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A Multiday Record-Assisted Fruit, Vegetable, and Snack Questionnaire to Assess Intake Among Fourth and Fifth Grade Students

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A MULTIDAY RECORD-ASSISTED FRUIT, VEGETABLE, AND SNACK

QUESIONNAIRE TO ASSESS INTAKE AMONG FOURTH AND

FIFTH GRADE STUDENTS

by

Anne B. Lambert

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ABSTRACT

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Childhood obesity is a serious public health concern in the United States. Consuming more fruits and vegetables (FV) is one proposed strategy to address the obesity epidemic. School-based interventions aimed at increasing FV consumption require reasonable estimates of intake among children. Obtaining accurate dietary information can require extensive resources and time. This study was designed to test the efficacy of a multiday record-assisted fruit, vegetable, and snack questionnaire (FVSQ) in measuring FV consumption in fourth and fifth graders.

The FVSQ was administered to students from six elementary schools (n = 547) during the time that plate-waste photo analysis (PWPA) data was being obtained from the *Food Dude* program. *Food Dudes* is a school-based intervention study aimed at increasing FV consumption in children. Consumption data was obtained during Baseline, Phase 1, and Phase II of the program.

FVSQ and PWPA data were compared to assess the efficacy of the FVSQ at estimating lunchtime FV consumption. The FVSQ was also compared to skin carotenoid scores to evaluate FVSQ measurements of total daily FV consumption. Comparisons between FVSQ and PWPA lunchtime consumption yielded Spearman correlation coefficients ranging from 0.387 to 0.4529 ($P < 0.000$). In comparing FVSQ total FV intake to skin carotenoid scores (SCS), weak correlations of 0.19 and 0.18 ($P = 0.007$ and 0.006, respectively) were found for Phase I and Phase II. Although FVSQ lunchtime FV consumption showed moderate correlations to PWPA data, it failed to detect important increases in FV consumption between Baseline and Phase I (0.11 cups for fruit and 0.12 cups for vegetables). Having students complete a food tracker during mealtime did not increase performance on the FVSQ ($P = 0.35$-0.70).

The findings in this study suggest that the FVSQ provided a moderately valid estimate of lunchtime FV consumption among fourth and fifth grade children, but was not sensitive enough to detect small but important changes in FV consumption. The FVSQ did not provide a valid measurement of total FV consumption. While it is difficult for children to recall dietary information, future studies should continue to explore the development of a self-report questionnaire that can accurately assess total FV intake in children.

(100 pages)

PUBLIC ABSTRACT

A Multiday Record-Assisted Fruit, Vegetable, and Snack Questionnaire to Assess Intake Among Fourth and Fifth Grade Students

Assessing FV intake among young children is difficult and can be a time-consuming, resource-intensive, and burdensome. The aim of this study was to create a simple, self-assessment tool to estimate and detect changes in FV consumption among fourth and fifth graders. Such a tool would ease the complications and resources of other diet assessment options that are used to measure FV consumption when implementing school-based nutrition programs.

The questionnaire provided a moderately valid estimate of lunchtime FV consumption, but it was inconsistent at detecting small, yet important increases in FV consumption between time points. The ability of the questionnaire to measure total FV consumption was also tested and found to be poor. In addition, having the students record what they ate on a food tracker during meals did not improve performance on the questionnaire.

The tool examined in this study could provide a reasonable estimate of average lunchtime FV consumption among fourth and fifth grade children, but could not be used to detect sensitive changes in consumption during a FV intervention study. While it is difficult for children to recall dietary information, it beneficial to continue to explore the development of a self-report questionnaire that can accurately assess total FV intake in children.

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Anne B. Lambert

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CHAPTER 1

INTRODUCTION AND BACKGROUND

ABSTRACT

Childhood obesity is a growing area of public health concern in the United States. Fruit and Vegetables (FV) are low energy-dense foods, rich with fiber, nutrients and water. As such, increasing FV consumption is one strategy researchers have proposed to address the obesity epidemic. Schools are good place to target behavioral changes in FV consumption and many different programs have been implemented to help children develop healthy eating habits. An accurate representation of food intake is important in evaluating the efficacy of school-based interventions. Estimation by observation is generally accepted as an accurate measure of food intake, but it is burdensome and resource and time intensive. This study assessed the efficacy of a multiday record-assisted fruit, vegetable, and snack questionnaire (FVSQ) in measuring lunchtime and total daily FV intake. The FVSQ was administered to students during the same period of time that plate-waste photo analysis (PWPA) data was collected in cafeterias. FVSQ data was compared to PWPA data to assess the efficacy of the FVSQ at estimating lunchtime FV consumption. The FVSQ was also compared to skin carotenoid score, a potential biomarker of highly pigmented fruit and vegetable intake. Fourth and fifth grade students from six elementary schools in Northern Utah who were participants in the Food Dudes study were included in these analyses (n=579). This project was funded by the United States Department of Agriculture.

INTRODUCTION

Childhood obesity is an area of growing public health concern in the United States. According to The National Health and Nutrition Examination Survey (NHANES) 2007-2008, 21.2% of children aged 2-5 were considered overweight, with 10.4% considered obese. In children aged 6-11, 35.5% were overweight, with 19.6% considered obese (1). Childhood overweight and obesity have grown considerably since the 1960s (2) but have leveled off over the last ten years (3). Nevertheless with 16.9% of U.S. children and adolescents being obese as of 2010 (3), improving childhood nutrition is a growing target for public health reform.

Consuming energy-dense food is one proposed contributor to childhood obesity. Using 24-hour recall data from the 2001-2004 NHANES, Vernarelli et al. (2) found that dietary energy density (excluding beverages) was positively associated with body weight in children aged two- to eight-years old. Diets high in energy-dense foods were associated with greater intakes of energy and added sugars, more energy from fat, and a significantly lower intake of fruits and vegetables (2).

Current child and adolescent overweight could be a consequence of excessive or inadequate consumption of certain food groups, specifically plant-based foods (4). Data from the cross-sectional analyses of NHANES II suggested that intakes of dairy, grains and total fruits and vegetables were inversely associated with central obesity among adolescents (5). Among children aged 6-11 in the United States, mean intakes of fruit consumption were reported as only 71.5% of the MyPyramid fruit recommendations and 58.3% of the MyPyramid vegetable recommendations (6), pointing to the fact that interventions are needed to increase fruit and vegetable (FV) consumption among children.

FVs are low energy-dense foods, rich with fiber, nutrients, and water. As such, increasing FV consumption is one strategy researchers have proposed to address the obesity epidemic (7). In a review of 21 studies, eight out of eleven experimental studies and three out of seven longitudinal studies found an inverse relationship between FV consumption and adiposity in adults. The studies that included children were few: one experimental study and four longitudinal studies. They found mixed results in regard to an inverse association. Although the relationship of FV intake to adiposity has been shown repeatedly in adults, it remains unclear in children according to this review (7).

In contrast, Epstein et al. (8) found that promoting healthy eating could be an effective strategy for childhood weight loss and developing healthy nutritional habits (8, 9). One study included 41 children ages 8-12-years, who were over the 85th BMI percentile. Each child was randomly placed in a group that either targeted healthy eating (including promotion of FV intake) or focused on decreasing energy-dense foods in order to assess which strategy had a greater effect on weight loss. Results showed that children who focused on increasing healthy eating showed a greater reduction in BMI than those who focused on reducing consumption of high energy-dense foods alone (-0.30 zBMI units vs. -0.15 zBMI units, $p= 0.01$) at both 12 and 24-month follow-ups. Although both groups showed a decrease in consumption of energy-dense foods after one year, those who focused on reducing energy-dense foods sustained a lower consumption of energy-dense foods than the healthy eating group (10). This study supports the idea that increasing FV intake while decreasing consumption of energy-dense foods could be one strategy to address childhood obesity.

Childhood obesity can be a concern for long-term health consequences (11). It has been suggested that the current obesity prevalence will yield a lifetime risk for Type 2 diabetes of 30% for children born in the year 2000 (10). In addition, heart disease is one worrisome chronic disease that sits as the leading cause of death in most developed countries today (12). Recent evidence has also shown that the development of atherosclerosis, dyslipidemia, and insulin resistance may begin in childhood (13-15).

In a meta-analysis of 13 total studies in adults, nine of the 13 cohorts showed associations for fruits and vegetables and coronary heart disease. A pooled analysis of all these studies revealed that both fruits and vegetables had a significant effect against CHD. When subjects increased their FV consumption from less than three to more than five servings a day, they decreased their risk for CHD by 17% (12). From this meta-analysis, FV consumption was identified as a significant factor in reducing heart disease.

Studies have shown childhood nutritional habits predict dietary patterns in adulthood (15, 16). Thus it is important to teach children when they are young to make healthy dietary choices. Schools are a good place to target behavioral changes in FV consumption as they focus on large numbers of children simultaneously (17) and offer an active learning environment. In addition, children spend a large part of their day, and consequently consume a significant portion of their calories at school (18). As over 30 million children participate in the National School Lunch program (19), the school food environment has potential to make a great impact on children's eating habits.

Many programs have been developed to encourage children to consume more fruits and vegetables (17, 20-22). School-based intervention programs are usually categorized into two groups: multicomponent programs that motivate children and families to alter eating patterns, and single-component programs that give away free or subsidized fruit and vegetables (20). In a review of 27 school-based intervention programs, researchers found that multi-component programs tended to make larger improvements in fruit and vegetable consumption, but they required extensive time and funds. They also noted that most programs were most successful at increasing fruit consumption, but often failed to increase vegetable consumption by a useful amount (20). Although it is difficult to help children develop better eating habits, some programs have been successful at increasing fruit and vegetable consumption including Food Dudes, High 5, and APPLE (20).

Many researchers use photo-analysis or other lunchtime observation techniques to measure intake in children. These methods for measuring food consumption can be expensive and time-consuming. There is a need to create a simpler tool that can adequately measure total FV consumption in order to reduce resource and time limitations for researchers. The purpose of this study was to develop a multiday record-assisted fruit, vegetable, and snack questionnaire (FVSQ) that could accurately assess lunchtime FV intake in fourth and fifth graders. The development of such a tool would simplify the research process, which could have great implications in addressing the issues of childhood obesity.

BACKGROUND

The Food Dude Program. One program that has proven successful in helping children increase FV intake is the *Food Dude* program. *Food Dudes* is a peer-modeling and rewards-based school intervention program that targets increasing children's FV consumption. This program implements the strategies of repeated tasting, role modeling, and rewarding to help children increase FV consumption (17, 22).

Baseline. Baseline is the same for all schools participating the in the *Food Dude* program (control and intervention) and it occurs before the program interventions have begun. During baseline 1, usual FV consumption is measured for four days during lunchtime. During baseline 2, children are offered one of four pairs of FV (carrots and pineapple, black bean salad and apples, broccoli and oranges, and cucumbers and grapes) over an additional four days. Intake is measured under these conditions as well to ensure that the selected FV served during the *Food Dude* program have no effect on consumption.

Phase 1. During the next sixteen days, children watch videos of their heroic peers, the 'Food Dudes,' eating FV and enjoying them. In the videos, the 'food dudes' fight off the evil 'junk punks,' who plan to deprive the world of FV. The 'food dudes' receive their power and energy by eating FV and they encourage the children to do the same. In addition to the videos, students are motivated by letters from the 'food dudes' that remind the children to eat their FV. During lunchtime, the children are offered FV in an increasing portion size over time and given a prize for consumption of the prescribed amount for that day. Lunchtime FV consumption is measured for the final four days of phase 1 (17, 22, 23).

Phase 2. Over the final three months of the program, prizes are gradually diminished. Instead of receiving a prize each day for eating their FV, students are required to consume all their FV over an increasing span of days (2-12) in order to receive a prize. Requiring the children to maintain FV intake, while increasing the time over which consumption is required, allows children to experience their own intrinsic rewards for eating FV. FV intake is measured during lunch on the final four days of phase 2 (17, 22).

Both Lowe et al. (17) and Horne et al. (22) evaluated a version of the *Food Dude* program in England and Ireland, respectively. Over a 5-month period, children were given FVs during snack time after watching the *Food Dude* videos. They were given a prize if they ate their FV during snack time. After the prizes had diminished and they had observed each of 16 videos, the children showed significant increases in both lunchtime and home consumption of FV (at least on week days) in both studies. Horne et al. (22) found that children who ate the least FV at baseline (11% and 4%, respectively) increased their consumption to 48% and 68% during the intervention and maintained and increased consumption of 43% and 48% at the follow-up assessment four-months later (22). Lowe et al. (17) found that overall, children increased consumption from 38% to 59% at the 4-month follow-up (17). In an additional study performed by Horne et al. (21), the *Food Dude* intervention was also effective in changing parental supply and children's consumption of lunchbox FVs in Ireland (21). Due to the success of the program, more than 100 schools in the UK have implemented the program, as well as all elementary schools in Ireland.

According to the Utah 2008 height and weight study, 20.4% of elementary-age Utah children are overweight or obese (24), which denotes a serious need to improve nutritional habits locally. In response to the effectiveness of the *Food Dude* program researchers have modified the program to fit school structure in Utah. During a five-month pilot study, Wengreen et al. (23) observed similar increases in FV consumption compared to those observed in the UK and Ireland among 250 children from one elementary school.

Currently, a USDA grant is funding research of the *Food Dude* program at six schools in the Cache County School District. One of the greatest modifications to the program is the use of a praise component in some of the schools in the place of a tangible prize (as seen in the original program). Prizes are one of the key elements of the program in enticing children to taste and later consume all of their FV at lunchtime. In order to reduce the use of these resources, researchers are studying the effects of using social praise in the classroom, instead of tangible rewards to entice the children to consume their FV. Of the six schools participating in the study two were randomly assigned to each of the following conditions: control, praise, or prize (full intervention).

While the effectiveness of the *Food Dude* program has been established, and continues to be confirmed, recording lunchtime food consumption is time-consuming and burdensome process. Many researchers, including those involved in *Food Dudes*, use photo-analysis or other lunchtime observation techniques to measure intake in children. There is a need to create a simpler tool that can adequately measure total FV consumption in order to reduce resource and time limitations for researchers.

Cognitive ability. Measurement of habitual food intake, especially among children, is a challenging aspect in nutrition research. Young children do not always demonstrate the cognitive ability to remember and review what they eat and they often require parental assistance when obtaining food consumption data (25). Obtaining diet information from parents is a common practice when studying the diets of young children (26). However, children eat meals away from parents and it is often necessary to obtain diet information from children (27), especially in the school setting.

There is little research that has been published on the relationship between cognitive ability and accuracy in dietary reporting in either adults or children and the existing research presents mixed results (28). In a study to better understand fourth-grade children's cognitive abilities in conjunction with performance on a dietary recall, researchers observed children while eating school lunch and then later interviewed the children to obtain a 24-hour dietary recall. Children's scores on standardized tests were used to create a cognitive ability index. They found that cognitive ability and dietary reporting error were significantly negatively associated ($P < 0.001$). In addition, gender and cognitive-ability were significantly associated ($P = 0.01\text{-}0.001$). Although cognitive ability was related to performance on the recall for both genders, the relation was stronger for girls than boys.

According to Livingstone and Robinson (25), children begin to develop the cognitive ability to accurately report food intake by the time they are 8-10 years of age, often with equal reliability as their parents (25). Children that are in the fourth grade, or about 10 years old, have been shown to give reasonably accurate information regarding their diet. In addition, the thinking of 10-year-old children is similar to that of adults (29).

Conversely, children who are younger than 10 years of age appear to be at lower cognitive levels, which limits their ability to accurately recall dietary information (30). It is thought by others that children rapidly increase in their capability to respond to questions about their eating behavior, and by the time they are 10-12, they can provide their own responses (31). The ability of children to accurately report food intake is an important factor to evaluate as children's dietary intake functions as a key variable in evaluating the efficacy of school-based interventions (32).

Diet Assessment Methods. In order to assess food consumption, researchers use a variety of methods based on the research question and available resources. Each dietary assessment method has its own strengths and weaknesses, which should be taken into consideration when choosing a method for a study. When developing a dietary tool, it should be assured that it is able to accurately measure (i) the amount of a particular food consumed at each time point tested and (ii) behavior change between time points (33).

Photo analysis was used in order to measure FV consumption at lunch time in the *Food Dude* program. Student volunteers from USU photographed each subject's tray before and after eating. The photographs were then analyzed by other trained USU students to estimate actual food consumption. Two raters estimated food consumption blind to the other's analysis and the estimations were required to be within 1 piece or 0.13 of a cup of one another. This process was repeated for over two thousand students on fourteen different days. Although this process provides a good estimation of actual consumption and is needed to answer some research questions, it requires a great deal of time, many volunteers/employees, and extensive resources.

Lunchtime observation is considered one of the most accurate methods for the diet analysis of young children and it is often used to validate other methods of estimating food consumption (32-34). Unfortunately, time, resources, and feasibility do not always allow such data to be obtained. Children have shown the ability to adequately self-report food consumption using tools such as a Food Frequency Questionnaire (FFQ) (31, 32, 35, 36), Food Record (33), or Recall Interval (37). Each method has different strengths and limitations allowing researchers to choose a tool catered to their specific research question. A full review of diet assessment methods is provided in Chapter 2 of this thesis.

While the effectiveness of the *Food Dude* program has been established and continues to be confirmed, recording lunchtime food consumption requires a great deal of time and is a burdensome process. Many researchers, including those involved in *Food Dudes*, use photo-analysis or other lunchtime observation techniques to measure intake in children. There is a need to create a simpler tool that can adequately measure total FV consumption among children in elementary schools.

OBJECTIVES

The purpose of this study was to develop and assess the efficacy of a simple tool that would allow students to self-report FV consumption. The research question and objectives were as follows:

1. Can a multiday record-assisted fruit, vegetable, and snack questionnaire (FVSQ) accurately assess usual intake of fruit, vegetable, milk, and energy dense snacks among fourth and fifth grade children?

a. Develop a multiday record-assisted FVSQ to assess usual intake of milk, fruit, vegetable, and energy dense snack foods in fourth and fifth grade children.
b. Measure overall fruit, vegetable, and snack food intake as well as lunchtime FV consumption using the FVSQ.
c. Compare lunchtime estimates of FV consumption obtained from the FVSQ to lunchtime photo observation data.
d. Compare estimates of total FV consumption to skin carotenoid score, a biomarker of the consumption of highly pigmented fruits and vegetables.

HYPOTHESIS

1. The proposed multiday record-assisted FVSQ will be able to accurately assess intake of fruit, vegetable, milk, and energy dense snacks among fourth and fifth graders.

METHODS

Subjects. The Institutional Review Board at USU reviewed and approved this research study to develop and examine the efficacy of a multiday record-assisted FVSQ. All fourth and fifth grade students at six elementary schools in Northern Utah were invited to participate in this study. Schools were assigned as control, praise, or incentive schools and were all included in this analysis in order to insure that the *Food Dude* program had no effect on the way children filled out the questionnaire. Of those participating in the *Food Dude* program, 65.6 % of the students provided usable FVSQ data for analysis.

Fruit, Vegetable, and Snack Questionnaire. In order to measure FV consumption, a multiday record-assisted FVSQ was developed. The FVSQ contained 33 questions and encompassed a variety of beverage, snack food, fruit, and vegetable groupings measured in cups (liquids) and handfuls (solids), to ensure easy comprehension and estimation among the fourth and fifth graders. The questionnaire asked students to report their consumption of these particular food items over the past 24-hour day. The questionnaire (**Appendix A**) is comprised as follows: a beverage section comprised of seven questions; a snack foods section of ten questions; and a FV section containing four questions for fruits and eight questions for vegetables. In addition, it includes two questions regarding FV consumption specifically during lunchtime. Responses to the two latter questions were compared with photo data from that day for each child and used as a general validation for the questionnaire. Questions were also included to assess whether the food tracker was filled out prior to the survey, and if the child ate school lunch and/or school breakfast. Although the FVSQ measured consumption of snack foods and beverages in addition to FV, only responses pertaining to FV consumption were analyzed in this study. Data for the other categories may be used in future studies.

The FVSQ is a semi-quantitative questionnaire that measures consumption in handfuls, as it is difficult for young children to estimate food in specific portion sizes (38). An early version of the FVSQ (**Appendix B**) asked the students to answer if they ate a particular item of food “at school” or “not at school,” as seen in Neuhouser et al. (36). During a pilot study of this version of the FVSQ at one elementary school, it was noted that the children had a difficult time with the “at school” and “not at school” categories as a significant number of questions were left blank. The questionnaire was then adjusted by combining the “at school” and “not at school” questions, which yielded the final version that was used for the rest of the study. The general questions for FV consumption during lunchtime were then added to use in validating the FVSQ.

Food Tracker. The food tracker is a one-page log that the fourth and fifth graders used to record beverage, snack, fruit, and vegetable consumption during the assessment period. It provided easy directions and space for the children to write down what they ate and drank for each meal and at snack-times. The food tracker was used as an aid for the children in remembering their food consumption over the 24-hours being assessed. It was compared to the FVSQ to ensure consistency of self-reported food consumption (34, 35, 37, 39). The children also used the food tracker as they completed the FVSQ in order to increase accuracy (39).

Skin Carotenoid Scores. Skin carotenoid scores (SCS) are often used as a biomarker for FV consumption in adults (40-43). Carotenoids are pigments that are responsible for red, orange, and yellow colors in plants (44). According to current literature, carotenoids are considered the best current biomarker for FV intake in adults, as they are prevalent in FV, but not other foods (45). Skin carotenoid levels were measured by a Pharmanex Biophotonic scanner, using Raman spectroscopy technology. This procedure measured carotenoid levels from the skin of the palm of the hand. While SCS have proved to be a valid marker for total FV consumption in adults, these assumptions have not been validated in children. For this reason, we are cautious in our approach at interpreting analyses involving SCS.

Validation Methods. As discussed above, validation methods were used to test the accuracy of the self-reported FVSQ consumption data. The food tracker was compared to the FVSQ for a sample of the children to ensure consistency and to check for foods omitted or excluded. Lunch FV consumption from the FVSQ was also compared with the plate-waste photo data from the *Food Dude* program on the days the assessment was administered. Finally, SCS were compared to FVSQ-reported total FV consumption to gain some additional information on the efficacy of the FVSQ. The SCS have only been validated in adults (40-43), so there is uncertainty as to the validity of these results.

Assessment Period, Data Collection, and Statistical Analyses. The food trackers and FVSQs were administered over a 3-day span (including one weekend day) at Baseline 1, end of Phase 1, and end of Phase 2 of the *Food Dude* program. Average FV consumption was analyzed and compared across the assessment periods to detect the sensitivity of the FVSQ in detecting changes in consumption throughout the *Food Dude* program. Data from the FVSQ was scanned using REMARK computer software.

Descriptive statistics provided information on overall data patterns. Paired sample t-tests, Spearman correlation coefficients, and Cohen's Kappa values were calculated during validation procedures. Tests were performed for the three assessment periods to assess for improvement in accuracy or other inconsistencies in the FVSQ. Overall analyses were examined for the effects the variables: gender, age, grade, school, condition, and ethnicity. SPSS was used for all statistical analyses.

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CHAPTER 2

ASSESSMENT METHODS USED FOR MEASURING DIETARY INTAKE OF CHILDREN: A LITERATURE REVIEW

ABSTRACT

Obesity has become a concerning epidemic in the United States over the past few decades. Consuming more fruit and vegetables (FV) may be one way to decrease energy intake and mitigate the prevalence of overweight and obesity. In order to help children develop better dietary habits, researchers have implemented programs aimed at increasing FV consumption. Weighed and observational techniques are the most precise method for measuring food consumption, but they are not always feasible and children are often required to self-report food intake. When recalling previous food consumption, children often under-report or over-report food; they often have a difficult time recalling items secondary to the main course, or fail to report less-common foods. In addition, it is challenging for children to quantify the amount of food eaten. There are a variety of tools that are currently used among researchers to obtain dietary information from children. These include food records, 24-hour dietary recalls, and food frequency questionnaires (FFQ). In addition to these methods, skin carotenoid concentration may also provide valuable information regarding habitual consumption of highly pigmented fruits and vegetables; although, using this method as a biomarker of fruit and vegetable intake has not been validated in children. Each method for assessing dietary intake has strengths and limitations and once validated, may provide accurate information. Tools

should be selected or developed based on the research question, available time and resources, feasibility, and participant age.

INTRODUCTION

The prevalence of overweight and obesity in the United States is substantially higher than it was a few decades ago (1). According to national data, approximately 17 percent of children and adolescents ages 2-19 are obese (2) and since 1980, the prevalence of obesity has almost tripled among children and adolescents (3). Concerns of overweight and obesity even reach to infants and toddlers as 9.7 percent had a high weight-for-recumbent length in 2010 (2). These statistics create serious public health concerns in the United States.

Researchers have proposed that increasing fruit and vegetable (FV) consumption may help in addressing the obesity epidemic. Despite available evidence of the health benefits of fruits and vegetables, consumption remains far from ideal (4). The 2010 Dietary Guidelines set forth by the USDA recommend that individuals stay within their calorie needs by making dietary changes including increasing FV intake and eating a variety of vegetables, especially dark-green, red, and orange vegetables, beans, and peas (1). A poor diet and physical inactivity are the leading factors contributing to an epidemic of overweight and obesity in men, women, and children today (1).

Childhood diet has been shown to greatly predict dietary patterns in adulthood (5), increasing the need to help children establish good dietary patterns when they are young. For example, in a study of 170 girls designed to characterize changes in beverage intake during childhood, researchers found that even soda consumption at five years of age predicted patterns of nutrient intake during childhood and into adolescence (6). In addition, Mikkilä et al. (5) found a significant association between childhood intakes of fat, fruit, and vegetable consumption and the quality of diet 21 years later (5).

The implementation of school intervention programs that aim to increase FV consumption is one strategy to help address the obesity epidemic and help children develop healthy eating habits (7, 8). Schools are an ideal place to target nutrition related behavioral changes; children spend a significant portion of their day in school and researchers can work with large numbers of children at one time in such intervention programs (8).

In order to assess the efficacy of a FV intervention program, a variety of measurement tools are used. The age at which children develop the cognitive ability to accurately report food intake is widely debated, but thought to be somewhere between the ages of 8-12 years (7). Some tools involve researcher observations and require very little of the student, while others ask students to report their own consumption or parents to assess their children's intake. Having children self-report food consumption is often necessary, but it is challenging as they do not always possess the ability to accurately report or remember what they consume (9). The selection and use of a tool is dependent upon the available resources and the question that is to be answered.

REVIEW OF COMMON DIET ASSESSMENT TOOLS

Food Record. The food record or food diary can be used to estimate an individual's average food consumption when administered for 3 to 7 days, including a weekend day, or a large number of children's consumption over at least a 24-hour period

(10). It can also serve as a helpful dietary analysis tool in comparing and validating other self-report methods (11, 12). Food records are filled out concurrently with mealtimes, limiting the recall bias that is often seen in other methods of diet analysis (11). Weighted dietary records can provide valuable estimates, but they are difficult to keep over an extended period of time because of the burden it places on participant's parents or trained researchers (13). Also, analysis costs can often be substantial and underreporting food intake is common (11).

Food records are a less objective method to measure food consumption when compared to other methods. To most accurately record food consumption, weighted measurements of each item before and after eating would arguably provide the most objective measure of a child's FV intake, but this is not always practical as it is time consuming and expensive (10). It is thought that if a food record measures a consumed amount that is not statistically different when given to the same person over several time points and proves to approximate its desired measurement, then the food record is considered reliable and valid in determining the efficacy of an intervention (10). Unfortunately, the time and resources that are needed to collect data are a major limitation in the usefulness of diet records in large-scale evaluations, especially in schools (14).

In a study to detect an increase in FV consumption for an intervention study in England (the *Food Dude* program), researchers measured FV consumption to the nearest half portion using a 24-hour diary (completed by teachers and parents). The record, called *Diet-24*, consisted of a list of 75 foods, which included 15 vegetables, 13 fruits, and 13 "blanks" for foods consumed that were not found on the list. When compared to the actual weighted measure for each food the child ate during snack time, they found that the tool failed to detect a significant 15.6g mean increase in fruit consumption in the intervention school (*n*=148) and a significant 12.9g mean decrease in vegetable consumption in the control school (*n*=43). They concluded that in order to discover sensitive changes in eating behavior, food consumption would need to be more precisely measured, rather than using all-or-none estimates (10).

The ability of young children to accurately complete a food record has been demonstrated in various studies (11, 15, 16). Domel et al. (11) conducted a study to determine the accuracy of fourth and fifth grade children in completing a food record during lunchtime compared with lunchtime observations (n = 24). The food records supplied areas for recording items consumed, number of servings, and location of meals. A random selection of students were observed during lunchtime for comparison. They concluded that fourth and fifth grade students were reasonably accurate in keeping food records. Pearson correlations were significant (r = 0.56-0.85, P = 0.01-0.001) for eight of nine meal items for students that were monitored daily (asked probing questions and checked for completion and legibility of food records). They also found that overall, underreporting was more common than over-reporting (11).

The use of a food record can also enhance the accuracy of information provided in a 24-hour recall. In a dietary recall and record validation study in fourth-graders targeted for use in evaluating children's FV study, Lytle et al. (16) found that food records functioned as an effective memory aid for a 24-hour recall interview. Some of the participants were given instructions on how to complete a food record and were asked to bring it with them to the interview, while others were given no instructions beforehand.

After validating the interview with lunchtime observations, they found that 60% of the foods and nutrient examined had higher correlations between observed and recalled values when a food record was used (16). Using a food record along with other dietary analysis methods may be an effective strategy to improve the accuracy of children's food consumption.

Diet Recall. Diet Recalls involve a comprehensive diet interview by a trained interviewer (17). Although they share many of the same qualities as a diet record, they are not kept concurrently as a record by the individual and involve probing questions by the interviewer to help the individual remember everything he or she ate the previous day (17). In contrast to the food record method, the diet recall method is dependent upon the subjects memory, which may introduce some recall bias (17). In addition, 24-hour recalls are often time- and resource intensive (18).

Since 24-hour recalls are often used to validate other diet assessment tools, it is important to maximize the validity of the reference method to enhance data quality (19). Food Records are sometimes used along with diet recalls in order to help children better remember what they ate over a designated period of time (16). Common reporting errors include: food items that were consumed, but not reported; food items reported, but not consumed; the total amount of food consumed not being equal to the amount reported; or a specific feature of the food being inaccurately reported (20). Baxter et al. found that observation of consumption during mealtime did not influence 24-hour recalls in fourth-grade children (19). This is an important point to make as thousands of children every year provide 24-hour recalls for national surveys, validation of other measurement techniques, and school interventions (19).

As with other self-report dietary methods, recall accuracy is often low in children (21-23). One study of a dietary recall was performed among 9- and 10-year-olds whose food consumption was observed during school lunch and breakfast. The children were interviewed individually at different times following the consumption period in question. Significant improvements were observed from the first to the third recall ($P = 0.006$), but the children's accuracy on individual interviews was inconsistent between the interviews (22). In another study with similar design, girls performed better when information was prompted from morning-to-evening of the previous day, while boys were more accurate when they recalled information from evening-to-morning (23). Regardless of the order in which the children recalled what they ate, accuracy was poor. Children reported less than 50 percent of observed items and more than 30 percent of the items that had not been observed. Baxter concluded that research is needed to increase the accuracy of children's dietary recalls (23).

Decreasing the retention interval is one way to increase the accuracy of a 24-hour recall (24). In a study by Baxter et al. (21), fourth graders were first observed eating school breakfast and school lunch ($n = 60$). They were assigned to a period of retention (previous day or previous 24 hours) and accuracy was determined by reporting the percentage of intrusions (uneaten items reported eaten). The percentage of interviews without intrusions was greater when recalling the preceding 24 hours, rather than for midnight to midnight recalls of the previous day ($P = 0.023$ for breakfast and $P = 0.003$ for lunch) (24). In another study, Baxter et al., found that using the prior 24 hours instead of the previous day yielded omission rates that were lower by one-third, intrusion rates by one-half and total inaccuracy by about one-third ($P < 0.01$ for all) (25). If a recall must ask about the previous day (midnight to midnight), improved accuracy can be achieved by conducting the interview in the morning (26).

In an effort to investigate the accuracy of children's abilities to recall school breakfast and lunch consumption, researchers performed a study to see if the method of interview affected accuracy. In this study, fourth-grade children were observed by three trained research dietitians during school breakfast and lunch. The children were then interviewed in person (n = 33) or by phone (n = 36) in the evening on the same day they were observed. Researchers found no significant difference in how accurately the children reported intake between these two methods (P = 0.62). While there proved to be no difference between the methods, children reported only 67 percent of items observed and 17 percent of items reported had not been observed when data were pooled across methods (27). Children in the fourth-grade have a difficult time accurately reporting consumption, so it is important to identify factors that may help increase accuracy.

Warren et al. conducted a study in children ages 5-7 to see if they could recall what they had eaten during lunchtime at school (n = 203). Within two hours of completing their lunch, the students participated in a recall interview of their meal. Interviewers gave non-directive prompts at the end of the recall to see if the child was able to recall anything else. The children's' responses were compared the observational estimates made by trained investigators during lunch. Researchers found that the children who ate school lunch provided a significantly less accurate recall than did children who brought their own lunch (P < 0.01). This could possibly be due to an increased familiarity to the foods in a packed lunch. It was concluded that children ages 5-7 possess a wide range of ability pertaining to dietary recall, and this method would not work at the individual level in such young children. Although this study didn't focus on quantity of food, it provided valuable information about the ability of children to recall what they eat at such a young age.

Food Frequency Questionnaire. A food frequency questionnaire (FFQ) provides a list of foods with questions referring to how often those specific foods were consumed over a certain time period. FFQs can differ by the time frame they are assessing; they can assess diet habits of the previous day or over a more extended period of time (week, month etc.). They can also vary in their quantification of portion sizes (17). Although a FFQ may not be as reliable as a dietary recall, it can assess the habitual dietary patterns of many subjects from a one-time administration (13) or individual dietary patterns when administered over several days. Although FFQs are generally less burdensome than a food record, they can be lengthy and tedious to complete depending on the foods being assessed.

While McPherson et al. concluded in a review of validation studies that food records and recalls seem to work better for school-aged children (28), several different types of FFQs have been validated for use in children (18, 29-30,31). Paxton et al. (18) used a semi-quantitative dietary recall questionnaire among third to fifth graders that proved to accurately measure school lunch intake (n = 18). Trained observers recorded the amount of food that students ate during lunch and then the students were given the diet recall immediately after lunch. Students were asked if they tasted, ate a little bit, ate half of, ate most of, or ate all of particular food items from the menu. Results showed an omission rate of 6% and intrusion of rate 10%, which validated this tool as an effective and efficient tool for assessing school lunch intake (18). However, researchers did note that data was collected during the summer, which limited the sample size to only 18 children. In addition, the school cafeteria was not running at full capacity and a more limited lunch menu was available for the children (28).

The validation and reproducibility of a more comprehensive food frequency questionnaire in sixth grade school children was evaluated in a study by Andersen et al. (29). A food diary was given to each participant to determine the children's reproducibility and accuracy at completing the 24-hour FFQ. The diaries were precoded with a list of 227 food items and they were instructed to indicate the foods eaten and amount of consumption during each of five time spans. Researchers found that the reproducibility of the questionnaire was quite high, observing no significant differences between two time points. However, the participants reported a significantly higher intake from the FFQ than from the food diaries for fruit, fruit juice, and potato, but not for vegetable consumption. Overall, Anderson et al. (29) concluded that the recall seemed to work better among school-aged children than a food frequency questionnaire, although the overestimation of the FFQ recall could have been due to an underestimation of the reference method (the food diary) (29). The sixth graders were capable of accurately recording vegetable consumption from the previous day, but they overestimated fruit and juice intake (29).

Roumelioti et al. (30) validated a semiquantitative FFQ that could measure comprehensive food consumption with reasonable reliability in 200 Greek fourth-, fifth-, and sixth-graders. This FFQ designed for children was validated against the results of the same questionnaire obtained by the parents as well as 24-hour recall interviews with both the parents (over the phone) and the children (at school). While researchers concluded that the 200-item FFQ could accurately measure overall food consumption, some individual food groups had poor agreement (Kappa < 0.20), such as fruits. In addition, vegetables had only fair agreement (Kappa = 0.21-0.40) (30). While this FFQ could be used in a large-scale epidemiologic study, it would not provide enough accuracy for a FV study.

Similar results were found in a population-based cohort study by Ambrosini et al (31). The reliability of a FFQ was assessed in 14-year-olds in Australia (n = 785). Agreement of specific nutrients was measured between the FFQ and a 3-day food record. Pearson's r ranged from 0.11 to 0.52 for individual nutrients and 80 to 90% of the subject's nutrients were categorized in the same or adjacent tertile between the FFQ and the food record. As with other similar studies (11, 31, 32) the subjects tended to overestimate consumption on the FFQ compared to the food record. It was concluded that the FFQ performed similarly in 14-year olds and adults and would be useful in analyzing diet-disease relationships with a large number of subjects.

In addition, Ambrosini found that boys performed slightly better than girls for all indicators of reliability between the FFQ and food record (31). Girls are usually more concerned about their body image than boys, which may make them more prone to dieting, inconsistent food intake, or recall bias (9, 31). In addition, it is often noted that girls have greater variation of dietary intake (9). These elements and potential confounding factors are important to consider when developing and determining the efficacy of a new tool.

Researchers have worked to develop a FFQ that even a child as young as 8 to 9 could complete. In a study of a simple 7-question FFQ, third graders (n = 1694) were asked to report how often they ate a particular grouping of fruit or vegetable per week. The students grossly overestimated their FV consumption as compared to a food record, even though FVs were placed in large groups (32). In addition, there were a large number of children who frequently used the highest category to report consumption (32). This method may have been too difficult for children at the age of 8 and 9; they may not have known how to estimate average consumption over a period of time (32), or they may not have been able to recall consumption for more than a short period of time. The results of this study support the idea that young children may perform better on questionnaires that require them to recall only the last 24-hours or less.

In contrast, Neuhouser et al. (33) developed and validated a beverage and snack questionnaire (BSQ) that assessed consumption over the past week for use among seventh-graders. The BSQ was comprised of a list of 19 questions about fruit, vegetables, snacks, and beverage intake and was validated against a four-day food record kept by each of 46 students. The BSQ differentiated consumption for items that were consumed “at school” or “not at school.” Correlations between the food record and BSQ for beverages, snacks and sweets, and fruits and vegetables consumed “at school” were r = 0.71, 0.70, and 0.69, respectively. Estimates showed similar results for items consumed “not at school” with correlations ranging from 0.63-0.70. Although, a food record is not the perfect criterion for determining the validity of an FFQ, the BSQ proved to be as reliable as keeping a food record for determining beverage, snack, fruit, and vegetable consumption in seventh-graders (33). These results, along with those of Baranowski et al. (32), indicate that there is a large disparity between the abilities of children in third grade (ages 8-9) and those in seventh grade (ages 12-13) in recalling dietary information. Both tools asked about consumption over the past week, contained simple categories of food, and were compared to a self-completed food record. Although there may be many factors that contributed to the difference in performance on the two tools, it is likely that age and cognitive ability played a significant role.

Researchers have used unique strategies to help younger children (ages 7-9) accurately report FV consumption (34). Edmunds and Ziebland (34) created The Day in the Life Questionnaire (DILQ), which was administered as a supervised classroom exercise. The target of this research was to collect information about diet without informing the children of the focus of the study (34). The DILQ used words and pictures to help the children remember and describe activities from the previous day, including their food intake. Children's responses were compared to observations made by a research team during snack time breaks and comparisons of FV consumption reached nearly 70 percent (n = 255). Although many children have a difficult time recalling what they consume, perhaps using a simple tool such as this could help obtain valuable self-reported information. One possible reason that this tool provided acceptable information from such young children could have been due to the involvement of the teacher. It was not recommended that the DILQ function as an entirely self-completed questionnaire because many children need help with writing, spelling, and annotating drawings of their food at that age (34). While this type of involvement isn't practical for all studies due to time restraints in the classroom, it may be helpful in obtaining more accurate information from young children when feasible.

In reviewing the current literature regarding FFQs and other similar questionnaires it is clear that such tools are difficult for children to complete and they often result is less accurate information than recall interviews or recalls (28, 35). Despite these limitations, FFQs can function as a valuable and resourceful tool in large epidemiologic studies (18, 30-32, 34, 36). To increase the accuracy by which children self-report FV intake, it may be helpful to have them recall only the past 24-hours or less, rather than ask them to report usual consumption of food items over a longer period of time (18, 33). Children tend to do well when they associate eating with other activities throughout the day or when they are unaware of the intent of the research (34). In addition, involvement of the teacher or research assistant may help increase the accuracy by which children report food consumption (34). Using a semiquantitative questionnaire may also help children report food intake as it is often difficult to estimate portion sizes (18).

It has been argued that portion sizes are not needed when administering a FFQ (17). Many FFQs ask subjects to record how often they eat a specific food item over a period of time and are better at ranking food intake, rather than providing absolute amounts. It is thought that variation in intake can be explained by frequency of consumption and that portion sizes are positively correlated with frequency of consumption (17). Adding portion sizes to an FFQ may actually reduce the validity of the questionnaire if the amount of variation due to error is greater than the amount of information gained on true variation in portion sizes. This subject needs further research, but data suggest that there is little to gain by having subjects record portion sizes on a FFQ (17).

Many of the FFQs that have been validated for use were administered to children ages 10-14 (29-32). It appears that these results are consistent with the thinking of some childhood cognition researchers (11, 31, 33), while other studies support the statement that children can accurately report consumption as early as age 8 (9). As demonstrated in the previous studies, the validity of FFQs depends on the design of the questionnaire, the age of the subjects, and the foods being assessed. FFQs are variable in their content and in the diet information they are able to provide and are most valuable in large population studies (18, 30-32, 34, 36). Once a FFQ has been validated, it can be an effective tool that is less resource- and time-intensive than a recall or food record.

Observation. Mealtime observations are considered a precise means of measuring food consumption in children (37). They require trained researchers who weigh or photograph food before and after consumption, or visually estimate consumption during a mealtime. Lunchtime observation studies are also used to validate another method of obtaining dietary information (10, 11, 18). Unlike recalls, food records, and FFQs, measuring food consumption through observation eliminates the error associated with recalling past food consumption (38).

The major limitation of all lunchtime observations is that they require many trained observers or other volunteers to photograph plates, which can be resource and time intensive in large-scale studies. This method can be obtrusive: It may cause an alteration in consumption patterns, and it is not always feasible to have researchers present during school lunchtime. In addition, there is always the possibility that young children will play with, give away, or take home some of their food, which could potentially invalidate the techniques (39). The most accurate method for reporting food consumption is weighing foods before and after they are eaten, but this is often more costly, time-consuming and burdensome than observing or photographing intake (40).

There are many advantages in using digital photography in comparison to visual estimation or weighing food items during mealtime. Preserving data by a photograph allows for observers to take as much time as needed to estimate accurately. Also, if two estimates do not match, a third may be obtained (39). Direct observation does not rely on the subject's ability to recall food consumption (37). It is less burdensome for the subject and may be less apt to trigger changes in eating behaviors. Swanson et al. (39) conducted a study to see if estimation through photography would provide an accurate estimation of school lunch intake. Two trained analysts estimated consumption of each food item on each child's plate. They found that 92% of the total items were rated within 10% of each other by the two independent raters (39).

An additional study examined the validity of digital photography compared to visual estimation at measuring food portion sizes (40). For both methods, three observers independently determined portion sizes of each food item. Estimators tended to make small over or under estimations with both methods. Estimates of portion sizes, food selections, plate waste, and intake of FVs were highly correlated with weighed analyses (r=0.89-0.96). Digital photography may be a good alternative to weighing individual food items or on-site estimate of food consumption when studying FV intake in elementary schools as it is less obtrusive and allows for unhurried and perhaps more precise estimates (40).

Skin Carotenoids. Skin carotenoid levels can function as a valid biomarker for FV consumption in adults (41-44). Carotenoids are lipophilic pigments that are responsible for red, orange, and yellow colors in plants. They function as antioxidants and may play a role in the prevention of diseases such as cancer, heart disease and age-related eye disease, as well as all-cause mortality (45). Lycopene, alpha-carotene, and beta-carotene make up about 60-70% of total carotenoid content (46). According to current literature, carotenoids are considered the best current biomarker for FV intake in adults, as they are prevalent in fruits and vegetables, but not other foods (47).

Determining skin carotenoid scores using resonance Ramen spectroscopy (RS) is a non-invasive technique for assessing FV intake (44). According to Hata et al. (46), carotenoid distribution in the skin is not equal throughout the body. In comparing carotenoid levels in the palm, forehead, inner arm, volar arm, and dorsal head, the palm was found to have the highest mean carotenoid concentration (46). Areas with thicker skin tissue contain higher concentrations of skin carotenoids because of the high lipid/protein ratio (41). For this reason, it is common to measure carotenoid levels in the palm of the hand.

Researchers have found the RS methodology of measuring skin carotenoid levels to be a valid and reliable measurement of serum carotenoids (41-43, 48). In a study by Mayne et al. (42), total carotenoid RS was correlated with total carotenoid level in the skin as measured by high-performance liquid chromatography (HPLC) ($r = 0.66$, $P = 0.0001$) and total plasma carotenoids ($r = 0.62$, $P = 0.006$). Additionally, plasma lipid carotenoid levels measured using HPLC were correlated to self-reported consumption of total FV ($r = 0.39$, $P = 0.008$) in adults (42). In addition, Zidichouski et al. (48) found that RRS showed 0.9% less variance ($P < 0.003$) between multiple tests than serum carotenoids (as measured by HPLC) in 372 healthy adults. Thus, RS has been validated to function as a noninvasive method of measuring skin carotenoid levels, with even less variability than serum carotenoids.

In a study by Scarmo et al. (49), researchers tested the variability of SCS at different time points. Good agreement was found between RS-measured SCS at baseline and six different time points approximately 2 months apart throughout the year (weighted kappa = 0.80). They concluded that a single measurement of skin carotenoids using RS is robust enough to indicate usual carotenoid status. It was also noted that SCS were significantly lower during the summer months ($P = 0.05$ at baseline, $P < 0.001$ over time). Additionally, self-reported recent sun exposure was a significant predictor of lower skin carotenoid status over time ($P = 0.01$) (49). Other factors that may reduce carotenoid levels in the skin include season of measurement (49), illness, smoking, alcohol consumption (50), and inter-scanner variation.

While the use of RS has been confirmed to be a valid measurement of total FV intake in adults, there has been little research as to its effectiveness in measuring FV consumption in children. Wengreen et al. (51), measured skin carotenoids in children aged 9-18 years using RS in the palm of the hand. Scanner scores were compared to self-reported FV intake using a single question. Scores were measured on two separate occasions during the year and were highly correlated to one another ($r = 0.79$, $P < 0.001$). The second score was moderately correlated to self-reported FV intake ($r = 0.33$, $P < 0.001$) (51).

A second study by Scarmo et al. (52) examined the feasibility of using RS in preschool children ($n = 381$). Skin carotenoid status was measured in the palm of the hand and FV consumption was assessed by a brief parent/guardian FFQ. Multiple regression analysis revealed that SCS were positively associated with parent-reported FV consumption ($P = 0.02$). They also found that lower carotenoid status was associated with younger children, those receiving food assistance, and those with greater adiposity ($P < 0.05$) (52).

Both of these studies (51, 52) pertaining to carotenoid status in children highlighted the importance of conducting more research to confirm the validity of using skin carotenoid status as a FV biomarker in children. While the use of RS has been validated in adults, additional studies of this technique will help determine the usefulness of SCS as a biomarker for FV consumption in children.

Choosing a Method. As discussed, each different dietary assessment method has its own strengths and weaknesses, which should be taken into consideration when choosing a method for a study. When developing a dietary tool, it should be assured that it is able to accurately measure (i) the amount of a particular food consumed at each time point tested and (ii) behavior change between time points (10).

One of the difficulties of having children self-assess food consumption is that it is difficult to estimate the portion of food they have consumed (9). Souverein et al. (20) found that adults were better able to estimate portion sizes of some foods over others; vegetables being one of the more difficult foods to quantify (20). In contrast, Lytle et al. (16) showed in a FV study that fourth-graders overestimated portions of fruit consumed, but accurately reported vegetable consumption when using a food record assisted recall method (16). This implies that some foods may be easier for a child to estimate more accurately than others, which is important to keep in mind when validating a diet analysis tool. Additionally, in a study to assess the validity of children's portion estimates researchers concluded that there were sizeable errors in the quantitative estimates that children provided (53). They also advised that caution be taken when interpreting data derived from children's self-reports (53).

Lunchtime observations are considered the "gold standard" (54) of diet analysis of young children, but time, resources, and feasibility do not always allow such data to be obtained. In this case, other dietary tools should be considered. In a study to determine the most accurate method to measure children's energy intakes and associated macronutrients between a FFQ, 24-hour recall, and food record, Crawford et al. (35) reported absolute errors ranging from 20-33% for the food frequency method, 19-39% for the 24-hour recall; and 12-22% for the food record. In addition, missing foods and phantom foods (foods reported, but not observed) respectively ranged from 46% and 40% for the 5-day food frequency, 30% and 33% for the 24-hour recall and 25% to 10% for the 3-day food record. From these findings, the 3-day food record proved to be the most accurate at reporting energy and macronutrient intake for 9- and 10-year-old girls (35).

In choosing a method in order to study food consumption, it is important to weigh all the benefits and limitations of each method and evaluate available resources and time. The selected tool should be that which would be most effective at answering the specific research question.

IMPLICATIONS FOR RESEARCH AND PRACTICE

Measuring food consumption is especially challenging in children, as they do not always demonstrate the ability to estimate food intake. Observation of food intake is not feasible in some research settings and children are often required to self-report food intake. Although many tools exist for self-reporting food consumption, reporting errors are inevitable and often substantial. More research is needed to better understand the abilities of young children when it comes to reporting food intake. As researchers gain insight about what elements help increase the accuracy by which children estimate food intake, more reliable tools can be developed. Self-assessment methods are fundamental in understanding the efficacy of intervention programs that target healthy dietary habits. As more accurate tools are developed, researchers can better evaluate FV programs, which could have valuable implications in addressing the obesity epidemic.

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CHAPTER 3

A MULTIDAY RECORD-ASSISTED FRUIT, VEGETABLE, AND SNACK QUESTIONNAIRE TO ASSESS INTAKE AMONG FOURTH- AND FIFTH-GRADE CHILDREN

ABSTRACT

The objective of this study was to assess the efficacy of a multiday record-assisted fruit, vegetable, and snack food questionnaire (FVSQ) in measuring lunchtime and total fruit and vegetable (FV) intake. The FVSQ was administered to students during the same time that plate-waste photo analysis (PWPA) data was being obtained from the *Food Dude* study, a school-based intervention study designed to increase FV consumption. FVSQ data was compared to PWPA data to assess the efficacy of the FVSQ at estimating lunchtime FV consumption. The FVSQ was also compared to skin carotenoid scores to obtain information about its ability to measure total FV consumption. Fourth and fifth graders attending six elementary schools in Northern Utah participated in the study (n = 579). Moderate spearman correlation coefficients were observed for FVSQ lunchtime FV consumption compared to PWPA (ranging from 0.39 to 0.45, $P < 0.000$). Weak correlations were observed for total FV consumption as measured by the FVSQ to skin carotenoid scores (SCS), (ranging from 0.18 to 0.19, $P = 0.006$ and 0.007, respectively). Although FVSQ lunchtime FV consumption showed moderate correlations to PWPA data, it detected a significantly smaller increase in FV consumption between Baseline and Phase I of the *Food Dudes* intervention (0.11 cup for fruit consumption and 0.12 for vegetable consumption). We conclude that the FVSQ provides a moderately valid

estimate of lunchtime FV intake, but it would not serve as an effective tool in detecting absolute changes in FV consumption during the period of an intervention program. It appears that the FVSQ was not effective at measuring total FV intake among fourth and fifth graders, but these results are interpreted with caution, as SCS have not yet been confirmed as a valid marker of FV intake in children. The use of a food tracker did not have a significant effect on the students' performance on the FVSQ. Additionally, grade, gender, ethnicity, condition, and school were evaluated for potential confounding, but made no significant contribution to the results of this study.

INTRODUCTION

Childhood obesity is a concerning epidemic in the United States as it is associated with an increased risk for a variety of diseases including cardiovascular disease, hypertension, diabetes mellitus, and hypercholesterolemia (1). In 2007-2008, 35.5% of children aged 6-11 were considered overweight, with 19.6% considered obese, according to The National Health and Nutrition Examination Survey (NHANES) (2). In addition, overweight and obesity have increased considerably in children since the 1960s (3) and as of 2010, 16.9% of U.S. children and adolescents were obese (4). In a review of literature from 1970 to 1992, researchers determined that 26-41% of obese preschool children and 42-63% of obese school-age children were obese as adults. With this data in mind, improving dietary habits in children is an important pursuit for researchers today (5).

Consuming more FVs may be one way to mitigate the obesity epidemic (6), as FV are plentiful in fiber, water, and nutrients. Among children aged 6-11 in the United

States, mean intakes of fruit consumption were reported as only 71.5% of the MyPyramid fruit recommendations and 58.3% of the MyPyramid vegetable recommendations (7). In another report, only 48% of children aged 2-3 years consumed the recommended 2 cups of fruit and vegetables a day (8). These numbers affirm the need for interventions that target increased FV consumption among young children.

Schools are a good place to target behavioral changes in FV consumption as children spend a large portion of their day, and consequently consume a significant portion of their calories at school (9). One school-based intervention program that has been proven successful is the *Food Dude* program, a peer-modeling and rewards-based school intervention program that focuses on increasing children's FV consumption (10, 11). *Food Dudes* uses the components of repeated tasting, role modeling, and rewarding to help children consume more FV. Children first watch videos of the heroes, the *Food Dudes,* eating FV and enjoying them. They are then offered FV in an increasing portion size over time and given a prize for consumption of the prescribed amount. Prizes are gradually diminished, which allows children to experience their own intrinsic rewards for eating FV (10, 11).

Both Lowe et al. (11) and Horne et al. (10) evaluated the *Food Dude* program in England and Ireland, respectively. Horne et al. (10) found that children who ate the least FV at Baseline (11% and 4%, respectively) increased their consumption to 48% and 68% during the intervention and maintained and increased consumption of 43% and 48% at the follow-up assessment 4 months later (10). Lowe et al. (11) found that overall, children increased consumption from 38% to 59% at the 4-month follow-up (11). Due to the success of the *Food Dude* program in England and Ireland (10,11) researchers have modified the program to fit school structure in Utah.

While the effectiveness of the *Food Dude* program continues to be confirmed, recording lunchtime food consumption is a time-consuming and burdensome process. Photo-analysis or other lunchtime observation techniques are commonly used to measure intake in children, but these methods require many trained researchers, analyzers, and significant time and funds. The age at which children begin to develop the ability to self-report food intake has been debated, but usually ranges between ages 8-12 according to other studies (12, 13). The method of reporting consumption is an important factor to evaluate as children's dietary intake functions as a key variable in evaluating the efficacy of school-based interventions (14). Creation of a simple self-assessment tool that is able to adequately measure total FV consumption could reduce resource and time limitations for researchers.

The aim of this study was to develop a multiday record-assisted dietary questionnaire, known as the Fruit, Vegetable, and Snack Questionnaire (FVSQ) that could assess lunchtime and total daily FV intake among fourth and fifth grade students. This aim was evaluated by 1) measuring overall fruit, vegetable, and snack food intake as well as lunchtime FV consumption using FVSQ, 2) comparing lunchtime estimates of FV consumption obtained from the FVSQ to lunchtime photo observation data, and 3) comparing estimates of total FV consumption to skin carotenoid scores (SCS).

METHODS

Subjects. All children in the fourth and fifth grades attending schools that were currently participating in a school-based intervention study, *Food Dudes,* were invited to participate in this study. FVSQ FV consumption was analyzed for all subsequent participating students at six elementary schools in Northern Utah. All students were automatically placed in the program on an opt-out basis. Within the *Food Dude* program, two schools were randomly assigned to one of three conditions: control, praise intervention, and full intervention. Praise schools received a modified version of the *Food Dude* program where students received social praise instead of tangible prizes as a reward for FV consumption. The schools along with the assigned condition and subject representation are presented in **Table 3.1**. Data was analyzed for 66% of those who participated in the *Food Dude* program. Data was excluded from the study if the student skipped a page of the FVSQ, was absent for at least one of the weekdays being assessed, or left more than 8 questions blank. It is noted that participation was especially low for schools 1, 2, and 5. This is because these schools were given an early version of the FVSQ for the first half of the study. As a result, it was necessary to discard Baseline data for schools, 1, 2, and 5, as well Phase 1 data for school 1 (phases are described below). This research was reviewed and approved by the Utah State University Institutional Review board.

Fruit, Vegetable, and Snack Questionnaire. A semi-quantitative FVSQ was developed to assess self-reported FV consumption of participants. The FVSQ contained 33 questions, which encompassed a variety of beverage, snack food, fruit, and vegetable groupings measured in cups (liquids) and handfuls (solids), to ensure easy comprehension and estimation among the fourth and fifth graders. The questionnaire asked students to report their consumption of these particular food items over the past 24-hour day. It was completed at school the morning following the 24-hour consumption period being measured. The questionnaire (**Appendix A**) was comprised as follows: a beverage section of seven questions; a snack foods section of ten questions; and a FV section containing four questions for fruits and eight questions for vegetables. In addition, it included two questions regarding FV consumption specifically during lunchtime. Responses to the two latter questions concerning lunchtime FV consumption were compared with photo data from that day for each child and used to check the validity of the questionnaire. Questions were also included to assess whether the food tracker (described below) was filled out prior to the survey, and if the child ate school lunch and/or school breakfast. Although questions regarding beverages and snack foods were included in the FVSQ, responses to these questions were not evaluated in this study, but may be used in future studies.

TABLE 3.1 Participating schools and assigned condition.

School	***n***	**Percent participation**	**Condition**
1	42	35.6%	Praise
2	49	28.5%	Full Intervention
3	151	84.8%	Control
4	105	76.6%	Control
5	67	69.1%	Praise
6	165	90.7%	Full Intervention
Total	579	65.6%	

When completing the FVSQ, the students self-estimated if they consumed none, a few bites/sips, 1 handful, 2 handfuls, 3 handfuls, and 4 or more handfuls of the food item in question. When converting these increments into cups for analyses, the following conversions were used: none=0, a few bite/sips=0.06 cups, 1 handful=0.5 cups, 2 handfuls=1 cup, 3 handfuls=1.5 cups, and 4 or more handfuls=2 cups. Data was obtained for two weekdays and the average consumption over those days was used in this study.

The original version of the FVSQ (**Appendix B**) included the distinctions of measuring the food items "at school" or "not at school," to denote when a particular food was eaten as was seen in Neuhouser et al. (15). During a pilot study of the original FVSQ at Sunrise Elementary School, it was noted that the children had a difficult time with the "at school" and "not at school" categories as a significant number of questions were left blank. The questionnaire was then adjusted by combining the "at school" and "not at school" to measure total consumption throughout the day. In addition, two general questions regarding FV consumption during lunch were added.

Food Tracker. The food tracker was a one-page log for the fourth and fifth graders to record beverage, snack, fruit, and vegetable consumption during the 24-hour assessment period (**Appendix C**). It provided easy directions and space for the children to write down what they ate and drank for each meal and at snack times. The aim of the food tracker was to function as both an aid for the children in remembering their food consumption over the 24-hours being assessed, and a comparison tool for the FVSQ (16-19). The students used their completed food trackers as they filled out the FVSQ in order to improve memory of items eaten during the previous day.

Plate-Waste Photo Data. The data used to test the validity of the FVSQ came from the *Food Dude* Program's photo analysis of the students' FV consumption. Photos were taken before and after food was eaten and they were analyzed by at least two raters that were blinded to the other's estimate. When it was determined that the estimates of consumed FV were within 1 piece or 0.13 of a cup, data was averaged (if different), uploaded into SPSS, and used to test the validity of the FVSQ. If the difference in estimation between the raters was more than 1 piece or 0.13 cups, photos were analyzed by a third rater. If at least two of the three estimates did not agree or were not close enough, a fourth individual (a registered dietician) made a final decision on how much was consumed. Analyzers assigned FV consumption on a scale of 0, 0.13, 0.25, 0.33, 0.5, 0.67, 0.75, 0.88, and 1 cups. The 3-day or 4-day average was calculated (depending on the phase) and used for analyses.

Skin Carotenoid Scores. Skin carotenoid levels can function as a validation tool for determining FV consumption in adults. Carotenoids are pigments that are responsible for red, orange, and yellow colors in plants. They function as antioxidants and may play a role in the prevention of diseases such as cancer, heart disease and age-related eye disease, as well as all-cause mortality (20). According to current literature, carotenoids are considered a valid biomarker for FV intake in adults, as they are prevalent in FV, but not other foods (21). In this study, SCS was used as a comparison tool to measure the validity of total FV consumption as reported by the FVSQ. SCS was obtained using Raman Spectroscopy and was measured from the palm of the hand. Although it has not been confirmed if SCS are an accurate biomarker for FV consumption in children, this study bases its analysis on the assumption that they function the same way in children.

FVSQ Administration and Timetable. The FVSQ was administered during class-time following two weekdays and one weekend day. The weekdays were paired with *Food Dude* photo days for validation procedures. Data from the weekend day was not used in this analysis. The FVSQs were administered during Baseline by *Food Dude* trained employees. For the other two phases, teachers were instructed and responsible for the administration of the FVSQ. The students completed the FVSQs during school, and teachers were advised to administer the FVSQ as early in the day as possible.

During Baseline, usual FV consumption was assessed prior to the *Food Dudes* intervention. During Phase 1, subjects were given pre-portioned FV that varied from grade and stage in the program. At the beginning of Phase 1, students were given only one small piece of the FV (1/8 cup) being served. The portions were gradually increased until they reached ¼ cup (first and second graders) or 1/3 cup (third-fifth graders). The *Food Dude* FV were provided in Praise (modified *Food Dudes*) and Incentivized schools (full *Food Dudes*). Phase 2 assessments measured FV consumption at the end of the study, after incentives or praise diminished in the *Food Dude* program and lunch time offerings of FV returned to those normally provided. The total program duration for each school was about five months. **Table 3.2** describes a typical time frame for the *Food Dude* program.

Statistical Analysis. Statistical analyses were performed using Statistical Product and Service Solutions (SPSS) version 18.0 to determine the validity of the FVSQ. Nonparametric analyses were used for statistical procedures, given that data from the FVSQ and plate-waste photo analysis (PWPA) were not normally distributed. Mean lunchtime and daily consumption of FV were calculated at three different time-points:

Baseline, Phase 1, and Phase 2. Spearman correlation coefficients were employed to compare lunchtime FV consumption between PWPA and FVSQ. Spearman correlation coefficients were also used to compare total daily FV consumption as reported by the FVSQ and skin carotenoid scores.

One additional measure was employed to test if the FVSQ was able to detect changes in FV consumption between different phases of the *Food Dude* study. The difference in FV consumption between different phases was calculated for both the FVSQ and the PWPA. The data were normally distributed and matched-pair t-tests were performed to determine if the FVSQ was sensitive enough to detect the changes represented by PWPA data.

Consistency between the FVSQ and the food tracker was assessed by calculating percentages of agreement and kappa values for lunchtime and daily FV consumption. Match percentages were calculated to represent the percent of items present on both the FVSQ and food tracker. For FV that were present on the FVSQ, but not the food tracker, percentages of intrusion were calculated. For FV that were not present on the FVSQ, but recorded on the food tracker, percentages of omission were calculated.

To test for potentially confounding factors, the difference in means for PWPA data and FVSQ data was calculated and followed a normal distribution. Independent sample-t-tests for equality of means were used to determine if the factors, grade, school, condition, ethnicity, and gender, made a significant contribution to the statistical results of this study. This same procedure was used to test if completion of the food tracker had an effect on the results of the FVSQ.

TABLE 3.2 Timetable of data collection.

	Baseline 1	Phase 1	Phase 2
Length	4 days	2 weeks	16 weeks
Assessment period[1]	4 days	4 days	4 days
Days since Baseline	0-4	5-31	32-149

[1]Assessment periods occurred at the end of each phase.

RESULTS

Demographics. During the 2011-2012 academic year, data was analyzed for 579 fourth and fifth grade students that completed the FVSQ for at least one phase of the study. Skin carotenoid scores were obtained for 552 of these subjects. Trackers were completed and returned for both assessment days from 71.0% of participants for Baseline, 56.4% for Phase 1, and 53.6% for Phase 2. The students were 53.5% male and 46.5% female (known for n = 325); 49.5% fourth graders and 50.5% fifth graders; 89.8% white, 7.4% Hispanic, and 2.9% other ethnicities (known for n = 344).

FVSQ Lunchtime FV Consumption vs. Plate Waste Photo Data. The FVSQ was administered over two weekdays during each phase of the *Food Dude* study. **Table 3.3** shows the means, standard deviations, medians, and interquartile ranges (IQR) of the data obtained by PWPA and the FVSQ. In comparing the two methods, similar mean values are observed, although median values differ much more than mean values for Phase 1 vegetable consumption (0.20 cups). **Table 3.4** presents Spearman correlations for FV consumption during lunchtime as recorded by PWPA and the FVSQ. For fruit eaten during lunchtime, Spearman correlations ranged from 0.43 to 0.45 (P < 0.000). For vegetable lunchtime consumption, Spearman correlations ranged from 0.39 to 0.46 (P <

0.000). These analyses show that the consumption measured by photo analysis and the FVSQ are significantly correlated, although the associations are only are weak to moderate. This suggests that the FVSQ provides a reasonable estimate of observed FV consumption.

TABLE 3.3 Means, standard deviations, medians, and interquartile ranges (IQR) for FV consumption during lunchtime.

	FVSQ[1] Mean[1] ± SD	**PWPA Mean ± SD**	**FVSQ Median (IQR)**	**PWPA Median (IQR)**
Fruit BI	0.29 ± 0.31	0.25 ± 0.27	0.25 (0.47)	0.18 (0.38)
Vegetable BI	0.18 ± 0.29	0.15 ± 0.24	0.03 (0.25)	0.04 (0.25)
Fruit PI	0.38 ± 0.35	0.35 ± 0.26	0.28 (0.44)	0.32 (0.25)
Vegetable PI	0.27 ± 0.33	0.28 ± 0.27	0.06 (0.48)	0.27 (0.36)
Fruit PII	0.32 ± 0.35	0.20 ± 0.25	0.25 (0.47)	0.11 (0.33)
Vegetable PII	0.21 ± 0.29	0.21 ± 0.23	0.03 (0.45)	0.00 (0.17)

[1]PWPA and FVSQ means and medians represent data from all six schools combined and are measured in cups

FVSQ Total FV Consumption vs. Skin Carotenoid Scores. **Table 3.5** shows the correlations between SCS and total daily FV consumption as measured by PWPA. The data suggest that there was no correlation between daily FV consumption and SCS during Baseline. Significant correlations between FV consumption and SCS were found during Phase 1 and Phase 2 ($P < 0.05$), although these correlations are weak (0.19 and 0.18, respectively). Assuming that SCS functions as a marker for total FV consumption in children, these data infer that the FVSQ failed to estimate total FV consumption.

TABLE 3.4 Correlation between FVSQ and PWPA data.

	Spearman's Rho	***P***	***n***
Fruit BI	0.45	<0.000	330
Vegetable BI	0.39	<0.000	333
Fruit PI	0.44	<0.000	374
Vegetable PI	0.39	<0.000	376
Fruit PII	0.43	<0.000	415
Vegetable PII	0.46	<0.000	415

FVSQ vs. Food Tracker. **Table 3.6** represents the comparison between the FVSQ and the food tracker. For lunchtime FV, the two different records contained 58.7% of the same reported food items. The FVSQ and the food tracker matched for 56.3% for vegetables and 69% for fruits. Kappa values for lunchtime consumption were 0.30 for vegetables and 0.26 for fruits ($P = 0.001$). Kappa values for total daily consumption were 0.17 for vegetables ($P = 0.04$) and 0.23 for fruits ($P = 0.007$). According to a 6-grade scale developed by Landis and Koch (22), these kappa statistics are estimated to be only slight to fair. In comparing the FVSQ to the food tracker (**table 3.6**), it was discovered that 38.7% of FV reported on FVSQ were absent on the food tracker (intrusions). In addition, 43.7% of total vegetables and 29.6% of total fruits were recorded on the FVSQ, but not the food tracker (intrusions). Students who completed their tracker for both days of the assessment period did not perform significantly better on the FVSQ than those who did not complete the tracker at all ($P = 0.30$-0.73) (**Table 3.7**).

TABLE 3.5 Means and standard deviations for total FV consumption and SCS.

	Total FV[1] **Mean**[2] **± SD**	**SCS**[3] **Mean ± SD**	**Spearman's Rho**	***P***	***n***
Baseline I	1.85 ± 1.66	23978 ± 8066	0.05	0.48	179
Phase I	1.55 ± 1.57	25033 ± 8619	0.19**	0.007	206
Phase II	1.43 ± 1.50	23094 ± 8340	0.18**	0.006	227

[1]Total FV consumption is measured in cups.
[2]Total FV and SCS means represent data from all six schools combined.
[3]SCS are measured in Raman counts.

Ability of FVSQ in Detecting Change in FV Consumption. **Table 3.8** represents the comparison between the photo observation data and FVSQ data in detecting a change in FV consumption between phases of the *Food Dude* program. Only data from Praise and Full Intervention schools were included in this table in order to observe the changes in FV consumption associated with the *Food Dude* program. According to PWPA, fruit consumption increased by 0.17 cups and vegetable consumption increased by 0.22 cups from Baseline to Phase 1. The FVSQ detected similar increases in consumption during this time period. PWPA also recorded a significant decrease in FV consumption from Phase 1 to Phase 2 (0.20 cups for fruit and 0.25 cups for vegetable). The FVSQ recorded a significantly smaller decrease in consumption than PWPA during that time period (0.12 cups for fruit and 0.13 cups for vegetable). In addition, the FVSQ overestimated vegetable consumption by 0.09 cups from Baseline to Phase 2 when compared to PWPA. These results suggest that the FVSQ is inconsistent at detecting changes in FV consumption over time.

TABLE 3.6 Comparisons of reported FV consumption between the FVSQ and Food Tracker.

	Percentage Matches	Percentage Omissions[1]	Percentage Intrusions	Kappa	*P*	*n*
Lunchtime Vegetable	58.7	2.7	38.7	0.30	0.001	75
Lunchtime Fruit	58.7	2.7	38.7	0.26	0.001	75
Total Vegetable	56.3	0	43.7	0.17	0.037	71
Total Fruit	69.0	1.4	29.6	0.23	0.007	71

[1]Percentage omissions and intrusions were calculated relative to the FVSQ.

TABLE 3.7 Comparison between students who filled out the food tracker prior to completing the FVSQ to those who did not.

	No Tracker	Tracker	*P*	*n*[1]
Lunchtime Fruit B1	-0.007	-0.04	0.48	39/238
Lunchtime Vegetable B1	0.002	-0.02	0.70	40/238
Lunchtime Fruit P1	-0.02	-0.04	0.60	84/209
Lunchtime Vegetable P1	-0.00	-0.02	0.35	85/211
Lunchtime Fruit P2	-0.10	-0.13	0.48	89/225
Lunchtime Vegetable P2	-0.08	-0.11	0.37	90/225

[1] Tracker/no tracker

TABLE 3.8 Comparison between the PWPA and FVSQ data in detecting a change in FV consumption between phases.

	PWPA[123]	**FVSQ**	***P***	***n***
Fruit B1-P1	-0.17	-0.15	0.75	85
Vegetable B1-P1	-0.22	-0.19	0.53	86
Fruit P1-P2	0.20	0.12	0.02	125
Vegetable P1-P2	0.25	0.13	0.001	124
Fruit P2-B1	-0.00	0.02	0.63	70
Vegetable P2-B1	-0.06	0.03	0.03	70

[1]PWPA and FVSQ refer to the difference in lunchtime consumption of fruit or vegetable (as labeled) between the two different time points
[2]PWPA and FVSQ are represented in cups
[3]Data are from Incentivized and Praise schools only

Exploration of Confounding Factors. No significant effects were observed for grade, gender, or ethnicity in analyses comparing the difference in estimates between methods by these factors (P = 0.15-0.92, P = 0.16-0.76, P = 0.06-0.94, respectively). As such, grade, gender, and ethnicity were eliminated as potential confounding factors in analyses.

Additionally, there were no general trends in the difference between schools. However, a significant difference between data from the PWPA and the FVSQ was noted during Baseline between School 3 and School 6 (P = 0.04) as well as School 3 and School 4 (P = 0.03). The results for the analysis by school do not have a great enough influence to change the results of the study and therefore will not be considered a confounding factor in our analysis.

One final factor that was explored for potential confounding was the condition of the school. There was no significant difference in accuracy that could be attributed to condition, except for lunchtime consumption of fruit during Phase 1. Mean lunchtime fruit consumption of control and full intervention schools differed significantly during Phase 1 ($P = 0.04$). In addition, mean lunchtime fruit consumption at control and praise schools differed significantly during Phase 1 ($P = 0.04$). As with the school factor, these results minimally contribute to the findings of this study and will not be considered a confounding factor in these analyses.

DISCUSSION

The results of this study suggest that the FVSQ is a moderately valid tool for estimating lunchtime FV consumption in fourth and fifth graders although may not be sensitive enough to detect the magnitude of change we observed in lunchtime FV consumption subsequent to an intervention to increase FV intake. In addition, the FVSQ does not appear to be effective at measuring total FV intake, that is FV intake at school and away from school. Using a food tracker along with the FVSQ did not improve performance.

The National Health and Nutrition Examination Survey measured total FV consumption as 1.37 cups daily (7). If lunchtime intake is calculated by taking 1/3 of this value, then children in the United States are consuming approximately 0.46 cups FV during lunchtime. Results from this study are consistent with national data as mean baseline FV intake during lunchtime measured 0.46 cups by the FVSQ and 0.40 cups by PWPA.

Measuring food intake is challenging in adults and children alike, especially when it is self-reported. While McPherson et al. concluded in a review of validation studies that food records and recalls seem to work better for school-aged children (23), several different types of FFQs have been validated for use in children (13-15). Ideally, when comparing methods of food consumption measurement, the reference method must be as accurate as possible. PWPA is usually a more accurate method of measurement than self-report methods, and was thus used as a reference to determine the validity of the FVSQ in reporting lunchtime FV intake.

We evaluated the efficacy of the FVSQ in measuring total FV consumption by comparing it to SCS. From this comparison it appears that the FVSQ was ineffective in measuring total FV consumption when compared to SCS. Although, these results should be considered with caution, as SCS have not yet been validated in children. While SCS are an accepted biomarker of total FV consumption in adults, it has not been confirmed that they can be used the same way with children. In addition, there are some confounding factors that may affect carotenoid levels in the skin including illness, UV and IR radiation of the sun, and smoking (or being exposed to second-hand smoke) (24) and variability between the scanning units used in this research. These factors make it difficult to conclude whether the poor correlations between SCS- and FVSQ-reported FV were entirely due to the FVSQ as SCS was the main resource used to determine its validity in measuring total FV consumption in this study. More research is needed to confirm the validity of the FVSQ in measuring total FV consumption.

Although our results suggest that the FVSQ may not be very reliable at estimating total FV consumption, the questions regarding lunchtime FV intake function as a moderately reliable representation of actual consumption when compared to the method of PWPA. By Cohen's conventions, a significant and moderate correlation of ≥0.50 denotes validity (25). Correlations between PWPA and FVSQ for lunchtime FV consumption ranged from 0.39 to 0.46 ($P < 0.000$), which suggests that the FVSQ is only a moderately valid tool at measuring lunchtime FV in children.

One possible reason that lunchtime FV consumption provided better results than total FV consumption on the FVSQ may have been because the subjects were more aware of what they were eating in school than at home and thus reported it more accurately. In addition, FV were often pre-portioned at the schools and children were allowed to choose which, if any, FV they took during lunchtime. This may have allowed for more awareness and memory of what they were eating. This availability and choice may not have been present in some homes or the children may not have been as observant of what they were consuming at home. In addition, the children spent a longer period of time at home and thus had more eating occasions there than at school.

The FVSQ was also evaluated to assess if it was sensitive enough to detect a change in lunchtime FV consumption between the phases. Significant changes in lunchtime FV consumption for the PWPA data occurred from Baseline to Phase 1 and from Phase 1 to Phase 2. As mentioned previously, the FVSQ detected a similar increase in consumption from Baseline to Phase 1, but it detected a significantly lower decrease in consumption from Phase 1 to Phase 2. This reveals the inconsistency of the FVSQ in detecting changes in lunchtime FV consumption over time. The fact that the FVSQ failed to detect similar decreases in FV consumption from Phase 1 to Phase 2 may have been due to a conscious overestimation of FV intake in the children. This inconsistency could also be due to the limited sensitivity of the questionnaire.

In general, the FVSQ overestimated FV consumption when compared to the food tracker. As food trackers are filled concurrently with mealtimes, they can help to limit the recall bias that is often noted with other analysis tools (18). There are a few possible explanations for the difference in reported food consumption on the food tracker and the FVSQ. The food tracker contained simple directions and it was not very specific. It merely asked the children to write down everything they ate or drank during the day. There were no directions to specifically target recording of FV consumption and most of the subjects did not record each item that was contained in each dish. This may be one of the reasons why intrusions were much more common than omissions. The items that appeared on the FVSQ and were absent on the food tracker may not have been specifically mentioned in a dish that was recorded. Some of the entries were too general and it was impossible to assign them to a specific category of food. It is also possible that the overestimation of the FVSQ compared to the food tracker may have been due to an underestimation of consumption the food tracker.

Although the food tracker was not very specific, underreporting of food items on a food log is a common error (16, 18, 26). When Roumelioti et al. (13) tested the validity of a semiquantitative FFQ against a 24-hour recall, kappa values revealed poor agreement (kappa < 20) for fruit and fair agreement (kappa = 0.21-0.40) for vegetables. The results of this study provide similar, but slightly lower kappa values (kappa = 0.17-0.30). Another reason that could contribute to the lower kappa coefficients and discrepancies in the matches is that the students may not have been very diligent at filling out their food tracker completely. There was no incentive to insure that it was filled out thoroughly. The aim of the food tracker was not to provide an accurate reference method, but to serve as a memory aid for the students as they filled out the FVSQ. Even though there was a lower return rate on the food trackers (54-71% for both days in an assessment period), performance on the FVSQ was not significantly different from those who did not complete a food tracker, contrary to reports by others (19). It is possible that no improvement was observed because of the lack of specificity of the food tracker or because the students were not motivated.

It is important to note the limitations of the FVSQ. First, the FVSQ provided a less precise measurement of FV, as FV consumption was measured in handfuls and then converted into cups. Measurements were designed this way with the hope that children would be better able to estimate consumption with an amount that was easy to understand and visualize, but increments of 0.5 cups do not allow for a great deal of specificity in how much was consumed. Perhaps a scale that included 0.13, 0.25, and 0.33 would have been more appropriate for estimating actual consumption. Secondly, children have a difficult time estimating portion sizes (27). It was thought that the subjects might find it more challenging to estimate consumption in cups as it may have been difficult to imagine how much food constituted a cup. This may have added some confusion, as one handful may be perceived differently between children. Third, The FVSQ provided only a limited food list of existing FV. Although categories of FV were grouped together to encompass all FV, a child may not have recorded eating a certain FV because it was not specifically listed. Finally, the timing of the administration of the FVSQ could have impacted the validity of the FVSQ as teachers were in charge of the administration of the

FVSQ (except for the Baseline assessment). It is possible that they did not always have their students fill out the FVSQ in the morning as instructed, but rather at a later time that was more convenient to their schedule. This may have impacted the students' abilities to remember what they ate during the previous day, especially if they completed these forms after lunch. Also, due to time restraints in the student's schedules, data was only obtained for two weekdays.

Literature comparing the results of similar questionnaires to observations is extremely limited in children, although there is more information about validating questionnaires with food records or interviews as the reference method (13-16). The correlations between the FVSQ and PWPA are similar to those seen by Haraldsdottir (28). Spearman correlations between a food frequency section of a FV questionnaire and a 7-day food record ranged from r = 0.40-0.53 in 11-12-year-olds. The authors concluded that the food frequency portion of the questionnaire provided a fairly good ranking of the children according to their FV intake. In contrast, Neuhouser et al. (15) developed a beverage and snack questionnaire (BSQ) that proved to be reliable at assessing beverage, snacks, sweets, and FV in seventh-graders. Pearson correlation coefficients between a self-completed food record and the BSQ for FV consumption were 0.85 for items consumed "at school" and 0.73 for items consumed "not at school." While these correlations are much higher than those presented in our study, the children who completed the BSQ were two to three years older than those in our study. This difference in correlations could be due to the design of the questionnaire, the reference method, or to contrasting cognitive levels between the two groups.

According to Livingstone and Robinson (12), children begin to develop the cognitive ability to accurately report food intake by the time they are 8-10 years of age, often with equal reliability as their parents (12). It is thought by others that children rapidly increase in their capability to respond to questions about their eating behavior, and by the time they are 10-12, they can provide their own responses (13). The subjects in this study were fourth and fifth graders with ages usually ranging from ages 9-11. It is likely that some students in this study may have lacked the ability or the motivation to fill out the FVSQ accurately, thus contributing to the lower performance on the FVSQ.

The results of this study denote that the FVSQ may not be effective at measuring total FV intake in fourth and fifth graders; more research will help confirm this. Conversely, the FVSQ proved to be moderately valid at estimating lunchtime FV intake, although it was significantly less sensitive at detecting a change in FV consumption between time points than PWPA. In addition, the use of a food tracker did not improve the students' performance on the FVSQ when compared to PWPA. These findings may be due to a variety of limitations associated with the FVSQ and food tracker, or they could be attributed to the difficult task of remembering and recording food consumption for children in the fourth and fifth grade.

IMPLICATIONS FOR FUTURE RESEARCH

Obesity remains a serious public health concern in the United States. In addition, children are consuming much less FVs than is recommended (7). Assessing FV intake among young children is difficult and can be a time-consuming, resource-intensive, and burdensome (9, 14, 18). There is a need to refine a simple, self-assessing tool to help estimate and detect changes in consumption when implementing school-based nutrition programs, such as *Food Dudes.* Such a tool could ease the complications and resources of other diet assessment options and help researchers learn valuable information about FV and possible associations with obesity.

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CHAPTER 4

SUMMARY AND CONCLUSION

SUMMARY

The purpose of this thesis study was to gain greater incite into the field of nutrition, specifically in regard to the measurement of fruit and vegetable (FV) consumption among children. Effective diet analysis tools are critical to measuring and typifying food consumption, detecting changes in intake, and understanding the efficacy of school or other intervention projects. Current literature affirms that childhood obesity is an area of public health concern in the United States as it is associated with a variety of health problems and conditions (1, 2). Increasing FV consumption may help address the obesity epidemic (3-5) as FV are low energy-dense foods, rich with fiber, nutrients, and water. Schools are good place to target behavioral changes in FV consumption (6) and a variety of programs have been implemented to help children develop healthy eating habits (7-10). An accurate estimation of fruit and vegetable consumption is important for evaluating the efficacy of school-based interventions.

The literature review of dietary assessment methods concluded that each diet assessment tool has benefits and limitations, and the selected tool should be that which is most effective at answering the specific research question. Lunchtime observations and food weighing are generally considered the most accurate methods of diet analysis of young children (11), but time, resources, and feasibility do not always allow such data to be obtained. Food records may produce the least absolute errors compared to the FFQ and the 24-hour recall (12), but it is not always plausible to use this method either. The development of a tool that is simple, easy to complete and administer, and could provide accurate estimates of consumption would be ideal for a FV intervention study. A multiday record-assisted fruit, vegetable, and snack questionnaire (FVSQ) was developed with the aim of evaluating FV consumption with limited resources and time. The objective of this study was to assess the efficacy of the FVSQ in measuring lunchtime and total FV intake.

The FVSQ was administered to students (n = 579) during the *Food Dude* Program, a school-based intervention aimed at increasing FV consumption in children. Plate-waste photo analysis (PWPA) data was obtained concurrently and used as a reference for determining the validity of the FVSQ in measuring lunchtime FV consumption. Food Trackers were filled out by the students during meal times and later used when completing the FVSQ. Total FV consumption from the FVSQ was compared to skin carotenoid scores (SCS) to obtain information regarding the validity of the questionnaire in measuring total FV intake. Researchers have confirmed that SCS can function as a valid biomarker of total FV consumption in adults (13-16), but more information is needed to confirm these assumptions in children.

The results of this study denote that the FVSQ is not a suitable tool for measuring total FV intake in children, although SCS have yet to be validated as a biomarker for total FV consumption in children. Alternatively, the FVSQ provided moderately valid estimations of lunchtime FV consumption in fourth and fifth grade children, but it was not sensitive enough to detect significant changes in lunchtime FV consumption over the span of the *Food Dude* intervention program (4 months). Also, the use of a food record did not improve performance on the FVSQ as has been seen by others (17). The age at which children develop the cognitive ability to accurately report food consumption has been debated, but is somewhere between the ages of 8-12 (18, 19). The discrepancies in FV intake found when the FVSQ was compared to PWPA and SCS data may have been due to limited cognitive ability to recall FV intake, the design of the questionnaire and food tracker, or the reference method (in the case of SCS).

CONCLUSION

Childhood obesity is a growing health concern in the United States and eating more FV may be one way to address the epidemic. School-based FV intervention programs have the potential to increase FV consumption in children. However, measuring FV consumption often demands extensive time and resources. The FVSQ was a simple tool that allowed fourth and fifth grade children to self-report FV consumption. While it was a moderately accurate tool for determining lunchtime FV intake, it could not detect important changes in FV consumption or provide a reasonable estimate of total FV intake. It is difficult for children to recall dietary information, but future studies should continue to explore the development of a self-report questionnaire that can accurately report FV consumption. Using a food tracker may not be effective at enhancing the performance of a questionnaire.

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APPENDICES

Appendix A. Final Version of FVSQ

What did you eat and drink yesterday?

ID#____________________

	Yes	No
Q1. Did you eat SCHOOL breakfast yesterday?	O	O
Q2. Did you eat SCHOOL lunch yesterday?	O	O
Q3. Did you fill out your Food Tracker yesterday?	O	O

	None	A few bites	1 Handful	2 Handfuls	3 Handfuls	4 or more Handfuls
Q4. How much fruit did you eat for **lunch** yesterday**?**	O	O	O	O	O	O
Q5. How much vegetable did you eat for **lunch** yesterday**?**	O	O	O	O	O	O

Please mark the column that shows how many times you ate the food ***yesterday***. Mark none if you did not eat or drink the item. Please do not leave any item blank.

Fill in the circle of things that you drank ***yesterday***. Think of one cup as one 8 oz carton of milk.

	None	A few sips	1 cup	2 cups	3 cups	4+ cups
Q6. 100% orange juice, apple juice or other 100% juice	O	O	O	O	O	O
Q7. Vegetable juice like V8, carrot, or tomato	O	O	O	O	O	O
Q8. Fruit flavored drinks and sports drinks like Capri Sun, Kool-Aid, Sunny Delight, Gatorade or PowerAde	O	O	O	O	O	O

	None	A few sips	1 cup	2 cups	3 cups	4+ cups
Q9. Regular soda pop (not diet) or energy drinks like Rockstar, Red Bull or Monster	O	O	O	O	O	O
Q10. Plain milk	O	O	O	O	O	O
Q11. Flavored milk	O	O	O	O	O	O
Q12. Smoothie made with yogurt and fruit	O	O	O	O	O	O

Fill in the circle of the things you ate ***yesterday***. Count one handful as about the amount that would fit in the cup of your hand. If you did not eat these snacks yesterday please mark none.

	None	A few bites	1 Handful	2 Handfuls	3 Handfuls	4 or more Handfuls
Q13. Potato or tortilla chips either flavored or plain	O	O	O	O	O	O
Q14. French fries or tater tots	O	O	O	O	O	O
Q15. Popcorn	O	O	O	O	O	O
Q16. Pretzels or salty crackers including gold fish crackers, Ritz crackers	O	O	O	O	O	O

	None	A few bites	1 Handful	2 Handfuls	3 Handfuls	4 or more Handfuls
Q17. Graham crackers or animal crackers	O	O	O	O	O	O
Q18. Candy such as jelly beans, licorice, or gummy bears	O	O	O	O	O	O
Q19. Chocolate or chocolate candy bars	O	O	O	O	O	O
Q20. Cookies, brownies, pies, cake, doughnuts, or pop tarts	O	O	O	O	O	O
Q21. Popsicles, Slurpees, or shaved ice	O	O	O	O	O	O
Q22. Ice cream or milkshakes	O	O	O	O	O	O

Please fill in the circle of the fruits and vegetables that you ate ***yesterday***. Count one handful as a medium sized piece of fruit or vegetable, or about the amount of canned or cooked vegetable that could fit in the cup of your hand. If you did not eat the item mark none.

Location	None	A few bites	1 Handful	2 Handfuls	3 Handfuls	4 or more Handfuls
Q23. Fresh or frozen fruit	O	O	O	O	O	O
Q24. Canned fruit like peaches, pears, applesauce, or pineapple	O	O	O	O	O	O

	None	A few bites	1 Handful	2 Handfuls	3 Handfuls	4 or more Handfuls
Q25. Dried fruit like raisins or Craisins	O	O	O	O	O	O
Q26. Baked or mashed potatoes	O	O	O	O	O	O
Q27. Green salad, spinach, kale or other dark green leafy vegetable	O	O	O	O	O	O
Q28. Spaghetti sauce, tomatoes or salsa	O	O	O	O	O	O
Q29. Yams, sweet potatoes or winter squash like butternut	O	O	O	O	O	O
Q30. Vegetable soup, or stew with vegetables	O	O	O	O	O	O
Q31. Carrots	O	O	O	O	O	O
Q32. Beans such as baked beans, garbonzo beans, kidney beans, or black beans	O	O	O	O	O	O
Q33. Any other vegetables, including string beans, peas, corn, broccoli, celery, or cauliflower	O	O	O	O	O	O

APPENDIX B. Early Version of FVSQ

What did you eat and drink yesterday? **ID#_____________**

Please mark the column that shows how many times you ate the food ***yesterday*** at school and not at school. Mark none if you did not eat or drink the item. Please do not leave any item blank.

Fill in the circle of things that you drank ***yesterday***. Think of one cup as one 8 oz carton of milk.

	Location	None	A few sips	1 cup	2 cups	3 cups	4+ cups
Q1. 100% orange juice, apple juice or other 100% juice	At School	O	O	O	O	O	O
	Not at School	O	O	O	O	O	O
Q2. Vegetable juice like V8, carrot, or tomato	At School	O	O	O	O	O	O
	Not at School	O	O	O	O	O	O
Q3. Fruit flavored drinks like Capri Sun, Kool-Aid, or Sunny Delight	At School	O	O	O	O	O	O
	Not at School	O	O	O	O	O	O
Q4. Sports drinks like Gatorade or PowerAde	At School	O	O	O	O	O	O
	Not at School	O	O	O	O	O	O
Q5. Flavored waters such as Propel or Vitamin Water	At School	O	O	O	O	O	O
	Not at School	O	O	O	O	O	O
Q6. Diet soda pop	At School	O	O	O	O	O	O
	Not at School	O	O	O	O	O	O
Q7. Regular soda pop	At School	O	O	O	O	O	O
	Not at School	O	O	O	O	O	O
Q8. Energy drinks that contain caffeine (Rockstar, Red Bull, Monster)	At School	O	O	O	O	O	O
	Not at School	O	O	O	O	O	O
Q9. Plain milk	At School	O	O	O	O	O	O
	Not at School	O	O	O	O	O	O
Q10. Flavored milk	At School	O	O	O	O	O	O
	Not at School	O	O	O	O	O	O

	Location	None	A few sips	1 cup	2 cups	3 cups	4+ cups
Q11. Smoothies made with yogurt and fruit	At School	O	O	O	O	O	O
	Not at School	O	O	O	O	O	O

Fill in the circle of the things you ate ***yesterday***. Count one handful as about the amount that would fit in the cup of your hand. If you did not eat these snacks yesterday please mark none.

	Location	None	A few or a few bites	1 Handful	2 Handfuls	3 Handfuls	4 or more
Q12. Potato chips, either flavored or plain	At School	O	O	O	O	O	O
	Not at School	O	O	O	O	O	O
Q13.Tortilla chips, either flavored or plain	At School	O	O	O	O	O	O
	Not at School	O	O	O	O	O	O
Q14. French fries or tater tots	At School	O	O	O	O	O	O
	Not at School	O	O	O	O	O	O
Q15. Pretzels	At School	O	O	O	O	O	O
	Not at School	O	O	O	O	O	O
Q16. Popcorn	At School	O	O	O	O	O	O
	Not at School	O	O	O	O	O	O
Q17. Salty crackers including gold fish crackers, Ritz crackers	At School	O	O	O	O	O	O
	Not at School	O	O	O	O	O	O
Q18. Graham crackers, animal crackers	At School	O	O	O	O	O	O
	Not at School	O	O	O	O	O	O
Q19. Candy such as jelly beans, licorice, and gummy bears	At School	O	O	O	O	O	O
	Not at School	O	O	O	O	O	O

	Location	None	A few or a few bites	1 Handful	2 Handfuls	3 Handfuls	4 or more
Q20. Chocolate and chocolate candy bars	At School	O	O	O	O	O	O
	Not at School	O	O	O	O	O	O
Q21. Doughnuts and pop tarts	At School	O	O	O	O	O	O
	Not at School	O	O	O	O	O	O
Q22. Cookies, brownies, pies and cake	At School	O	O	O	O	O	O
	Not at School	O	O	O	O	O	O
Q23. Popsicles, Slurpees, or shaved ice	At School	O	O	O	O	O	O
	Not at School	O	O	O	O	O	O
Q24. Ice cream and milkshakes	At School	O	O	O	O	O	O
	Not at School	O	O	O	O	O	O

Please fill in the circle of the fruits and vegetables that you ate ***yesterday***. Count one handful as a medium sized piece of fruit or vegetable, or about the amount of canned or cooked vegetable that could fit in the cup of your hand. If you did not eat the item mark none.

	Location	None	A few bites	1 Handful	2 Handfuls	3 Handfuls	4 or more
Q25. Fresh or frozen fruit	At School	O	O	O	O	O	O
	Not at school	O	O	O	O	O	O
Q26. Canned fruit like peaches, pears, applesauce, pineapple	At School	O	O	O	O	O	O
	Not at School	O	O	O	O	O	O
Q27. Dried fruit like raisins and Craisins	At School	O	O	O	O	O	O
	Not at School	O	O	O	O	O	O
Q28. Baked or mashed potatoes	At School	O	O	O	O	O	O
	Not at School	O	O	O	O	O	O

	Location	None	A few bites	1 Handful	2 Handfuls	3 Handfuls	4 or more
Q29. Green salad	At School	O	O	O	O	O	O
	Not at School	O	O	O	O	O	O
Q30. Spinach, kale or other dark green leafy vegetables	At School	O	O	O	O	O	O
	Not at School	O	O	O	O	O	O
Q31. Spaghetti sauce, tomatoes or salsa	At School	O	O	O	O	O	O
	Not at School	O	O	O	O	O	O
Q32. Yams, sweet potatoes or winter squash like butternut	At School	O	O	O	O	O	O
	Not at School	O	O	O	O	O	O
Q33. Vegetable soup, or stew with vegetables	At School	O	O	O	O	O	O
	Not at School	O	O	O	O	O	O
Q34. Carrots	At School	O	O	O	O	O	O
	Not at School	O	O	O	O	O	O
Q35. Beans such as baked beans, garbonzo beans, kidney beans, black beans	At School	O	O	O	O	O	O
	Not at School	O	O	O	O	O	O
Q36. Any other vegetables, including string beans, peas, corn, broccoli	At School	O	O	O	O	O	O
	Not at School	O	O	O	O	O	O

Q37. Did you eat school breakfast?	Yes	O	Q38. Did you eat school lunch?	Yes	O
	No	O		No	O
Q39. Did you fill out your Food Tracker yesterday?	Yes	O			
	No	O			

Appendix C. Food Tracker

This Food and Beverage Tracker belongs to:

____

My ID number is:

____

Remember to write down everything you eat and drink every day that your teacher tells you to.

Please write down everything you eat and drink today.

Today is **Sunday February 12**

	List what you ate/drank here:	How much?
What did you eat for breakfast?		
What did you drink for breakfast?		
Did you eat or drink anything between breakfast and lunch?		
What did you eat for lunch?		
What did you drink with lunch?		
Did you eat or drink anything between lunch and dinner?		
What did you eat for dinner?		
What did you drink with dinner?		
Did you eat or drink anything between dinner and going to bed?		

Please write down everything you eat and drink today.

Today is **Wednesday February 8**

	List what you ate/drank here:	How much?
What did you eat for breakfast?		
What did you drink for breakfast?		
Did you eat or drink anything between breakfast and lunch?		
What did you eat for lunch?		
What did you drink with lunch?		
Did you eat or drink anything between lunch and dinner?		
What did you eat for dinner?		
What did you drink with dinner?		
Did you eat or drink anything between dinner and going to bed?		

Please write down everything you eat and drink today.

Today is **Thursday February 9**

	List what you ate/drank here:	How much?
What did you eat for breakfast?		
What did you drink for breakfast?		
Did you eat or drink anything between breakfast and lunch?		
What did you eat for lunch?		
What did you drink with lunch?		
Did you eat or drink anything between lunch and dinner?		
What did you eat for dinner?		
What did you drink with dinner?		
Did you eat or drink anything between dinner and going to bed?		