Using Skin Carotenoids to Assess Dietary Changes in Students After 1 Academic Year of Participating in the *Shaping Healthy Choices Program*

Lori M. Beccarelli, PhD[1,2]; Rachel E. Scherr, PhD[1,2]; Madan Dharmar, PhD, MBBS[3,4]; Igor V. Ermakov, PhD[5]; Werner Gellermann, PhD[5]; Lisa Jahns, PhD, RD[6]; Jessica D. Linnell, PhD[7]; Carl L. Keen, PhD[1,8,9]; Francene M. Steinberg, PhD, RD[1,8]; Heather M. Young, PhD, RN, FAAN[4]; Sheri Zidenberg-Cherr, PhD[1,2,8]

ABSTRACT

Objective: To determine whether fourth-grade students participating in the *Shaping Healthy Choices Program* (SHCP), a school-based nutrition intervention, would change vegetable and carotenoid intake measured by skin carotenoids and dietary intake.

Methods: Single-group pretest–posttest with a self-selected, convenience sample of students (n = 30) participating in the SHCP, which lasted 1 academic year (9 months). Dietary intake of vegetables and carotenoids as measured by Block food frequency questionnaire and skin carotenoids as measured by Raman spectroscopy were collected at the school preintervention and postintervention.

Results: Reported carotenoid intake decreased by 1.5 mg ($P = .05$) and skin carotenoids decreased by 2,247.9 RRS intensity units ($P = .04$). Change in reported intake correlated with change in skin carotenoids ($r = .43$; $P = .02$).

Conclusions and Implications: The reported decrease in vegetable and carotenoid intake was unanticipated; nevertheless, the RRS measurements confirmed this. RRS data can help evaluate changes in fruit and vegetable intake.

Key Words: skin carotenoids, school nutrition, dietary assessment, nutrition education, garden, vegetable (*J Nutr Educ Behav*. 2017;49:73-78.)

Accepted September 15, 2016. Published online October 26, 2016.

INTRODUCTION

Most children in the US are not meeting the Dietary Guidelines for Americans' recommendations for fruit and vegetable intake.[1] The *Shaping Healthy Choices Program* (SHCP) was developed based on Social Cognitive Theory[2] and the Social Ecological Model[3] to encourage the consumption and enjoyment of fruits and vegetables. The SHCP is a multicomponent, school-based nutrition intervention that aims to improve dietary behaviors and prevent childhood obesity by improving students' individual factors, as well as factors in the home and school environments, while creating a community-based support system.[4] In this study, the researchers evaluated changes in dietary intake of fruits and vegetables using 2 methods: reported dietary intake and skin carotenoids.

Numerous intervention studies aimed at increasing fruit and vegetable intakes in children have been conducted, but the assessment of changes in dietary behavior in children remains challenging.[5-7] Reported dietary intake is often used in community-based interventions; however, it can be unreliable and is time- and labor-intensive.[8-11] Skin carotenoid status measured by resonance Raman spectroscopy (RRS) can be used as a biomarker to assess fruit and vegetable intake because carotenoids are predominately found in fruits and vegetables and their presence in the body can reflect cumulative dietary intakes of these foods.[12-15] The RRS method is a quick, noninvasive, and non-biased method

[1]Department of Nutrition, University of California, Davis, Davis, CA
[2]Center for Nutrition in Schools, University of California, Davis, Davis, CA
[3]Department of Pediatrics, University of California Davis Health System, Sacramento, CA
[4]Betty Irene Moore School of Nursing, University of California Davis Health System, Sacramento, CA
[5]Image Technologies Corporation, Salt Lake City, UT
[6]US Department of Agriculture–Agricultural Research Service Grand Forks Human Nutrition Research Center, Grand Forks, ND
[7]Family and Community Health, Extension Service–Tillamook and Lincoln Counties, Oregon State University, Tillamook, OR
[8]University of California Agriculture and Natural Resources, Davis, CA
[9]Department of Internal Medicine, University of California, Davis, Davis, CA

Conflict of Interest Disclosures: The authors' conflict of interest disclosures can be found online with this article on www.jneb.org.

Address for correspondence: Rachel E. Scherr, PhD, Department of Nutrition, University of California, Davis, 3149 Meyer Hall, One Shields Ave, Davis, CA 95616; Phone: (530) 752-3817; Fax: (530) 752-8905; E-mail: rescherr@ucdavis.edu

http://dx.doi.org/10.1016/j.jneb.2016.09.007

to assess skin carotenoids and was previously validated in children.[15] Skin carotenoid status using RRS was also reported to change in response to dietary intake, which made it possible to use this methodology to detect changes in dietary behavior.[16,17] However, those reports were largely a result of feeding studies in which there were substantial changes in carotenoid intake. Few studies to date have used RRS to measure changes in usual dietary intake in children. In addition, no studies used this RRS instrument to measure skin carotenoid changes in response to a multicomponent, school-based nutrition program.

The objective of the current study was to determine whether students participating in the SHCP changed their consumption of fruits, vegetables, and carotenoids measured by a food-frequency questionnaire (FFQ) and an RRS instrument that was developed for research purposes (a research-grade RRS). A secondary objective was to determine whether the RRS instrument could be useful to measure changes in fruit and vegetable intake after an intervention lasting 1 academic year. It was hypothesized that students participating in the SHCP for 1 academic year would increase consumption of vegetables and therefore have greater reported intake of vegetables and carotenoids and greater skin carotenoid concentrations. In addition, it was hypothesized that increased skin carotenoid intensity would be associated with a greater carotenoid intake.

METHODS

Study Design

This study was a substudy of the larger SHCP study based on available dietary intake and skin carotenoid data. It was a single-group pretest–posttest design in which a self-selected convenience sample of students was assessed before and after the intervention.

Participants

Students (n = 30) were recruited at the beginning of each academic year over 2 years from fourth-grade classrooms in a northern California elementary school participating in the SHCP.[4] The intervention was implemented twice: once over the course of the 2012–2013 academic year and again in the 2013–2014 academic year. Exclusion criteria included living in a smoking household or having illnesses or chronic conditions known to change carotenoid status.[12,18] According to these criteria, no students were excluded from the study. The University of California, Davis Institutional Review Board approved the study protocol. Parents provided written informed consent and children provided oral assent.

Intervention

The SHCP intervention is described in detail elsewhere.[4] Briefly, the SHCP aimed to (1) increase nutrition knowledge and use of science processing skills; (2) promote availability, consumption, and enjoyment of fruits and vegetables; (3) improve dietary patterns and encourage physical activity; (4) foster positive changes in the school environment; and (5) facilitate development of an infrastructure to sustain the program. Intervention activities included an inquiry-based, garden-enhanced nutrition curriculum, *Discovering Healthy Choices*, taught in the classroom[19]; cooking demonstrations in the classroom using the *Cooking Up Healthy Choices* curriculum[20]; family newsletters sent home to parents; health fairs or health screenings at the school; improvements to the school lunchroom including installing a salad bar and increasing procurement of regional produce; and development of a school-site wellness committee. In the 2012–2013 school year (August to May), the nutrition curriculum was delivered by an SHCP educator. In the 2013–2014 school year (August to May), the intervention was repeated with a new cohort of fourth-grade students and the teachers delivered the *Discovering Healthy Choices* curriculum after participating in a comprehensive professional development program. Because the overall results regarding dietary intake across both years were consistent, students' data from both years were combined.

Data Collection and Analysis

Preintervention data collection occurred before the intervention activities began in August and postintervention data collection occurred immediately after the intervention's completion in May. Measurements are described in the subsequent sections.

For anthropometrics, height and weight were measured at the school site.[4] The methods followed guidelines published by the Centers for Disease Control and Prevention (CDC). Height was measured using a transportable stadiometer (Seca 213; Seca, Chino, CA) and body weight was measured using an electronic scale (Seca 803b; Seca). Body mass index (BMI) (in kg/m^2) was calculated, and age and sex-specific BMI percentiles were derived. Classifications for adiposity were based on those determined by the CDC and the Expert Committee on Childhood and Adolescent Overweight and Obesity using the 2000 CDC growth charts.[21-23] Under these classifications, overweight was defined as ≥85th percentile and obese was defined ≥95th percentile of the sex-specific BMI-for-age growth chart.[23]

For demographics, the race and ethnicity of the student were reported by the parents using a demographic questionnaire that was sent home.[4]

Dietary intake was self-reported by students with the help of their parents at home using the 2004 Block FFQ for students aged 8–17. Students were provided detailed classroom instruction on completing the FFQ and were given standardized bowls and a plate consistent with the diagram provided with the FFQ to use as a reference.[4] Questionnaires were returned to the teachers for researchers to collect. Completed FFQs were analyzed by NutritionQuest (Berkeley, CA). In the analysis report, α-carotene, β-carotene, β-cryptoxanthin, lutein, and lycopene were quantified. Total dietary carotenoids were calculated by taking the sum of the individual carotenoids reported by the FFQ analysis. Total vegetables (not including white potatoes) were calculated by taking the difference between total vegetables and white potatoes reported by the FFQ analysis report.

In the 2012–2013 school year, preintervention total skin carotenoids were assessed in November through December using RRS at a health fair event organized by SHCP researchers at the school site. Student attendance at the health fair was optional but was required for participation in the evaluation. In May, 2013, a similar health fair event was hosted and students volunteered to return for postintervention measurements. In the 2013–2014 school year, skin carotenoids were assessed