Associations Between Farmers' Market Shopping Behaviors and Objectively-Measured and Self-Reported Fruit and Vegetable Intake in a Diverse Sample of Farmers' Market Shoppers: A Cross-Sectional Study

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Research

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Abstract

Background: Fruit and vegetable (FV) intake is associated with reduced risk of numerous chronic diseases. The community food environment can support FV intake through enhanced access via food outlets, such as farmers' markets. This paper examines cross-sectional associations between farmers' market shopping behaviors and objectively-measured and self-reported FV intake to better understand whether farmers' market shopping behavior relates to FV intake among farmers' market shoppers.

Methods: Farmers' market shoppers were surveyed at 17 farmers' markets in rural North Carolina and New York City. A questionnaire assessed self-reported FV intake and three measures of farmers' market shopping behavior: (1) frequency, (2) variety of FV purchased, and (3) dollars spent on FV. Skin carotenoid status, a non-invasive biomarker for FV intake, was objectively measured using pressure-mediated reflection spectroscopy. Associations between shopping behaviors at farmers' markets and FV intake were examined using regression models that controlled for individual demographics (age, sex, race, smoking status, education, income, and site).

Results: Farmers' market shoppers in New York City purchased a greater variety of FV and had higher skin carotenoid scores than in North Carolina. There was a positive, statistically significant association between self-reported frequency of shopping at farmers' markets and both self-reported and objectively assessed FV intake. We also observed that variety of FV purchased and farmers' market spending were positively associated with self-reported FV intake, but not skin carotenoid status.

Conclusion: Those who shop more frequently at a farmers' markets, purchase a greater variety of FV, and spend more money on FV have higher self-reported, and in some cases, higher objectively measured FV intake. Further research is needed to understand these associations and test causality.

Background

Obesity is a major public health issue in the United States, and its prevalence continues to rise.[1] Obesity is linked to greater risk of various cancers, cardiovascular disease, and type 2 diabetes mellitus.[2] Inadequate intake of fruits and vegetables (FV) is associated with higher risk of obesity and other diet-related chronic diseases like heart disease and cancer.[3–8] Furthermore, while variety of FV consumed is known to support good health,[3,8] Americans eat few types of FV.[3,9] Rural populations and racially/ethnically diverse populations have disproportionate rates of chronic diseases and obesity, with low FV intake cited as a contributing factor.[10–12]

Evidence suggests that diet-related health disparities may be due, in part, to negative aspects of community food environments.[13,14] Access to healthy food sources, such as supermarkets and farmers' markets, has been inversely associated with obesity; whereas, the presence of convenience stores and fast food restaurants has been associated with an increased prevalence of obesity.[13,14] Limited evidence suggests that greater access to and use of farmers' markets are associated with greater self-reported intake of FV.[15–18] Additionally, greater overall expenditure on FV has been associated with lower mortality.[19]

Most studies examining associations between shopping at farmers' markets and FV intake have only used self-reported measures of FV intake, which may be subject to errors in recall, which can increase both random error and systematic bias which tends to overestimate consumption of healthier foods.[20–24] Thus, objective measures of FV intake are needed to accurately quantify intake and determine effectiveness of interventions and policies to improve dietary behaviors. Carotenoids are antioxidants that are found in high concentrations in yellow, orange, red, and dark green FV, which deposit and accumulate in blood plasma and skin.[25] The current gold standard for objective assessment of FV intake is measurement of carotenoids in blood plasma.[26] However, collection, storage and analysis of blood plasma for assessment of carotenoids is invasive, time-consuming, and resource-intensive. As an alternative, skin carotenoids measured with pressure-mediated reflection spectroscopy is a validated method to approximate FV intake.[27–29]

In this paper, we explored associations between self-reported and objectively-measured FV intake and three measures of farmers' market shopping behavior: (1) monthly frequency of farmers' market shopping, (2) variety of FV purchased on one market day, and (3) money and/or benefits typically spent on FV at the farmers' market per week, in both a rural population and a racially/ethnically diverse urban population. We hypothesized that FV intake, measured both by self-report and skin carotenoids, would be positively associated with shopping frequency at farmers' markets, variety of FV purchased, and money and/or benefits spent on FV.

Methods

Study population

This cross-sectional study used a convenience sample of farmers' market shoppers identified through public intercept at 10 farmers' markets in 6 counties in rural eastern North Carolina (NC), and 7 farmers' markets in New York City (NYC). Participants were recruited during the farmers' market season, June – August 2019. Eligible participants were at least 18 years of age and able to speak English. The study purpose was explained to each prospective participant, after which they were given the opportunity to ask questions. When participants agreed to participate in the study, they provided informed, verbal consent to the research staff. Individuals that were deemed eligible and consented to participate in the study were asked to answer a short (approximately 5–10 min.) questionnaire and complete three skin carotenoid measurements using the Veggie Meter® (Longevity Link Corporation, Salt Lake City, UT, USA). The questionnaire was completed electronically on a tablet device and was self-administered, unless the participant requested it be administered by the researcher. Individuals who agreed to participate in this study and completed all study measures received a canvas tote bag as compensation for their time. The study was reviewed and approved by the Institutional Review Boards at Cornell University (IRB# 1806008085) and East Carolina University (IRB# 19-001223). A cross-site training was held to ensure that data collection occurred in the same manner by all study research staff.

Farmers' market shopping behaviors

Three farmers' market shopping behaviors were queried. Participants reported approximately how often they purchased FV from the farmers' market during the farmers' market season. Response options were never (0),

less than once a month (0.5), once a month (1), every other week (2), and once a week (4). Response codes were chosen to approximate how many times per month the participant purchased FV at the farmers' market, and the resulting frequency variable was considered to be continuous. Participants also reported which FV they purchased at the farmers' market that day via check boxes and open text response. The sum of items was used to approximate the variety of FV purchased at the farmers' market. The questionnaire also assessed the cash and/or benefits typically spent on FV at the farmers' market with open-text responses which were translated into a continuous variable (dollars).

Self-reported FV intake

The questionnaire also included items to assess self-reported FV intake. Self-reported fruit intake was assessed by asking participants "How much fruit (in cups) do you eat in an average day?" providing examples and prompting participants not to include fruit juice. Likewise, vegetable intake was assessed by asking participants "How many vegetables (in cups) do you eat in an average day?" with examples and prompting participants not to include French fries. Response options were whole and half numbers from 0 to 6 cups. These two fruit and vegetable questions were adapted from the American Heart Association's (AHA) Life's Simple 7 score.[30]

Skin carotenoid measurement

The Veggie Meter® uses pressure-mediated reflection spectroscopy on the index finger to assess skin carotenoids, which is a valid method to assess skin carotenoid status and approximate FV intake.[28,29] Three measurements were taken, and the mean of all measures was used in analysis.

Participant Characteristics

Participants reported height in feet and inches and weight in pounds as part of the questionnaire. Body Mass Index (BMI) (kg/m^2) was calculated using inches and pounds by dividing weight by height squared, then multiplying by a conversion factor of 703.[31] Participants' age, sex, race, smoking status, education, and income were also reported.

Data analysis

Farmers' market shoppers were characterized using descriptive statistics, including means and standard deviations for continuous variables and frequencies for categorical variables. Descriptive statistics were calculated for the pooled sample of farmers' market shoppers, and for NYC and NC separately. To test for significant differences between NYC and NC shoppers, chi-square tests (for nominal variables), Wilcoxon-Mann-Whitney tests (for ordinal variables), and t-tests (for continuous variables) were used.

Linear regression models were used to estimate the unadjusted relationships between each shopping behavior and each measure of FV intake separately. Then, multivariable regression models were used to control for age, sex, race, smoking status, education, income, and site. Multi-level models included farmers' market as a random effect when there was enough variation across markets to make this computation possible, which was only the case for skin carotenoids. All models used age less than 60 years, male, Caucasian, less than college graduate, income less than $40,000, and NYC as reference groups. Reference groups were chosen based on the median responses to demographic questions. Analysis was performed

using SAS version 9.4 (SAS Institute Inc., Cary, NC, USA). The $\alpha < 0.05$ significance level was used to determine statistical significance.

Results

We surveyed a total of 649 shoppers, in 7 farmers' markets in NYC (n = 381) and 10 farmers' markets in rural NC (n = 268). The number of participants surveyed in each market ranged from 1 to 96. Farmers' market shoppers were mostly female (79.9%) and more fell into the age 60 + years (37.1%) category than the other age categories. The shoppers surveyed were racially and ethnically diverse (45.1% Caucasian, 28.8% African American, 21.6% Hispanic/Latino) and had a household income of at least $40,000 (54.2%). About half of shoppers were college graduates (53.0%), few currently smoked (8.2%), and mean BMI was 28.0 kg/m^2. Age, race, ethnicity, and BMI differed significantly between shoppers in NYC and rural NC: NC shoppers were older, less racially/ethnically diverse, and had higher BMI than NYC shoppers (Table 1).

Table 1
Participant characteristics among farmers' market shoppers.

	Total (n = 649)		**New York City (n = 381)**		**North Carolina (n = 268)**		
	Count	**%**	**Count**	**%**	**Count**	**%**	**p-value**
Sex							0.546
Male	125	19.4	68	18.1	57	21.4	
Female	514	79.9	306	81.4	208	77.9	
Other/prefer not to answer	4	0.6	2	0.5	2	0.8	
Age							**< 0.001**
<20	13	2.0	8	2.1	5	1.9	
20–29	64	9.9	42	11.2	22	8.2	
30–39	74	11.5	53	14.1	21	7.8	
40–49	101	15.7	67	17.8	34	12.7	
50–59	153	23.8	93	24.7	60	22.4	
60+	239	37.1	113	30.1	126	47.0	
Race							**< 0.001**
American Indian	15	2.5	10	2.9	5	1.9	
Asian	28	4.6	28	8.1	0	0.0	
African American	176	28.8	115	33.2	61	22.9	
Native Hawaiian/Pacific Islander	2	0.3	2	0.6	0	0.0	
Caucasian	276	45.1	88	25.4	188	70.7	
Multiracial	45	7.4	38	11.0	7	2.6	
Refused	70	11.4	65	18.8	5	1.9	
Hispanic/Latino							**< 0.001**
Yes	131	21.6	128	37.0	3	1.2	
No	477	78.4	218	63.0	259	98.8	
Income							0.351
<$20,999	89	14.2	60	16.6	29	10.9	
$21,000 - $39,999	116	18.4	66	18.2	50	18.7	
$40,000 - $59,999	116	18.4	68	18.8	48	18.0	

	Total (n = 649)		New York City (n = 381)		North Carolina (n = 268)		
$60,000 - $79,999	66	10.5	35	9.7	31	11.6	
$80,000 - $99,999	68	10.8	28	7.7	40	15.0	
>$100,000	91	14.5	50	13.8	41	15.4	
Refused	83	13.2	55	15.2	28	10.5	
Education							0.770
Less than high school graduate	28	4.4	24	6.4	4	1.5	
High school graduate or GED	118	18.4	58	15.6	60	22.4	
Some college	155	24.2	95	25.5	60	22.4	
College graduate	340	53.0	196	52.6	144	53.7	
Current smoker	52	8.2	30	8.1	22	8.4	0.892
	Mean	**St. Dev.**	**Mean**	**St. Dev.**	**Mean**	**St. Dev.**	
Body mass index, BMI (kg/m^2)	28.0	6.7	27.5	6.6	28.7	6.9	**0.032**
Significance at the α < 0.05 level indicated using boldface type.							
Number of missing values ranged from 5 (age) to 41 (ethnicity).							

On average, farmers' market shoppers purchased FV at the farmers' market approximately 2.5 times per month, spent $23.11 on FV, and purchased 3.0 different varieties of FV (Table 2). Farmers' market shoppers in NYC, on average, purchased 3.5 different varieties of FV, compared to rural NC shoppers who purchased 2.4 varieties ($p = 0.001$). On average, participants reported consuming 2.2 cups of fruits per day, 2.5 cups of vegetables per day and had a mean skin carotenoid score of 289.7. There was a significant difference in the mean skin carotenoid scores of NYC shoppers and NC shoppers (314.5 vs. 253.2, $p < 0.001$), but no state differences in self-reported FV intake.

Table 2
Farmers' market shopping and fruit and vegetable consumption among farmers' market shoppers (n = 649).

	Total (n = 649)		**New York City (n = 381)**		**North Carolina (n = 268)**		
	Mean	**St. Dev.**	**Mean**	**St. Dev.**	**Mean**	**St. Dev.**	**p-value**
Farmers' market shopping behaviors							
Frequency of FV purchase (times/mo)	2.5	1.5	2.4	1.5	2.6	1.5	0.065
FV purchase variety (# of different types of FV)	3.0	4.5	3.5	5.4	2.4	2.9	**0.001**
Usual FV purchases ($/wk)	23.1	22.7	24.8	21.6	20.9	24.0	0.039
Fruit and vegetable intake							
Fruit intake (cups/day)	2.2	1.4	2.3	1.4	2.1	1.3	0.066
Vegetable intake (cups/day)	2.5	1.4	2.4	1.4	2.5	1.3	0.362
Mean skin carotenoid score	289.7	131.6	314.5	141.0	253.2	106.7	**< 0.001**
Significance at the $\alpha < 0.05$ level indicated using boldface type.							

There were positive, statistically significant associations between FV purchasing frequency (times/mo) and self-reported fruit ($p = 0.007$) and vegetable intake ($p < 0.001$), and mean skin carotenoid scores ($p = 0.010$) in the adjusted models (See Table 3). Fruit and vegetable purchase variety was also positively associated with self-reported fruit intake ($p = 0.002$) and self-reported vegetable intake ($p = 0.003$), but not skin carotenoids, in the multivariate regression models. After adjustment, the amount of money typically spent on FV at a farmers' market was positively associated with self-reported fruit intake ($p < 0.001$) and self-reported vegetable intake ($p < 0.001$), but not skin carotenoids. Adjustment for state was not significant in any models.

Table 3
Associations between farmers' market shopping behaviors and FV intake (n = 649)

	Self-reported fruit intake			Self-reported vegetable intake			Mean skin carotenoid score†		
	n	Estimate	p-value	n	Estimate	p-value	n	Estimate	p-value
Frequency of FV purchases (times/mo)									
Unadjusted	649	0.09	**0.012**	649	0.14	**< 0.001**	649	6.80	0.050
+Adjustment for	504	0.11	**0.007**	504	0.16	**< 0.001**	476	9.81	**0.010**
Age (60 + yrs)		0.04	0.768		0.10	0.451		-3.03	0.803
Female		0.03	0.847		-0.13	0.379		-32.27	**0.022**
Race									
African American		0.17	0.249		0.23	0.100		20.99	0.118
Other/multi-race		-0.00	0.980		-0.12	0.497		-2.84	0.868
Current smoker		-0.09	0.678		-0.05	0.806		-67.09	**< 0.001**
Education (College graduate)		-0.05	0.702		0.05	0.691		46.74	**< 0.001**
Income (≥$40,000)		0.04	0.758		0.14	0.293		17.24	0.169
Site (North Carolina)		-0.20	0.127		0.13	0.322		-59.07	**< 0.001**
FV purchase variety (# of types of FV)									
Unadjusted	649	0.04	**0.002**	649	0.03	**0.011**	649	0.12	0.921
+Adjustment for	479	0.05	**0.002**	479	0.04	**0.003**	452	0.19	0.891
Age (60 + yrs)		0.07	0.584		0.17	0.197		9.26	0.453
Female		0.07	0.636		-0.13	0.392		-33.69	**0.022**
Race									

	Self-reported fruit intake			Self-reported vegetable intake			Mean skin carotenoid score†		
African American		0.17	0.259		0.21	0.151		18.95	0.174
Other/multi-race		-0.04	0.853		-0.16	0.406		4.06	0.821
Current smoker		-0.05	0.821		-0.02	0.918		-69.92	**< 0.001**
Education (College graduate)		-0.05	0.704		0.05	0.680		42.95	**< 0.001**
Income (≥$40,000)		0.01	0.924		0.12	0.396		14.49	0.265
Site (North Carolina)		-0.10	0.469		0.24	0.064		-56.76	**< 0.001**
Usual FV purchases ($/wk)									
Unadjusted	649	0.01	**< 0.001**	649	0.01	**< 0.001**	649	0.11	0.642
+Adjustment for	464	0.01	**< 0.001**	464	0.01	**< 0.001**	439	0.39	0.151
Age (60 + yrs)		0.09	0.484		0.17	0.199		5.64	0.655
Female		-0.03	0.857		-0.19	0.231		-35.24	**0.017**
Race									
African American		0.17	0.266		0.17	0.255		15.69	0.273
Other/multi-race		-0.02	0.938		-0.17	0.387		-4.91	0.790
Current smoker		-0.21	0.380		-0.11	0.630		-76.17	**< 0.001**
Education (College graduate)		-0.08	0.569		0.01	0.952		43.82	**< 0.001**
Income (≥$40,000)		0.02	0.873		0.14	0.323		19.74	0.138
Site (North Carolina)		-0.13	0.328		0.17	0.216		-55.02	**< 0.001**

Significance at the $\alpha < 0.05$ level indicated using boldface type.

†Farmers' market was included as a random effect in this model to account for clustering.

Discussion

In the current study, we found that frequency of shopping at farmers' markets was positively associated with self-reported and objectively-assessed FV intake in a diverse sample of farmers' markets shoppers from two geographic areas – one urban (NYC) and one rural (NC). This is in agreement with prior studies which found that increased shopping at farmers' markets is associated with greater FV intake,[15–18] yet adds to the current literature by demonstrating this cross-sectional association persists when FV intake is assessed by a valid, objective measure (skin carotenoids). We also found that the money spent on FV purchases at the farmers' market and the variety of FV purchased at the farmers' market on the day of survey were positively associated with self-reported FV intake, but neither was associated with skin carotenoids. These seemingly contradictory findings may be because many of the vegetables sold at farmers' markets, such as cucumbers, squash, onions, and potatoes are low in carotenoids.[32] Our findings support the evidence that the farmers' market shopping experience is associated with greater FV intake, and adds data regarding two other relevant dimensions of the farmers' market shopping experience. Our findings are in agreement with others that have found that greater vegetable variety is associated with higher intake of vegetables.[33–35]

This study also adds to the literature regarding expenditures at farmers' markets: A Canadian study revealed that farmers' market shoppers spent, on average $5 CAD (~$3.60 USD)/trip to the market versus $20/trip in our sample. [36] In addition, the total variety of FV purchased in the Canadian study was 2.8, [36] and in ours was approximately three FV. In addition, Freedman et al [37] suggested that an approach that includes establishment of farmers' markets in low-income neighborhoods, acceptance of federal food assistance benefits for payment, and availability of healthy food incentive programming may increase purchasing at farmers' markets among underserved populations. In the current paper, we examined cross-sectional associations between farmers' market shopping behaviors and FV intake. We hypothesized that more intense shopping behaviors (greater frequency, variety, monetary value of FV purchased at farmers' markets) would be positively associated with FV intake. This hypothesis was supported, suggesting that research should explore programs to increase FM shopping intensity (e.g., double-up bucks, variety incentives, return visitor incentives) in addition to mechanisms that simply incentivize initial FM attendance (e.g., first time shopper coupons, introduction coupons).

Strengths of the study include the geographic and racial/ethnic variability of the sample, the assessment of three dimensions of farmers' market shopping behavior, and the use of an objective measure of FV intake (skin carotenoids) in addition to self-reported data. However, the study was limited by its cross-sectional design from which we could not infer causality between farmers' market shopping behaviors and FV intake nor understand the direction of any potential links. The study is also limited in generalizability based upon the use of convenience samples in rural eastern NC and urban NYC. The study is also limited by the use of self-reported shopping behaviors, which are subject to potential overestimation of positive behavior due to social desirability bias. An additional limitation of this study is the non-normality of FV purchase variety (skewness = 3.5, kurtosis = 18.8). A sensitivity analysis using a log transformation was performed that produced results that were similar in direction and significance, thus results from non-transformed data were reported.

Conclusions

The current study contributes important findings related to shopping behaviors and spending at farmers' markets and their relationship with FV intake among shoppers. Further research is needed to better determine causality between farmers' market shopping behaviors and FV intake, and to learn how to effectively promote FV intake in a variety of community food environments.

Abbreviations

Fruit and vegetable (FV), North Carolina (NC), New York City (NYC), Body mass index (BMI), American Heart Association (AHA), Canadian dollars (CAD), United States dollars (USD)

Declarations

- Ethics approval and consent to participate: The study was reviewed and approved by the Institutional Review Boards at Cornell University (IRB# 1806008085) and East Carolina University (IRB# 19-001223). Verbal informed consent was obtained prior to data collection. Written informed consent was waived.
- Consent for publication
- Availability of data and materials: Data are available upon request.
- Competing interests
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- Authors' contributions: CJK, SBJP, LCV, KLH, and RSF conceived of the study. LCV, KLH, AR, RSF, and SBJP collaborated on questionnaire design and development. CJK, LCV, RSF and SBJP supervised data collection. CJK and GM completed statistical analyses, guided by KLH. CJK drafted the manuscript, with guidance from SBJP and KLH. All authors reviewed and approved the manuscript as submitted.
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- Authors' information (optional)

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