

Fruit and Vegetable Intake During Infancy and Early Childhood

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KEY WORDS

fruits, vegetables, frequency of intake, age of introduction, Infant Feeding Practice Study II, Year 6 Follow-Up Study

ABBREVIATIONS

aOR—adjusted odds ratio

CI—confidence interval

DGA—Dietary Guidelines for Americans

IFPS II—Infant Feeding Practices Study II

NHANES—National Health and Nutrition Information Survey

OR—odds ratio

WIC—Special Supplemental Nutrition Program for Women, Infants, and Children

Y6FU—Year 6 Follow-Up Study

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abstract

OBJECTIVES: To examine the association of timing of introduction and frequency of fruit and vegetable intake during infancy with frequency of fruit and vegetable intake at age 6 years in a cohort of US children.

METHODS: We analyzed data on fruit and vegetable intake during late infancy, age of fruit and vegetable introduction, and frequency of fruit and vegetable intake at 6 years from the Infant Feeding Practices Study II and the Year 6 Follow-Up (Y6FU) Study. We determined the percent of 6-year-old children consuming fruits and vegetables less than once per day and examined associations with infant fruit and vegetable intake using logistic regression modeling, controlling for multiple covariates ($n = 1078$).

RESULTS: Based on maternal report, 31.9% of 6-year-old children consumed fruit less than once daily and 19.0% consumed vegetables less than once daily. In adjusted analyses, children who consumed fruits and vegetables less than once daily during late infancy had increased odds of eating fruits and vegetables less than once daily at age 6 years (fruit, adjusted odds ratio: 2.48; vegetables, adjusted odds ratio: 2.40). Age of introduction of fruits and vegetables was not associated with intake at age 6 years.

CONCLUSIONS: Our study suggests that infrequent intake of fruits and vegetables during late infancy is associated with infrequent intake of these foods at 6 years of age. These findings highlight the importance of infant feeding guidance that encourages intake of fruits and vegetables and the need to examine barriers to fruit and vegetable intake during infancy. *Pediatrics* 2014;134:S63–S69

Fruits and vegetables are an excellent source of important nutrients in the diet, including potassium, folate, fiber, vitamin A, vitamin C, vitamin K,¹ and many phytochemicals.² A diet high in fruits and vegetables is associated with reduced risk for chronic diseases, including coronary heart disease,³ stroke,⁴ diabetes,⁵ and some cancers.⁶ In addition, replacing energy-dense foods with fruits and vegetables may assist in healthy weight management.^{7,8} This latter benefit is especially important given that in the United States ~17% of children 2 to 19 years of age are obese.⁹

Because of the importance of fruits and vegetables to overall health, the 2010 Dietary Guidelines for Americans (DGA) recommends increased intake of fruits and vegetables for all Americans 2 years of age and older, and emphasizes the importance of whole food sources of fruits and vegetables rather than juice.¹ Specific intake recommendations based on the DGA call for a minimum of 1 to 1.5 cups of fruit and 1 to 1.5 cups of vegetables daily for children 2 to 8 years old, depending on age, gender, and physical activity level (more is recommended for children who are more active). The American Academy of Pediatrics' general feeding guidance to parents is to introduce fruits, single-grain cereals, and vegetables when complementary foods are introduced to a milk-based diet at ~6 months of age. However, the order and exact age of introduction for specific foods is not stated.¹⁰

Despite the known health benefits of fruit and vegetable intake, a majority of children do not meet recommendations.¹¹ In 2001 to 2004, ~32% of 2- to 3-year-old children and 63% of 4- to 8-year-old children had a total fruit intake below recommended levels.¹¹ For vegetables, the prevalence was even higher: 80% of 2- to 3-year-old and 92% of 4- to 8-year-old children consumed less than recommended lev-

els.¹¹ Although there are no nationally representative studies on intake of fruits and vegetables among infants, the 2008 Feeding Infants and Toddlers Study found that among infants 9 to 11.9 months old, ~30% did not eat a fruit and 28% did not eat a vegetable on a given day.¹² Although research indicates the importance of establishing healthy dietary patterns from early life,^{13–16} few studies have examined the association of fruit and vegetable intake during infancy with intake later in childhood. A longitudinal study of 60 mother/child dyads found that the frequency of fruit and vegetable intake among 2-year-old children was significantly associated with intake 1 year earlier after accounting for factors such as availability and feeding practices.¹⁷ A second longitudinal study of 70 mother/child dyads found that fruit variety in children 6 to 8 years of age was positively associated with either fruit variety or frequency of fruit exposure in the first 2 years of life.¹⁸ However, both of these studies were limited by a small sample size and a single geographic location, and 1 had a follow-up time of only 1 year. Additionally, there is limited research regarding the impact of age of fruit and vegetable introduction on intake during early childhood. A retrospective study of 564 children found that age of introduction of fruit was inversely correlated with frequency of fruit intake among 2- to 6-year-old children, although frequency of intake during infancy was not taken into account.¹⁹

The purpose of the current study was to examine the association of timing of introduction and frequency of fruit and vegetable intake during late infancy with the frequency of fruit and vegetable intake at age 6 years among a large longitudinal cohort of US children with dietary information collected from birth through the first year of life and again at 6 years of age.

METHODS

Data Source

We analyzed data from both the Infant Feeding Practices Study II (IFPS II) and the Year 6 Follow-Up (Y6FU) Study. Both studies were collaboratively conducted by the US Food and Drug Administration and the Centers for Disease Control and Prevention. IFPS II is a longitudinal study of a national cohort conducted from 2005 to 2007 among a large group of pregnant women ≥ 18 years of age who were identified through a mail consumer opinion panel of 500 000 households. Questionnaires were sent to eligible study participants during their third trimester and nearly monthly throughout the first year of their infant's life at ~1, 2, 3, 4, 5, 6, 7, 9, 10.5, and 12 months of age. Further information about the methods of IFPS II was detailed by Fein et al.²⁰ Of the 3033 mother/infant dyads who participated in the neonatal survey of IFPS II, 2958 were eligible for Y6FU based on criterion that mothers answered at least the prenatal and neonatal questionnaires in IFPS II and infants were not disqualified from IFPS II subsequently.²¹ Contact for follow-up was attempted using mail and phone interview. Of the 1624 successfully contacted, 1542 agreed to participate in the Y6FU study, yielding a cooperation rate of 95% and an overall response rate of 52%. The methodology of Y6FU is detailed by Fein et al in this supplement.²¹

Outcome Measure

The outcome of interest (frequency of fruit and vegetable intake at age 6 years) was obtained from Y6FU. We used responses for 6 items (1 item about fruit intake and 5 items about vegetable intake) from the 28-item dietary screener included on the Y6FU questionnaire. The dietary screener was modeled on the National Health and Nutrition Information Survey (NHANES)

dietary screener questionnaire. Mothers were asked how many times during the past 30 days their 6-year-old children ate the following: fruits (fresh, frozen, or canned); green leafy or lettuce salad with or without other vegetables; non-fried potatoes such as baked, boiled, or mashed potatoes, potato salad, or sweet potatoes; refried beans, baked beans, beans in soup, pork and beans, or any other cooked dried beans (not including green beans); tomato sauces including salsa, spaghetti with tomato sauce, or mixed into foods such as lasagna; and other vegetables, fresh, frozen, or canned (not including salad, potatoes, or beans). Mothers reported intake in frequency (times) per day, week, or month. All responses were converted to times per day for analysis. We created 2 dichotomous variables from these data, 1 for total fruit intake and 1 for total vegetable intake (summed from the 5 vegetable questions). Frequency of fruit juice intake was not included in total fruit intake, because the DGA 2010 stresses the importance of whole food sources (fresh, frozen, canned, and dried), rather than juice, because juice may contain less fiber and other important nutrients.¹ When juice is consumed, it should be 100% fruit or vegetable juice. The American Academy of Pediatrics recommends no >120 to 180 mL (4–6 ounces) of 100% juice daily for children 1 to 6 years of age.²² Intake of fried potatoes and pizza was not included in vegetable intake calculations because we wanted to assess healthier vegetable options. However, a sensitivity analysis was conducted including fried potatoes to determine whether inclusion would meaningfully change the results of the analyses. Our outcome categories for total fruit intake and for total vegetable intake at age 6 years were less than once daily, which we describe as “infrequent intake,” and 1 or more times daily. These categories were chosen because it was our intent to estimate the odds of low frequency of

intake. Once per day was the median fruit intake in this sample (median vegetable intake was 1.8 times daily).

Main Exposures

Our primary exposures were frequency of fruit intake during late infancy, age at fruit introduction, frequency of vegetable intake during late infancy, and age at vegetable introduction. During nearly each month of the first year of life, mothers were asked to report the times per day or week their infant ate fruits and vegetables over the previous 7 days, separately. Because our interest was frequency of fruit and vegetable intake once fruits and vegetable were introduced, we chose an indicator of intake during late infancy defined in our study as the frequency of intake at the 10.5-month questionnaire. We chose this cutpoint based on findings from previous analyses reporting that approximately 98% of infants in IFPS II had been introduced to fruits and vegetables by age 10.5 months.²³ For those infants who had missing data on fruit and vegetable intake at the 10.5-month survey, we were able to use the average of intake reported at the 9- and 12-month questionnaire to estimate intake at 10.5 months because we confirmed a linear relationship between age of infant (9 to 12 months) and fruit and vegetable intake in this study population. We excluded children if they were missing a response at 10.5 months and did not have a response for both the 9- and 12-month questionnaire ($n = 375$). Frequency of fruit and vegetable intake at the 10.5-month survey was categorized as less than once daily, between once daily and less than twice daily, and 2 or more times daily. These categories were chosen based on the 25th, 50th, and 75th percentiles of fruit and vegetable intake in the study sample.

Our analysis of age at introduction to fruits and vegetables was limited to

those respondents who had fruit and vegetable intake data, either for the 10.5-month questionnaire or at both the 9- and 12-month questionnaires. Age of introduction to fruit was calculated as the midpoint between the age of the infant when fruit was first reported as being eaten and the age on the previous questionnaire in which the mother did not report fruit being eaten. Age of introduction to vegetables was calculated similarly. We categorized introduction as <4 months, between 4 and <8 months, and at ≥ 8 months, based on the recommendation at the time of the survey that introduction of solid foods should not occur before 4 months²⁴ and previous analyses of this study population showing that 90% introduced fruits and vegetables by 7.5 months.²³

Analytic Sample

Our final analytic sample was 1078 respondents who had complete outcome data on fruit and vegetable intake at 6 years, exposure data of fruit and vegetable intake during late infancy and age at fruit and vegetable introduction, along with data on all covariates examined. The initial sample had 1542 respondents. We excluded 6 respondents because of missing data on fruit and vegetable intake at 6 years, 2 respondents because of outlying values of fruit and vegetable intake at age 6 years, 375 respondents because of incomplete data on fruit and vegetable intake during infancy, and an additional 81 respondents because of missing sociodemographic data. Respondents included in the final analytic sample were more likely to be older, non-Hispanic white, have more education, have higher income, not receive Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) benefits, be married, and have breastfed longer compared with those excluded from analyses.

Statistical Analyses

We used SAS 9.3 (SAS Institute, Inc, Cary, NC) to conduct statistical analyses. Initially, we examined the overall difference in the percent consuming fruits and vegetables by demographic characteristics using χ^2 test. Four separate regression analyses were conducted for each of the following exposures: frequency of fruit intake during late infancy, age at fruit introduction, frequency of vegetable intake during late infancy, and age at vegetable introduction for the corresponding outcome of fruit or vegetable intake at age 6 years. Models were adjusted for the following sociodemographic variables obtained from the baseline IFPS II: maternal age (in years) (18–25, 26–29, 30–34, 35+), race/ethnicity (non-Hispanic white, non-Hispanic black, Hispanic, other), maternal education (high school or less, some college, college graduate), poverty income ratio (0 to <185, 185 to <350, \geq 350%), receipt of WIC benefits during the infant's first year (yes, no), marital status (married, single), birth order (first-born, not first-born), gender of infant, birth weight of infant (low birth weight [$<$ 2500 g], normal birth weight [2500 to <4000 g], high birth weight [\geq 4000 g]), and gestational age of infant (\geq 37 weeks, <37 weeks). We also adjusted for duration of any breastfeeding (never breastfed, breastfed <3 months, breastfed 3 to <6 months, breastfed 6 to <12 months, and breastfed \geq 12 months) based on previous studies showing that breastfeeding increases acceptance of foods during infancy²⁵ and a study in this supplement that breastfeeding is associated with intake of fruits and vegetables at age 6 years.

RESULTS

Maternal reports of dietary intake of their children revealed that 31.9% of 6-year-old children consumed fruit less

than once daily and 19.0% consumed vegetables less than once daily. The prevalence of infrequent fruit intake varied by race/ethnicity, maternal education, and breastfeeding duration, whereas infrequent vegetable intake varied by gender and breastfeeding duration (Table 1).

The prevalence of infrequent fruit intake at 6 years of age, defined as less than once

daily, was 48.2% among children who consumed fruit <1 time daily compared with 37.2% among those who consumed fruit 1 to <2 times daily and 25.6% who consumed fruit 2 or more times daily during infancy. In unadjusted analyses, children who had an infrequent fruit intake (0 to <1 times per day) during infancy had 2.7 times the odds of having an infrequent fruit intake (0 to <1 times per

TABLE 1 Sample Characteristics by Fruit and Vegetable Intake at 6 Years of Age, IFPS II, 2005–2007 and Y6FU Study, 2012

	n	Fruit Intake at Age 6 y		Vegetable Intake at Age 6 y	
		\geq 1 time/d, %	0 to <1 time/d, %	\geq 1 time/d, %	0 to <1 time/d, %
Overall	1078				
Maternal age (y)					
18–25	177	16.5	16.3	16.4	16.6
26–29	288	28.5	23.0	27.0	25.4
30–34	367	32.4	37.5	33.3	37.1
35+	246	22.6	23.3	23.3	21.0
Race/ethnicity					
Hispanic	44	3.1	6.1 ^a	3.8	5.4
Non-Hispanic white	961	91.3	84.6	89.6	87.3
Non-Hispanic black	29	1.8	4.7	2.5	3.4
Other	44	3.8	4.7	4.1	3.9
Maternal education					
High school or less	164	13.8	18.3 ^a	14.9	16.6
Some college	356	29.6	40.4	32.7	34.6
College graduate	558	56.7	41.3	52.5	48.8
Poverty income ratio (%)					
0 to <185	353	30.7	37.2	32.2	35.1
185 to <350	414	39.5	36.1	39.4	34.2
\geq 350	311	29.8	26.7	28.4	30.7
Receipt of WIC benefits					
Yes	302	26.2	32.0	27.8	28.8
No	776	73.8	68.0	72.2	71.2
Marital status					
Married	931	87.5	84.0	86.6	85.4
Unmarried	147	12.5	16.0	13.4	14.6
Birth order					
First-born	307	29.6	26.2	28.5	28.3
Not first-born	771	70.4	73.8	71.5	71.7
Gender of infant					
Boy	535	49.9	49.1	47.0	61.0 ^a
Girl	543	50.1	50.9	53.0	39.0
Birth weight of infant					
Low birth weight	17	1.4	2.0	1.5	2.0
Normal birth weight	914	83.7	87.2	85.1	83.4
High birth weight	147	15.0	10.8	13.4	14.6
Gestational age of infant					
\geq 37 wk	1033	95.6	96.2	96.0	95.1
<37 wk	45	4.4	3.8	4.0	4.9
Breastfeeding duration					
Never breastfed	129	10.2	15.7 ^a	11.1	15.6 ^a
Breastfed <3 mo	242	19.4	29.1	21.5	26.3
Breastfed 3 to <6 mo	108	10.5	9.0	10.5	7.8
Breastfed 6 to <12 mo	289	27.4	25.6	25.8	31.2
Breastfed \geq 12 mo	310	32.6	20.6	31.0	19.0

^a $P < .05$ for χ^2 test of significance for categorical variables.

day) at age 6 years compared with those who had an intake of 2 or more times per day during infancy (95% confidence interval [CI], 1.77–4.11). This association remained significant after adjusting for covariates (adjusted odds ratio [aOR], 2.48; 95% CI, 1.59–3.88). Children who had a fruit intake between 1 to <2 times per day during infancy also had an increased odds of infrequent intake at age 6 years compared with those who had an intake of 2+ times per day (OR, 1.73; 95% CI, 1.31–2.28), an association that remained significant after controlling for multiple covariates (aOR, 1.67; 95% CI, 1.25–2.24) (Table 2). There was no association between infrequent fruit intake at age 6 years and age at fruit introduction in infancy in unadjusted or adjusted analyses.

The prevalence of infrequent vegetable intake of less than once daily was 38.1% among 6-year-old children who consumed vegetables <1 time daily compared with 26.6% and 21.4% among those who consumed vegetables 1 to <2 times daily and 2+ times daily during infancy, respectively. Children who had infrequent vegetable intake during infancy (0 to <1 times per day) had 2.2 times the odds of having low vegetable intake at age 6 years compared with those who had an intake of 2+ times per day (95% CI, 1.38–3.50). This association remained significant after adjustment for covariates (aOR, 2.48; 95% CI, 1.59–3.88). Additionally, the association between vegetable intake of 1 to <2 times per day during infancy and infrequent vegetable intake at age 6 years approached significance (Table 3). We found no association between the age at introduction of vegetables during infancy and infrequent vegetable intake at age 6 years (Table 3). Sensitivity analysis that included fried potatoes in the total vegetable measure intake yielded very similar findings (data not shown).

TABLE 2 Prevalence and Odds of Infrequent Fruit Intake Among 6-Year-Old Children by Frequency of Fruit Intake During Late Infancy and Age of Fruit Introduction, IFPS II, 2005–2007 and Y6FU Study, 2012

	Infrequent Fruit Intake at Age 6 y (0 to <1 Time/d)			
	<i>n</i>	%	OR (95% CI)	aOR ^a (95% CI)
Fruit intake during late infancy				
0 to <1 times/d	108	48.2	2.70 (1.77–4.11)	2.48 (1.59–3.88)
1 to <2 times/d	376	37.2	1.73 (1.31–2.28)	1.67 (1.25–2.24)
2+ times/d	594	25.6	Reference	Reference
Age at fruit introduction				
0 to <4 mo	123	42.3	1.54 (0.81–2.92)	1.45 (0.73–2.87)
4 to <8 mo	893	30.5	0.92 (0.55–1.60)	1.02 (0.57–1.84)
8+ months	62	32.3	Reference	Reference

^a Adjusted for maternal age, race/ethnicity, maternal education, poverty income ratio, receipt of WIC benefits, marital status, birth order, gender, birth weight, and gestational age of infant, and breastfeeding duration.

DISCUSSION

We found that ~1 in 3 6-year-old children consumed fruit less than once daily and ~1 in 5 consumed vegetables less than once daily. After adjustment for several factors, children in our study who consumed fruits and vegetables less than once daily during late infancy had a 2.5 times higher odds of eating fruit, and 2.4 times higher odds of eating vegetables less than once daily at age 6 years. These findings highlight the importance of infant feeding guidance that encourages the intake of fruits and vegetables.

Our finding from a national cohort of infants that the infrequent intake of fruits and vegetables during infancy is associated with intake in childhood is consistent with 2 previous, yet smaller, studies.^{17,18} There are several possible

explanations for these findings. Infants consuming fruits and vegetables more frequently during late infancy may have been offered fruits and vegetables more frequently, establishing a taste preference and familiarity for fruits and vegetables that continued into childhood. Studies have shown that repeated exposure to foods increases acceptance of foods during infancy.^{26–29} One study found that child food neophobia, the rejection of unfamiliar foods, was independently associated with lower fruit and vegetable intake at 2 to 6 years of age.¹⁹ However, we cannot discern from the IFPS II whether infants who consumed fruits and vegetables less frequently were exposed to or offered fruits and vegetables less frequently and therefore did not develop a preference for or familiarity

TABLE 3 Prevalence and Odds of Infrequent Vegetable Intake Among 6-Year-Old Children by Frequency of Vegetable Intake During Late Infancy and Age of Vegetable Introduction, IFPS II, 2005–2007 and Y6FU Study, 2012

	Infrequent Vegetable Intake at Age 6 y (0 to <1 Time/d)			
	<i>n</i>	%	OR (95% CI)	aOR ^a (95% CI)
Vegetable intake during late infancy				
0 to <1 times per day	113	38.1	2.20 (1.38–3.50)	2.40 (1.48–3.90)
1 to <2 times per day	395	26.6	1.40 (1.00–1.95)	1.42 (1.01–1.99)
2+ times per day	570	21.4	Reference	Reference
Age at vegetable introduction				
0 to <4 mo	96	19.8	0.97 (0.42–2.21)	0.63 (0.26–1.50)
4 to <8 mo	928	18.9	0.91 (0.46–1.80)	0.74 (0.36–1.51)
8+ months	54	20.4	Reference	Reference

^a Adjusted for maternal age, race/ethnicity, maternal education, poverty income ratio, receipt of WIC benefits, marital status, birth order, gender, birth weight, and gestational age of infant, and breastfeeding duration.

with fruits and vegetables. If the offering of fruits and vegetables was similar in both groups, intake may have differed owing to parental modeling or intake of fruits and vegetables. Previous studies have shown that parental fruit and vegetable intake is associated with children's intake.^{19,30–32} Parents who offer more fruits and vegetables to their children may be modeling their own healthy dietary behaviors, which are known to influence children's intake of healthier foods.^{33,34} These potential explanations described above are not mutually exclusive, and we do not have enough information to identify which factors, either separately or in combination, may explain our findings. A study by Cooke et al showed that age at introduction to fruit and age at introduction to vegetables was inversely correlated with frequency of fruit intake in early childhood and the frequency of vegetable intake in early childhood, although the magnitude of the associations were small (fruit, $r = -0.13$, $P < .005$; vegetables, $r = -0.10$, $P < .05$).¹⁹ We did not find an association with either age at introduction of fruits or vegetables to intake at age 6 years. A sensitivity analysis of age at introduction using the categories of <4 months, 4 to <6 months, and ≥ 6 months yielded consistent findings.

Breastfeeding status may play a role in dietary intake, as infants are exposed to flavors after birth, but before complementary feeding, through mother's milk.³⁵ Previous research suggests

that infants who are breastfed may be more likely to accept new foods once complementary foods are introduced, potentially owing to the varied flavors found in breast milk compared with the consistent flavor of formula.^{19,23} The study by Perrine et al in this supplement reports a positive association between breastfeeding duration and exclusivity and fruit and vegetable intake at age 6 years, controlling for covariates. In our study, our primary models assessing the association between infant and child intake of fruits and vegetables remained significant when including breastfeeding duration. These results suggest an independent relationship between the frequency of fruit and vegetable intake during infancy and early childhood.

There are several strengths to this study. First, IFPS II is the largest national longitudinal study of mother-infant dyads on infant feeding practices. Second, the potential for recall bias was reduced in this study as detailed dietary information was collected nearly monthly during infancy using a 7-day recall of the infant's intake. Third, diet was reassessed at age 6 years using an instrument closely modeled on the NHANES dietary screener questionnaire. However, this study also has several limitations. The study is not nationally representative and minority populations are underrepresented. Six-year follow-up data were available on 52% of children who participated in the infant study, which further reduced the

representativeness of the linked data set, as reported by Fein et al in a separate article in this supplement. We do not have information on dietary intake between age 1 and 6 years, but studies suggest that dietary preferences and behaviors track through childhood.^{16,18} Also, although the dietary screener used in this study is modeled on the NHANES dietary screener that has been cognitively tested among adults, it has not been validated for use among children. Finally, because this survey uses a frequency screener, it is not possible to determine the association between servings of fruits and vegetables consumed in late infancy and servings of fruits and vegetables consumed at age 6 years. However, it seems reasonable to assume that a higher frequency of intake correlates with a greater amount of fruits and vegetables consumed.

CONCLUSIONS

Our study indicates that an infrequent intake of fruits and vegetables during late infancy is associated with an infrequent intake of these foods at 6 years of age. In addition to highlighting the importance of infant feeding guidelines, this study highlights the need to examine factors that impact fruit and vegetable intake during late infancy so that health care providers, early care and education staff, and other childcare providers can provide support to parents during complementary feeding.

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