Method Year 1 (n = 455)		**Individual Method Year 2 (n = 50)**	
Serving)	Served	Consumed	Served	Consumed
Total fruit & vegetable	1.5 ± 0.3	0.6 ± 0.2	1.2 ± 0.2	0.4 ± 0.2
Total fruit	0.7 ± 0.4	0.2 ± 0.2	0.8 ± 0.2	0.2 ± 0.2
Total vegetable	0.8 ± 0.2	0.4 ± 0.3	0.4 ± 0.2	0.2 ± 0.2
Starchy vegetable	0.4 ± 0.2	0.2 ± 0.1	0.2 ± 0.1	0.2 ± 0.2
Non-starchy vegetable	0.4 ± 0.2	0.2 ± 0.3	0.2 ± 0	0.0 ± 0.1
Milk	1 ± 0	0.5 ± 0.1	1 ± 0	0.6 ± 0.3

Discussion

The plate-waste methodology, an established food intake method that has not been compared to more precise techniques, allows for both the estimation of energy and macronutrient intake in children at school. Because many schools and school districts are beginning to monitor and modify their school lunch programs in an effort to prevent the rising prevalence of childhood obesity, it is vital to have a simple, validated method by which changes can be assessed. Our results suggest the following.

- Plate waste methodology is useful for estimating food intake in children in school settings, without having to interact with the children. This can provide less biased results and minimize the need for ethical review approval and parental consent.
- Using the aggregated plate waste method, percent waste, macronutrient consumption, and actual weight and caloric density of foods consumed and discarded can be determined. Although individual plate waste data cannot be used to obtain more specific information such as correlations between age, sex, BMI, etc., aggregate selective plate waste measurements can yield accurate results for groups of children, without the time and logistical constraints involved with other methods, thereby accommodating larger sample sizes.
- Plate waste methodology can be used as a teaching tool for school children as well as dietetics students and can be integrated into many curricula including math, science, and health.

We found the aggregated plate waste method to be as accurate, but more easily implemented, than actual weighed food measurements. Thus, this can be use as a simple method to measure food intake in school children.

- The plate waste method does not require student contact, thus minimizes the need for informed consents and assents.
- There is limited interaction with the kitchen staff, which allows the evaluators to remain as unobtrusive as necessary while still collecting accurate data.
- Information can be gathered to help in the planning and evaluation of nutrition education without any interference with classroom time.

With increased attention placed on prevention of childhood obesity, many schools are initiating changes in both nutrition education programs and lunch menus. Thus, it is becoming of the utmost importance to be able to access children's energy intake at school. The aggregate plate waste method can be used to evaluate the impact of these programs on the in-school food intake of children. This will provide excellent data that can be used to make future decisions regarding nutrition education programs as well as lunch menu options. Thus, our data showing that the plate waste method is comparable to more invasive, yet precise methods, suggest that it is ideal for assessments of breakfast and lunch programs, nutrition education programs, and general

monitoring of dietary patterns of school children

Application

The risk for adult obesity for a child who is overweight is great because most overweight children become overweight adults. Because dietary habits of most adults are formed in childhood, it is important that nutrition professionals have quality tools available to assess childhood food intake. The plate-waste methodology is a valid tool to estimate eating habits of school children, with limited interference with either the school staff or children.

Extension professionals can incorporate this methodology into existing school-based nutrition education programs, such as:

- Health classes for older students on diet and methods to measure food intake.
- Mathematics classes when students to analyze plate-waste data they collected on other students.
- Extension service by creating a teach-the-teacher curriculum for nutrition education.

In the university setting, dietetics and nutrition students can learn the methodology as part of their education, creating a network of data on food intake among school children. The limits of this methodology exceed the reality of "measuring garbage" because a wealth of knowledge can be gained from measuring food thrown away by students.

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