Appetite 120 (2018) 196–204

Contents lists available at ScienceDirect

Appetite

journal homepage: www.elsevier.com/locate/appet

Feasibility and reliability of digital imaging for estimating food selection and consumption from students' packed lunches

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ARTICLE INFO

Article history:
Received 1 May 2017
Received in revised form
6 August 2017
Accepted 30 August 2017

Keywords:
School nutrition
Dietary assessment
Packed lunch
Children
Digital imaging
Reliability

ABSTRACT

Although increasing attention is placed on the quality of foods in children's packed lunches, few studies have examined the capacity of observational methods to reliably determine both what is selected and consumed from these lunches. The objective of this project was to assess the feasibility and inter-rater reliability of digital imaging for determining selection and consumption from students' packed lunches, by adapting approaches previously applied to school lunches. Study 1 assessed feasibility and reliability of data collection among a sample of packed lunches ($n = 155$), while Study 2 further examined reliability in a larger sample of packed ($n = 386$) as well as school ($n = 583$) lunches. Based on the results from Study 1, it was feasible to collect and code most items in packed lunch images; missing data were most commonly attributed to packaging that limited visibility of contents. Across both studies, there was satisfactory reliability for determining food types selected, quantities selected, and quantities consumed in the eight food categories examined (weighted kappa coefficients 0.68–0.97 for packed lunches, 0.74–0.97 for school lunches), with lowest reliability for estimating condiments and meats/meat alternatives in packed lunches. In extending methods predominately applied to school lunches, these findings demonstrate the capacity of digital imaging for the objective estimation of selection and consumption from both school and packed lunches.

1. Introduction

Dietary intake among US children falls short of national recommendations in several areas, including consumption of fruits, vegetables, and whole grains (Hiza, Casavale, Guenther, & Davis, 2013; Kim et al., 2014). As children spend more time away from home during the school-aged years, foods available in other environments, including during lunch at school, may become more central to food preferences and eating habits. While programs and policies have frequently targeted nutritional quality and appeal of foods available through the National School Lunch Program (Cohen et al., 2015b; Food and Nutrition Service US Department of Agriculture, 2012a; Reicks, Redden, & Mann, 2012; Swanson, Branscum, & Nakayima, 2009), growing attention has shifted to foods brought from home in packed lunches (e.g., Goldberg et al., 2015; Roberts-Gray et al., 2016). This extension of school-based nutrition research to packed lunches represents an important area because close to half of children may bring a packed lunch to school each day (Food and Nutrition Service US Department of Agriculture, 2012b), yet an expanding body of evidence indicates the nutritional quality of these lunches falls short of school lunches (Caruso & Cullen, 2015; Farris et al., 2014; Hubbard, Must, Eliasziw, Folta, & Goldberg, 2014; Romo-Palafox et al., 2015). For example, in a sample of elementary schools in Massachusetts, the contents of most packed lunches fell short of National School Lunch Program standards for fruits, vegetables, and fluid milk (Hubbard et al., 2014).

Similar to research on school lunches, the focus on lunchtime eating behaviors among children choosing packed lunches can be examined using objective, observation-based methods (Tugault-Lafleur, Black, & Barr, 2017). These methods do not rely on a

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http://dx.doi.org/10.1016/j.appet.2017.08.037
0195-6663/

child's ability to report or recall their own eating behaviors and thus minimize measurement error and bias common to self-report dietary assessment methods. Nevertheless, there are limitations to the current applications of observation-based methods for the assessment of packed lunches. First, studies often examine what was selected in packed lunches (i.e., contents) prior to lunchtime but do not also collect information during or after lunch to ascertain food consumption and waste (Farris et al., 2014; Johnston, Moreno, El-Mubasher, & Woehler, 2012; Mitchell, Miles, Brennan, & Matthews, 2010; Sweitzer, Briley, & Robert-Gray, 2009). Second, in relying predominately on direct observation methods, where trained researchers observe and estimate packed lunch contents in real time (Caruso & Cullen, 2015; Richter et al., 2012; Romo-Palafox et al., 2015), data collection can be labor- and time-intensive with few observations possible during each lunch period (Ball, Benjamin, & Ward, 2007; Baxter et al., 2013; Caruso & Cullen, 2015; Richter et al., 2012). Digital imaging (i.e., digital photography), a method in which images of food selections and food waste are collected at the beginning and end of the meal, respectively, may help address these limitations because food estimations can occur at a later time, separate from field data collection. This may allow the same number of researchers to collect a larger sample of lunches than achievable using direct observation. Although more commonly applied to observations of school lunches (Amin, Yon, Taylor, & Johnson, 2014; Morrill, Madden, Wengreen, Fargo, & Aguilar, 2016; Smith & Cunningham-Sabo, 2014; Williamson, Han, Johnson, Martin, & Newton, 2013), digital imaging has been previously used for the assessment of food selections in packed lunches (Gauthier et al., 2013; Goldberg et al., 2015; Hubbard et al., 2014; Mitchell et al., 2010). However, to our knowledge, no studies have applied digital imaging to visually estimate consumption from packed lunches. Drawing from digital imaging protocols for school lunches may provide a feasible and reliable means by which to do similar consumption estimations for packed lunches (Martin et al., 2007; Taylor, Yon, & Johnson, 2014).

In order to better understand the strengths and limitations of digital imaging toward this purpose, two separate studies were conducted to examine the feasibility and reliability of digital imaging for food selection and consumption from packed lunches among elementary school-aged students. Study 1 assessed feasibility and inter-rater reliability of data collection procedures for packed lunches. Study 2 examined inter-rater reliability within a larger sample of packed lunches and school lunches to allow comparison of the digital imaging method's application to different lunch types.

In terms of feasibility, potential challenges with packed lunches may include limited visibility or absence of plate waste within post-meal images (Hanks, Wansink, & Just, 2014; Taylor et al., 2014). Time required for data collection may also limit the number of lunches sampled per lunch period. To this end, we collected information on image quality and time requirements for these procedures. These considerations are especially relevant to packed lunches since lunch contents must be unpacked and re-packed, in contrast to school lunches where foods are usually already visually accessible on a lunch tray.

In terms of reliability, the estimation of food consumption from packed lunches may occur alone or alongside estimations for school lunches, underscoring the importance of establishing methods that can be applied to both lunch types. Whereas school lunch items may be served directly onto plates or trays, thereby limiting use of packaging, a recent intervention targeting packed lunches observed that more than half of items were brought in single-use packaging (Goldberg et al., 2015). Packaging may be helpful for identifying and estimating food selection since it provides information on contents (e.g., portion sizes), but it may be problematic for estimating food consumption if it limits visibility of contents (Steele, 2015). In the present study, we determined whether the wide variety of foods present in both school and packed lunches can be reliably coded by trained researchers.

2. Study 1

2.1. Methods

2.1.1. Study design and participants

Studies 1 and 2 were part of a larger project, Parents to Peers, examining social influences on eating behaviors during school lunch (Sutter, Taylor, Nishina, & Ontai, 2016). Study 1 tested methods for assessing packed lunches in spring 2015. Thirty-eight students (54% boys) were recruited from three fourth-, fifth-, and sixth-grade classrooms in one elementary school in northern California (see 'Study 1' column of Table 1 for additional student characteristics). The school was selected because the majority of students brought packed lunches to school, while about a quarter (23.1%) were eligible for free or reduced-price meals. Each classroom was observed over 5 consecutive days. Among the 38 students, three were excluded because they did not bring a packed lunch on any of the study days. The study was approved by the University's Institutional Review Board. Students and their parents provided written assent and consent, respectively. Students were compensated at the end of the study period ($1 to student and $1 to his or her classroom for each day of participation).

2.1.2. Procedure

Packed lunch selection and consumption was assessed using a three-step process. First, prior to lunch, trained researchers met individually with students, who were asked to unpack the contents of their lunch onto a standardized matboard marked with one-inch gridlines. Students unpacked their own contents in order to avoid any food handling by researchers as in other protocols (Hubbard et al., 2014; Mitchell et al., 2010). As the lunch was unpacked, the researcher recorded written notes on all foods brought in the lunch

Table 1
Characteristics of students participating in feasibility and reliability testing of a digital imaging-based method for assessing packed lunches.

	Study 1 ($N = 35$)	Study 2 ($N = 315$)
	n (%)	
Gender		
Male	19 (54)	135 (45)
Female	16 (46)	168 (55)
Grade		
4	10 (29)	100 (33)
5	11 (31)	93 (31)
6	14 (40)	110 (36)
Race/ethnicity		
African American/Black	0 (0)	27 (9)
Asian/Pacific Islander	3 (9)	21 (7)
Caucasian/White	24 (69)	112 (37)
Latino/Hispanic	1 (3)	55 (18)
Multiethnic	0 (0)	78 (26)
Other	7 (20)	10 (3)
Parent education (highest)		
Less than Bachelor's degree	6 (17)	148 (50)
Bachelor's degree or above	29 (83)	150 (50)
Household income[a]		
<$20,000	2 (6)	47 (16)
$20,000-$39,999	2 (6)	57 (20)
$40,000-$59,999	0 (0)	54 (19)
$60,000-$79,999	3 (9)	31 (11)
$80,000-$99,999	6 (18)	25 (9)
$100,000 or more	21 (62)	76 (26)

[a] Sample sizes unequal due to missing data.