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Evaluation of “Together, We Inspire Smart Eating” (WISE) nutrition intervention for young children: Assessment of fruit and vegetable consumption with parent reports and measurements of skin carotenoids as biomarkers

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Abstract

Resonance Raman spectroscopy (RRS) and parent report were used to assess dietary intake of fruit and vegetable (FV) consumption among young children experiencing a nutrition intervention. The nutrition intervention was “Together, We Inspire Smart Eating” (WISE). The study followed a convenience sample of low-income children in preschool (N=175) and early elementary (N=199) classrooms over an academic school year. Data were collected in a Southern, rural U.S state. Results of pre- and post-assessments indicated statistically improved consumption of FV at follow-up compared to baseline. Results were consistent using both assessment methods supporting the use of either assessment method.

Keywords

Obesity; Nutrition; Preschool; Poverty; Skin carotenoids as a biomarker

Introduction

In the current epidemic of obesity, interventions to prevent obesity and promote good nutrition are becoming prevalent in school and community settings.¹ Increasing consumption of fruits and vegetables (FV) is a common goal of such programs as this has been shown to help young children establish life-long habits.^{2,3} To evaluate the success in altering the consumption habits in school-based interventions, researchers need assessment tools that are feasible in large-scale studies.

Self-report methods, such as Food Frequency Questionnaire (FFQ), can be unreliable and time-consuming, and often those using these methods must first undergo extensive training.⁴⁻⁷ Assessing consumption for young children presents additional challenges because obtaining reliable information requires an informed adult reporter,⁸ and identifying the best respondent to complete a child’s FFQ can be problematic. Because young children consume

a significant amount of their daily intake outside the home, parent reports can be incomplete; ^{9,10} however, educator reports are difficult because, during group meals in school settings, the educators either are not present (e.g., outside school) or are serving many children.¹¹

Observer-recorded assessments, including photo diaries and plate weighing, address some challenges of the FFQ, but such methods are labor-intensive and less feasible for large studies.¹² The observations are limited to community/school settings and may not reflect usual intake at home. Furthermore, it is common in preschool settings for meals to be served family-style, rather than controlled portions to each child, which adds to the difficulty in determining consumption.

Use of Resonance Raman Spectroscopy (RRS) technology to assess skin carotenoid as a biomarker of diet is a promising alternative to traditional methods. RRS is a non-invasive laser technique that can assess the total concentration of carotenoids.¹³ Intake of FV with green, orange, yellow, and red coloring—such as carrots, sweet potatoes, dark leafy greens, and tomatoes—can be detected by the color of blood and cell tissues, which are influenced by plant pigments and phytochemicals¹⁴. Because the body does not produce carotenoids and other foods do not have significant levels of carotenoids, RRS is a potentially useful technology for determining FV consumption. RRS scans detect individual differences in carotenoid levels and indicate dietary habits over the previous 4 weeks.^{15–17}

RRS overcomes many limitations of prior methods and requires minimal time or effort to derive a numerical indicator of FV intake.¹² Scarmo and colleagues (2012) validated the use of RRS technology with a compact, portable RRS scan,¹⁸ which was used in this study. Other researchers have provided additional evidence that RRS biomarkers are valid for assessing children's dietary intake.¹⁹ Specifically, Aguilar et al. found that skin carotenoid scores from RRS strongly correlated with FFQ estimates for children.¹⁹ However, few studies have reported on the use of RRS to examine whether an intervention results in changes in dietary intake of preschool children or in community settings.²⁰ Use of RRS could increase the ability of researchers and others to assess large numbers of study participants more efficiently and at less expense.

In this study, we evaluated FV consumption of young children experiencing the *Together, We Inspire Smart Eating* (WISE) program. We used RRS and a targeted, intervention-specific FFQ of parent report of the child's FV consumption. WISE is an evidence-supported curriculum that includes a classroom-based structured weekly food experience, educator training, and parent outreach.²¹ WISE was developed to consider the barriers and circumstances of low-income families.²² In a previous quasi-experimental WISE evaluation, we compared preschool children that experienced WISE to a non-randomized control group that was not exposed to WISE. Our results supported intervention effects based on parent report.²³ The present study expanded the sample to include children in kindergarten and first grade. We expected that results of this study that used pre- to post-assessments and objective RRS assessment would be similar to those of the previous study and generally consistent with parent report.

Methods

Study Sample

This study represents data collected in 2014–2015 from rural families of preschool children attending one of 12 Head Start classrooms or 12 public elementary school classrooms (6 kindergarten, 6 first grade). All children in target classrooms were eligible to participate in the evaluation study. In preschool programs, program staff interviewed parents.^{24,25} Research staff conducted parent interviews with a similar tool for elementary parents. All interviews were conducted in English or Spanish, as preferred by parents, at study enrollment and at the end of the school year. The University of Arkansas for Medical Sciences Institutional Review Board approved the study protocol. Our trained research staff collected RRS hand scans from all children after distribution of passive consent forms to parents. All children present on the day of scanning were included unless parents requested exclusion. Parents reported most children as white (42%). The largest minority group reported was Black (33%).

WISE Curriculum/Intervention

We developed WISE specifically for preschool and elementary schools serving children from resource-poor backgrounds. WISE is summarized here and described in detail elsewhere.^{21,26,27} We implemented the three key components of WISE: (a) a manualized classroom curriculum, (b) educator training, and (c) material and technology to educate parents.²⁶ WISE includes Windy, the barn owl mascot, to engage children in the lesson and take the message home. WISE includes a lesson plan/schedule, suggestions for integration into educational activities (e.g., math), and hands-on recipes. We provided educators with standardized, hands-on training on best-practice messages and implementation.²⁶

WISE focuses on one target food each month in a specific order that begins with typically familiar foods (e.g., apples) and moves to less familiar, in-season foods throughout the school year (e.g., greens). Carotenoid levels of WISE foods vary from low (e.g., apples) to moderate (e.g., tomatoes) to high (e.g., spinach). WISE engages families via monthly letters from a farmer and on social media (e.g., Facebook and Pinterest).²⁸ Training for preschool educators consists of an interactive session based on adult learning theories. Changing adult behavior is thought to require increases in both knowledge and practice.^{29,30} Adult learners benefit from active rather than passive instruction, appropriate levels of challenge, monitoring and feedback, time to organize and integrate new ideas and concepts, and help generalizing to different contexts. Training content should be related to participants' own practice situations,³¹ and use learners' experiences as a point of departure.³⁰ Training includes an overview of the roles of educators and parents in child nutrition and exploration of the participant's food attitudes and beliefs. Training also includes positive role modeling, food experiences in small groups, appropriate use of the WISE mascot, and positive feeding practices (e.g., reduced pressure).

Measures

We used the RRS technique to obtain a biomarker of skin carotenoid status. A representative from the manufacturer (NSE Products, Inc., Provo, Utah) trained research staff to use the

Pharmanex Biophotonic Scanner. We transported the RRS to the schools and calibrated it for each day's assessment. The children washed their hands and the research staff member scanned the children's palms. We conducted RRS assessments in a low-traffic area of the classroom to avoid disruptions to lessons. We gave the students a sticker for participation.

Data included carotenoid-level scores that represent total carotenoid concentrations. Regardless of an individual's age, higher concentrations of carotenoid molecules are represented with higher intensity counts.¹⁹ Most Americans score between 17,000 and 23,000; 40,000 is a wellness goal. Readings below 3,000 are not considered reliable.

We used a modified FFQ with parents to assess FV consumption specific to WISE target foods.³² One question asked, "In the last month, how often have you seen your child eat at least a bit of:" followed by a list of the 10 WISE-targeted FV (i.e., tomatoes, sweet potatoes, carrots, bell peppers, spinach, greens, green beans, apples, strawberries, blueberries). Responses ranged from never to "more than two-per-day" (e.g., 1=Never, 2=1× per month or less, 3=2–3× per month, up to 9=2+x per day). We computed a summary score as the mean of consumption of all FV and subscores for fruits or vegetables. High scores indicated more consumption.

Preschool parents were asked two additional questions about child FV consumption as part of the preschool agency assessments.^{24,25} Questions were prefaced with, "About how often does your child eat a food from the following groups?" The specific groups were "dark green or orange/yellow vegetables like greens, carrots, broccoli, squash, sweet potatoes" and "fruits like apples, oranges, bananas, grapes, peaches, applesauce." Response options ranged from "1=More than 1 a day" to "5=None." Scores were averaged to create a FV general score, with high scores indicating lower consumption. Test-retest reliabilities ranged from 68% to 95%.^{24,25,33}

Statistical Analysis

We performed pre- and post-intervention comparisons with McNemar-Bowker's Test from SPSS v23 paired *t*-tests. McNemar-Bowker's Test ($p < .05$) is useful for paired nominal data, where the test assumes symmetry between baseline and follow-up.^{34,35} Cohen's *d* was computed for the independent *t*-tests to examine effect sizes. Chi-square statistics compared categorical data.

Results

Food Frequency Questionnaire

Educators interviewed 267 preschool parents at program enrollment and in 165 follow-up home visits at the end of the school year; 161 (63%) were assessed both times. Most of the missing follow-up interviews were due to a fire that destroyed agency data files ($n=51$). Adjusting for these missing data results in an assessment rate of 80%. Research staff recruited for interviews 74 parents of children in Kindergarten and first grade across 12 classrooms. Of the 74, 70% ($n=52$) were interviewed at follow-up. Data collectors completed assessments at baseline and follow-up within 6-week data-collection spans each time.

Parent report of child consumption of WISE foods increased from baseline to follow-up (Cohen's $d=.51$, $t(212)=-7.30$, $p<.000$) and moved toward once a week from "more than 2–3 times a month" (Table 1). Follow-up analyses compared results by school setting and by FV. When examined by setting, preschool children increased toward once a week from "more than 2–3 times a month" ($t(160)=-5.46$, $p<.000$), and elementary children improved similarly ($t(51)=-5.18$, $p<.001$). When WISE fruit and WISE vegetables were examined separately, both showed significant increased consumption (vegetables: $M=2.55$, $SD=1.03$ baseline; $M=3.11$, $SD=1.40$ follow-up; $t(212)=-6.67$, $p<.000$) (fruit: $M=3.91$, $SD=1.31$ baseline; $M=4.33$, $SD=1.23$ follow-up; $t(211)=-4.79$, $p<.000$).

We conducted additional follow-up analyses among just the preschool children as their parents reported on two additional questions using a preschool-agency specific tool. We found that consumption significantly increased from "once a day" ($M=2.11$, $SD=.87$) to almost "more than once a day" (not shown in Table 1, $M=1.87$, $SD=.72$; $t(162)=3.71$, $p<.000$). When we examined the two general consumption questions separately, both showed significant improvement in consumption (vegetables: $M=2.46$, $SD=1.19$ baseline; $M=2.19$, $SD=1.08$ follow-up; $t(162)=3.07$, $p<.000$) (fruit: $M=1.76$, $SD=.87$ baseline; $M=1.59$, $SD=.67$ follow-up; $t(164)=2.60$, $p<.003$).

Resonance Raman Spectroscopy

Of 336 children assessed with RRS scans at baseline, 66 were not assessed at follow-up. Of the 267 (80%) with data at both times, three had scores below 3,000 and were excluded. Of 199 elementary children present the day of assessment at baseline, 16% ($N=31$) were not scanned because the parent declined the assessment. Of 175 preschool children present the day of assessment at baseline, 4% ($N=7$) were not scanned because the parent declined the assessment; one child was distressed and refused.

Research staff obtained RRS baseline assessments over 10 days, with an average of 33 assessments each day (3.5 minutes, $SD=.81$). Follow-up assessments were obtained over 7 days, with an average of 43 per day (3.3 minutes, $SD=.87$).

Follow-up RRS scores were significantly higher than baseline RRS scores, indicating increased consumption of carotenoid-rich FV at follow-up ($t(263)=-.08$, $p<.039$, Cohen's $d=1.1$). The baseline score was 23,784.76 ($SD=9,104.05$), and the follow-up score was 24,800.16 ($SD=9,162.88$). We stratified the scores in categories based on the ranges typically seen in Americans: below 17,000, 17,000 to 23,000, and above 23,000. Scores above 40,000 are ideal; however, fewer than 16 children had scores in this ideal range. To examine the shifts into healthy categories, we compared the categories and found a marginally significant shift to higher categories ($\chi^2(3)=7.99$, $p=.046$). At follow-up, we found a 3.8% decrease in the least healthy group and an 8% increase in the healthiest group compared to baseline. At follow-up, we examined the RRS scores for preschool children and elementary school children separately. We found marginal statistical differences, with follow-up scores higher but not significantly so ($p<.15$).

Discussion

The results of this study that used parent-reported FFQ and objective RRS assessments of children in preschool and public school settings suggest that the WISE intervention was linked to significantly increased consumption of FV for the children. The results were consistent across the pre- and post-assessments and showed significantly increased consumption of FV. These results indicate that skin carotenoid biomarkers can be used to detect dietary changes, which provides support for a potentially cost-effective and simple assessment of interventions in large, school-based settings.

This is one of a few studies to embed RRS scans in a large school-based evaluation effort of nutrition and obesity interventions for children.^{20,36,37} The convergence of RRS results with results of multiple evaluation methods suggests that RRS may be appropriate as a stand-alone measure of dietary intake. However, RRS findings demonstrated smaller effect sizes than FFQ in our sample. Further, when the subgroups of children were examined by school setting, only marginal significance levels were observed. This suggests that large samples are needed when using RRS.

Our study provided useful information about selection of assessment methods for school-based studies. For example, the RRS assessments took minimal time; few parents declined to allow their children to participate; and RRS resulted in a more complete data set (about 20% lost to follow-up, compared to 26–37% for parent interviews). Data collected with RRS was more concentrated with 7–10-day data-collection windows, as compared to 6–8 weeks for parent report. Time per assessment also was lower for RRS (3–3.5 minutes) than for parent interviews (~20 minutes), and scores require less processing.

Limitations

Our study has several limitations. Other studies suggest RRS scores are linked to a child's exposure to environmental tobacco smoke, exposure to the sun, and body weight^{38,39}. Unfortunately, these factors were not measured, although children serve as their own controls across time. A second concern is the lack of a comparison group; however, convergence of two diverse measurement tools (e.g., RRS and parent interviews) lends support to the validity of the findings about the evaluation of the WISE intervention. While the RRS assessment has many advantages over parent report, it is limited in that the individual may be consuming a range of other fruits and vegetables that are not well represented or consuming a narrow but measureable fruit or vegetable. For example, if a child is only consuming fruit, they may have a high score on the RRS.

Nevertheless, ours is one of the largest published studies that used RRS in a community sample and is one of few that implemented RRS as part of an evaluation of a school-based intervention.^{12,37} Assessment of young children's consumption of FV is critical in the study of obesity-prevention interventions. Our study suggested that RRS is a feasible and useful tool.^{12,19,40}

Conclusions

The RRS technology and parent-reported FFQs were consistent in supporting *Together, We Inspire Smart Eating* (WISE). Children experiencing WISE consumed more FV after a year's exposure to the multiple-component, evidence-based curriculum than before exposure. RRS technology may be a useful assessment tool for large community-based interventions to improve healthy eating.

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Table 1.

Baseline and Follow-up Assessment of Fruit and Vegetable Consumption at Home by FFQ and RRS

	N	Baseline		Follow-up		Effect size
		Mean	SD	Mean	SD	
Parent report FFQ WISE foods ^a **	213	2.95	0.91	3.48	1.14	.51
RRS Score ^b *	264	23784.76	9104.05	24800.16	9162.88	.11
Percent RRS in health ranges						
% below 17000		23.1		19.3		
% 17,000 to 23,000		27.7		23.5		
% above 23000 [*]		49.2		57.2		

*
 $p < .05$;

**
 $p < .01$, listwise deletion

^a FFQ WISE foods includes a list of 10 specific F/V. Score range: 1, Never consumed; to 9, 2+x per day; n=52 elementary school children, n=161 preschool children

^b RRS scans for N=199 elementary school children, N=175 preschool children