Skin Carotenoid Levels Over Time and Differences by Age, Sex, and Race Among Head Start Children (3-5 years) Living in Eastern North Carolina

Sarah Burkholder, BS[1], Jocelyn Bayles[1], Stephanie Jilcott-Pitt, PhD[2] & Virginia C. Stage PhD, RDN, LDN[1]

[1]Department of Nutrition Science, College of Allied Health Science, East Carolina University; [2]Department of Public Health, East Carolina University

INTRODUCTION

- Low intake of fruits/vegetables (FV) among preschoolers is well documented, establishing a need for interventions that can improve intake.[1,2,3,4,5]
- However, in order to determine effectiveness of interventions, valid and objective methods are needed.[3,6]

A promising non-invasive tool for objectively measuring FV consumption is the Veggie Meter® (VM), which uses reflection spectroscopy to assess skin carotenoids.[7]

- While the tool has been used and validated in adults, limited research exists to describe its use in children.[8,9,10]

PURPOSE

The purpose of this study was to investigate skin carotenoid levels in 3-5-year-old children enrolled in Head Start (HS) centers in North Carolina by using an objective measure of FV intake to assess changes over time and differences between sex, race, and age.

METHODS

STUDY DESIGN

- Three HS (federally funded preschool[11]) centers located in Eastern North Carolina participated in this prospective cohort study.
- East Carolina University IRB approved study methods and protocols (UMCIRB 19-001535).

DATA COLLECTION TOOLS

- Survey data was collected from families including demographic information and strong food likes/dislikes.
- Participating children's **height, weight,** and **skin carotenoids** using the Veggie Meter® (VM®) were measured as shown in **Table 1.**
- Height and weight were measured using adapted NHANES procedures for collecting anthropometry measurements from children.[12]
- The VM® was used to measure skin carotenoids reflective of a diet high in carotenoids such as FV (**Figure 4**). [10,13]
- The child's finger was inserted into the VM® and the multiple measurement mode was utilized to derive a single carotenoid score on a spectral range of 350-850 nanometers.[10]

DATA COLLECTION

- Four Research assistants attended a 2-hour training on research ethics, protocols, and procedures. Research assistants also completed mock data collection sessions in a local non-HS preschool site prior to collecting data.
- Parent-reported data was collected at Time 1.
- Height, weight, and skin carotenoids (VM®) were measured at Times 1-3.

DATA ANALYSIS

- Over the 2018-2019 school year, Site 1 was participating in a nutrition education intervention focused on improving FV consumption which resulted in significant differences between the two groups ($F(2,76) = 3.98$, $p=.02$, $r=.10$).[14]
- Site 1 (n=67) was excluded from the repeated measures ANOVA analyses since these children had significantly higher SCL at Time 3 compared to children attending Sites 2 and 3 ($t(85)=2.54$, $p=.01$).[14]
- Data was analyzed using ANOVA (group differences at baseline) with a Greenhouse-Geisser correction and repeated measures ANOVA with Bonferroni correction to assess changes over time. *P-values* < .05 were considered statistically significant.

Table 1. Study Timeline for Data Collection and Assessments

Collection Timeline	Activities/Assessments Completed
Time 1 – Baseline Data Collection (n=112) October 2018 *Reflective of diet in summer prior to HS (n=112)	Parent Survey (age, sex, ethnicity/race, history of food allergies) Veggie Meter® (skin carotenoid measurements) Height & Weight Measurements
Time 2 – Mid Data Collection (n=45) December 2018 *Reflective of diet provided partially by HS	Veggie Meter® (skin carotenoid measurements) Height & Weight Measurements
Time 3 – Post Data Collection (n=45) February 2019 *Reflective of diet during winter break	Veggie Meter® (skin carotenoid measurements) Height & Weight Measurements

RESULTS

- The final sample consisted of 112 HS children.
- Participants were 57% male, an average age of 4.1 (SD=.5) years, and predominantly Black/AA (81.3%) followed by Hispanic (6.3%).
- 8.9% of children had parent-reported food allergies.
- Mean skin carotenoid levels were 266 (SD 82.9) (n=112).
- Skin carotenoid levels over time had significant differences ($F(1,58)=17.66$) from Time 1 to Time 3 ($p<.001$) and from Time 2 to Time 3 ($p=.001$). No significant differences from Time 1 to Time 3 ($p=.496$) (**Figure 1**).

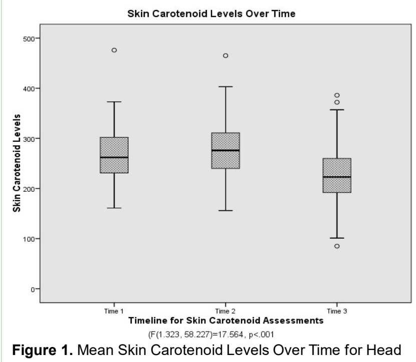

Figure 1. Mean Skin Carotenoid Levels Over Time for Head Start Children (N=45)

Skin carotenoid levels changed significantly over time and were significantly different between sex and age groups. No significant differences were observed between race.

- Significant differences were seen between males (282, SE 9.3) and females (243, SE 12.8) ($F(1,153)=.76$, $p=.01$ at Time 1 (**Figure 2**).
- Although the test was not significant, there were slight variations on skin carotenoid levels and race ($F(1,153)=.76$, $p=.67$.
- Hispanics had the highest skin carotenoid levels at 297 (SE 19.7), followed by white at 281 (SE 35.8), AA with 265 (SE 8.8), and "other races" at 234 (SE 35.8).
- Age ($F(1,153)=1.45$, $p=.01$ was significant with higher skin carotenoid levels found in 5-year-olds (**Figure 3**).

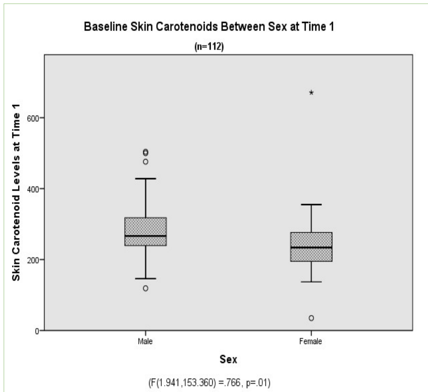

Figure 2. Mean Skin Carotenoid Levels Between Sex for Head Start Children at Time 1 (n=112)

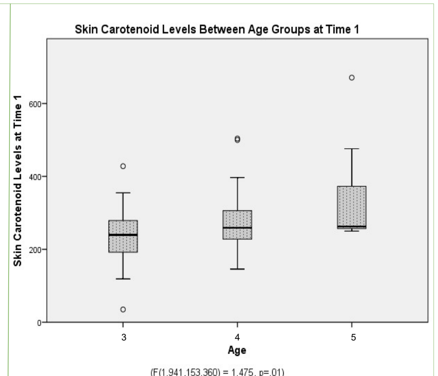

Figure 3. Mean Skin Carotenoid Levels Between Age for Head Start Children at Time 1 (n=112)

DISCUSSION

- The goal of this study was to establish skin carotenoid levels in a low-resource preschool-age population and examine changes over time and differences between sex, race, and age groups.

Sex and age appear to have significant effects on children's FV intake as measured by reflection spectroscopy (VM®) to measure skin carotenoids.

- In the current study, significant differences were observed in skin carotenoid levels over time from Time 1 to Time 3 and Time 2 to Time 3. This could potentially be due to the Child and Adult Care Food Program (CACFP) mandating children receive 1 cup of FV daily.[15] The changes in skin carotenoid levels could also be due to seasonality which affects availability of FV.[16]
- Prior research is inconclusive as to whether males or females have higher FV intake.[3] However, this study found that males had higher skin carotenoid levels compared to females, suggesting that males had higher intake of FV.
- Findings also suggest preschooler's age group is a significant predictor FV intake assessed by skin carotenoids. This finding is supported by existing literature describing neophobia emerging around the second year of life, peaking in preschool years and then slowly declining.[17]
- Although not significant, variations were observed between race and skin carotenoid levels possibly due to the cultural food differences seen among different race groups.[9,10]

LIMITATIONS & STRENGTHS

- The reflection spectroscopy approach in young children has not been validated, although community-based validation in adults has been demonstrated.[9,10,11]
- Current understanding of VM® scores does not allow for estimation of actual portions of FV consumed.
- The current study filled the gap in assessing skin carotenoid levels in low-resource, minority children by using a portable, non-invasive, objective measurement tool.

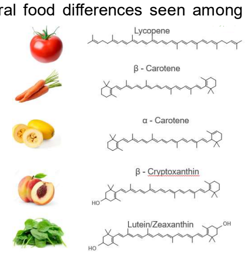

Figure 4. Carotenoids Commonly Found in North American Diet

FUTURE RESEARCH

- The VM® is a useful tool for objectively measuring FV intake in preschool-aged children; however, the tool should be validated using blood plasma and traditional subjective measures of intake.
- More research is also needed to explore the impact of skin carotenoid levels in evenly distributed sex, race, age groups in a larger sample while also utilizing subjective methods of dietary intake.

REFERENCES

1. Kirkpatrick S, Dodd K, Reedy J, Krebs-Smith S. Income and race/ethnicity are associated with adherence to food-based dietary guidance among US adults and children. *J Acad Nutr Diet.* 2012; 112:624-635. doi:10.1016/j.jand.2011.11.012
2. Mikkelsen M, Husby S, Skov L, Perex-Cueto F. A systematic review of types of healthy eating interventions in preschools. *Nutrition Journal.* 2014. doi:10.1186/1475-2891-13-56
3. Kirkpatrick S, Dodd K, Reedy J, Krebs-Smith S. Income and race/ethnicity are associated with adherence to food-based dietary guidance among US adults and children. *J Acad Nutr Diet.* 2012; 112:624-635. doi:10.1016/j.jand.2011.11.012
4. Dubowitz T, Heron M, Bird C, et al. Neighborhood socioeconomic status and fruit and vegetable intake among whites, blacks, and Mexican-Americans in the United States. *Am J Clin Nutr. 2008;87(6):1883-1891. doi:10.1093/ajcn/87.6.1883*
5. Rasmussen M, Kroiner R, Klepp KI, et al. Determinants of fruit and vegetable consumption among children and adolescents: a review of the literature. Part I: quantitative studies. Int J Behav Nutr Phys Act. 2006;3:22. doi:10.1186/1479-5868-3-22
6. Shim J, Oh K, Kim K. Dietary assessment methods in epidemiologic studies. 2014
7. Jahns L, Johnson L, Mayne S, et al. Skin and plasma carotenoid response to a provided intervention diet high in vegetables and fruit: uptake and depletion kinetics. *American Journal of Clinical Nutrition.* 2014;100(3)930-937.

**Additional References Available Upon Request

ACKNOWEDGEMENTS

FEEd Lab Research Team:
Virginia C. Stage, Mentor
Jocelyn Bayles, Undergraduate Research Assistant

FUNDING: ECU College of Allied Health Science Thesis Award