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CURRENT DEVELOPMENTS IN NUTRITION

Fruit and Vegetable Consumption of US Adults by Level of Variety, What We Eat in America, NHANES 2013–2016

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ABSTRACT

Background: Dietary guidance encourages consuming a variety of fruit and vegetables (FVs), which has been associated with higher FV intake and nutrient adequacy. Dietary intake of adults in the United States has not been described in the context of variety.

Objectives: The objective of this study was to describe FV consumption of adults in the United States by level of FV variety.

Methods: One day of dietary intake data of adults aged ≥20 y (n = 10,064) in What We Eat in America, NHANES 2013–2016 were used. FV variety was the count of foods consumed that contributed to total FV intake. Each FV was counted only once; a mixed dish counted as 1. Variety levels were high (≥5 items, n = 2316); moderate (3–4 items, n = 3423); or low (1–2 items, n = 3746). Differences between each level of variety were compared by t test.

Results: Among the low, moderate, and high levels, total FV intakes were 1.4, 2.6, and 4.4 cup equivalents (CE), respectively. CE amounts of FVs consumed were 0.3, 0.6, and 1.4 of vegetables excluding potatoes; 0.2, 0.3, and 0.3 of potatoes; 0.3, 0.6, and 1.2 of fruit; and 0.4, 0.4, and 0.5 from mixed dishes, respectively; percentages of each level reporting intake were 34%, 64%, and 89% for vegetables excluding potatoes; 23%, 34%, and 32% for potatoes; 22%, 49%, and 75% for fruit; and 72%, 71%, and 72% for mixed dishes, respectively.

Conclusions: Those with more variety of FV intake include whole FVs more frequently and in higher amounts. These results support suggestions for encouraging more FVs at snacks and as side dishes and salads at meals to increase total intake. *Curr Dev Nutr* 2020;4:nzaa014.

Keywords: fruit and vegetable intake, variety, What We Eat in America, NHANES, dietary guidance, adults, salads, fruit and vegetable side dishes

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Abbreviations used: CAD, coronary artery disease; CE, cup equivalents; CVD, cardiovascular disease; FNDDS, Food and Nutrition Database for Dietary Studies; FV, fruit and vegetable; WWEIA, What We Eat in America.

Introduction

The health benefits of fruit and vegetable (FV) intake have been attributed to the micronutrients, dietary fiber, and other bioactive components they contain (1, 2). Amounts of these components vary among FVs and optimal requirements for health are not yet known. Therefore, dietary guidance encourages variety to enhance intake. A variety of FVs in the diet has been associated with higher total FV intake (3–6), and therefore higher intakes of micronutrients (3) and nutrient adequacy (7–9). Meeting recommendations for FV consumption has also been associated with higher phytonutrient intakes (10, 11). Although variety was not a component of the analyses in these studies, it is notable that 1 or 2 foods contributed to most of the intake of several phytonutrients, suggesting a lack of variety (11).

Few studies have evaluated relations between chronic disease risk and variety of intake, independent of quantity. In 2 cross-sectional studies, FV variety but not quantity was associated with reduced risk of inflammation (12, 13) and cognitive decline (14). In 1 prospective cohort study, those in the highest tertile of FV variety had a lower risk of type 2 diabetes than those in the lowest tertile (15); quantity of vegetable but not fruit intake was also associated with lower risk. In EPIC (the European Prospective Investigation into Cancer and Nutrition), reduced risk of some cancers was observed with FV variety (16) and, among current smokers, with vegetable variety (17). However, no relations were observed with colon or rectal cancers in this cohort (18). Although other prospective cohort studies did not observe relations between FV variety and reduced risk of coronary artery disease (CAD) (4, 19), a cross-sectional analysis of NHANES data did find an inverse association between vegetable variety and prevalent CAD but not prevalent cardiovascular disease (CVD) or mortality from CVD and CAD (6).

Associations between specific types of FVs and chronic disease risk also suggest potential health benefits of FV variety. Intakes of dark green vegetables and green leafy vegetables were associated with lower risk of CAD (4, 6) and lipid parameters (9), whereas other studies observed

relations with deep orange FVs (19), β-carotene-rich FVs (4), and yellow FVs (9). Similarly, colorectal cancer risk was reduced with intake of orange/yellow, red/purple, and white, but not green FVs (20), whereas Brassica and cooked leafy greens were associated with lower risk of colon but not rectal cancer (21). Taken together, results of these studies suggest that variety of FV intake potentially has important health benefits beyond contributing to nutrient adequacy.

FV consumption by adults in the United States is below recommendations (22–24). Further, the variety of their FV intake needs improvement (25). In laboratory studies, providing a variety of vegetables (26, 27) resulted in higher intakes. Interventions that incorporated the concept of variety also showed increases in FV intake (28, 29). Dietary guidance encourages variety, but FV intake of adults in the United States has not been evaluated within that context. Therefore, the purpose of this study was to describe FV intake of US adults using the What We Eat in America (WWEIA) (30) food categories and to compare intake by variety level.

Methods

Estimates are based on 1 d of dietary intake data from 10,064 adults aged ≥20 y (5235 females and 4829 males) that provided a complete 24-h recall in WWEIA, NHANES 2013–2016 (31, 32). The NHANES sample was designed to be representative of the civilian noninstitutionalized US population, with oversampling of non-Hispanic blacks, non-Hispanic Asians, Hispanics, adults aged 80 y and older, and low-income persons to improve the accuracy of estimates of health status indicators for these population subgroups (33). The NHANES protocol was approved by the National Center for Health Statistics Research Ethics Review Board (CDC, 2015). Because this study was a secondary analysis of NHANES data, which are publicly available, institutional review board approval was not needed or obtained, the study being exempt from further review under Title 45 Code of Federal Regulations section 46.101(b). For NHANES, written informed consent was obtained from all participants. The survey protocol was approved by the US Department of Health and Human Services, CDC, National Center for Health Statistics, Research Ethics Review Board.

Dietary intake data collection and coding

Dietary intake data from one 24-h recall were collected in person by trained interviewers using the USDA Automated Multiple-Pass Method (34). All foods were coded using the USDA Food and Nutrient Database for Dietary Studies (FNDDS), which is the database of >7000 foods and beverages, their nutrient values, and weights for typical portions used to process data from WWEIA, NHANES. Data were coded using FNDDS 2013–2014 and FNDDS 2015–2016 (USDA-Agricultural Research Service, 2016 and 2018, respectively) (35). Total FV intakes and intakes from the WWEIA Food Categories were determined using the Food Patterns Equivalents Database (2016) (36), which provides the cup equivalent (CE) amount of fruit and/or vegetable in a food.

FV variety level classification

FV variety was the count of unique foods that contributed to total FV intake. To be counted, minimal amounts consumed were ≥0.1 CE FV of each single FV item and ≥0.2 CE FV from a mixed dish. Each FV was counted only once, and a mixed dish counted as 1 FV. Individuals were classified by variety of intake as high (≥5 items), moderate (3–4 items), low (1–2 items), or none (0 items). These cutoffs were chosen because upon review of frequencies and distribution of the data, the numbers in each group most closely approximated tertiles of intake.

Statistical analysis

Analyses were carried out using SAS version 9.4 software (SAS Institute Inc.) (37). SUDAAN version 11.0 (Research Triangle Institute) (38) was used to adjust for survey design effects resulting from NHANES' complex, multistage probability sampling. In all analyses, sample weights were used to produce nationally representative estimates (31, 32). To describe foods contributing to FV intake by each variety level, the percentage reporting intake, percentage contribution, and the mean amounts consumed from the WWEIA Food Categories were determined. All comparisons were made using *t* tests; those in the "none" group ($n = 579$) were not included in the analyses. Unadjusted results are presented because adjusting for energy, sex, age, and race/ethnicity did not change the significance of the results (data not shown).

Results

Distribution of FV intake by adults among the low, moderate, and high levels of variety score was 37%, 34%, and 23%, respectively; 5% of adults did not consume any FVs on the reporting day. As previously reported (39), there were higher percentages in the low variety level of 20- to 29-y-olds compared with ≥60 y; non-Hispanic blacks and other race/ethnic groups compared with non-Hispanic whites, Hispanics, and non-Hispanic Asians; those at ≤350% Poverty Income Ratio compared with >350%; those with some college education or less compared with the college educated; and among smokers compared with nonsmokers, but no differences by weight status. The reverse was observed in the high level for race/ethnicity, income, education, smoking status, and weight status, but not age. There were no differences in demographic characteristics among those within the moderate level. Also, there were no differences by gender within any of the variety levels.

Table 1 shows that as variety level went from low to high, there were increases in the total number of foods and beverages reported, energy intake, and CE intake of FVs, both total and per 1000 kcal energy intake. Mean differences between the groups were significant ($P < 0.001$). The ranges of intake within each level were wide, with some overlap of intakes between the 3 levels resulting primarily from large amounts of FVs being consumed regardless of variety count.

The primary difference between the 3 variety levels was related to FV consumption from the "Fruit" and the "Vegetables (excluding potatoes)" food categories. As **Figure 1** shows, larger amounts of FVs were consumed from these food categories as variety level went from low to high. The foods in these categories include items not in mixtures such as side dishes, salads, and FVs added to sandwiches or consumed as snacks. Although FVs from "Mixed dishes" were higher among the moderate and high variety levels than among the low, the differences were small.

TABLE 1 Dietary intake of US adults by FV variety level, What We Eat in America, NHANES 2013–2016[1]

	All	Low (1–2 items)	Moderate (3–4 items)	High (≥5 items)
N	10,064	3746	3423	2316
Energy, kcal	2123 ± 14.0	1954 ± 17.1[a]	2215 ± 22.1[b]	2339 ± 26.9[c]
Total foods/beverages	16.1 ± 0.2	12.9 ± 0.1[a]	16.7 ± 0.1[b]	21.2 ± 0.2[c]
FV variety count	3.3 ± 0.05	1.6 ± 0.01[a]	3.4 ± 0.01[b]	6.3 ± 0.05[c]
Fruit variety count	1.0 ± 0.03	0.4 ± 0.01[a]	1.0 ± 0.01[b]	2.0 ± 0.05[c]
Vegetable variety count	2.3 ± 0.03	1.2 ± 0.02[a]	2.5 ± 0.02[b]	4.3 ± 0.05[c]
Total FV intake, CE	2.5 ± 0.4	1.3 ± 0.02[a]	2.6 ± 0.03[b]	4.4 ± 0.07[c]
Range, CE	0–31	0.1–10	0.5–31	0.9–23
Per 1000 kcal	1.27 ± 0.02	0.81 ± 0.02[a]	1.4 ± 0.02[b]	2.1 ± 0.04[c]
Total fruit intake, CE	0.9 ± 0.03	0.4 ± 0.02[a]	1.0 ± 0.03[b]	1.8 ± 0.05[c]
Range, CE	0–9.6	0–10	0–19	0–20
Per 1000 kcal, CE	0.5 ± 0.01	0.3 ± 0.01[a]	0.5 ± 0.02[b]	0.9 ± 0.03[c]
Total vegetable intake, CE	1.5 ± 0.02	0.9 ± 0.02[a]	1.7 ± 0.02[b]	2.6 ± 0.05[c]
Range, CE	0–13	0–9	0–13	0.1–13
Per 1000 kcal, CE	0.8 ± 0.1	0.5 ± 0.01[a]	0.8 ± 0.01[b]	1.24 ± 0.03[c]

[1]Values are means ± SEs unless otherwise indicated. Within each food category, values without a common letter are significantly different, $P < 0.001$. CE, cup equivalent; FV, fruit and vegetable.

Figure 2 shows differences between the 3 levels in percentages reporting intake from the WWEIA food categories. Again, the largest differences were in the percentages reporting intake from the "Fruit" and the "Vegetables (excluding potatoes)" categories, which were significantly different between all 3 variety levels. Percentages reporting 100% juice were also significantly different between the 3 groups.

There were no differences between levels in the percentages who reported intake from "Mixed dishes." **Figure 3** shows that the proportion of intake from "Mixed dishes" decreased as variety level went from low to high, whereas foods from the "Fruit" and the "Vegetables (excluding potatoes)" food categories contributed larger amounts as variety level went from low to high. There were no differences between variety levels in the contributions to FV intake by snacks and sweets, sweetened beverages, and condiments and sauces, which together accounted for 11% (data not shown); most of these foods did not count toward the variety count because they did not meet study criteria.

Discussion

Consistent with observations from other studies, this study showed that consuming a variety of FVs was positively associated with total FV intake. Although this relation may seem intuitive, the differences between the variety levels are informative, and further support promoting variety of FV intake to increase consumption.

A key behavior that distinguishes intake between each level is the inclusion of FVs as side dishes or salads, on sandwiches, or as snacks. As variety level went from low to high, the contribution of the "Fruit" and the "Vegetables (excluding potatoes)" food categories to total FV intake increased, as did the percentage who reported intake of foods from them. However, percentages reporting intake and mean amounts of FVs from "Mixed dishes" were similar between levels. Several other analyses of NHANES data have also shown positive relations between total FV intake and including FVs as side dishes at meals and/or as

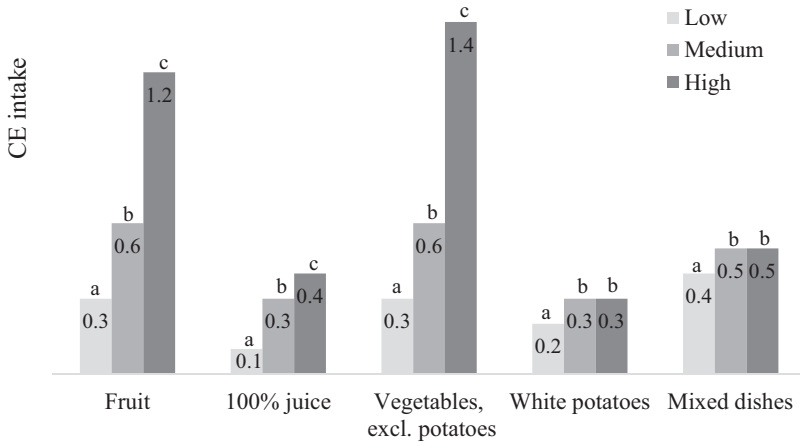

FIGURE 1 Mean CE intake of fruit and vegetables from WWEIA food categories among US adults by variety level, WWEIA, NHANES 2013–2016. Within each food category, values with different letters are significantly different, $P < 0.001$. CE, cup equivalent; WWEIA, What We Eat in America.

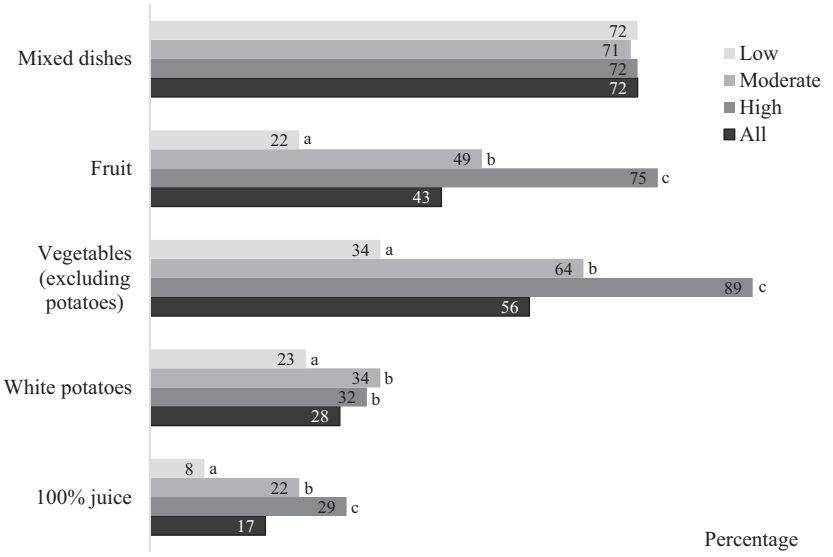

FIGURE 2 Percentage of adults reporting intake from WWEIA food categories by variety level, WWEIA, NHANES 2013–2016. Within each food category, values with different letters are significantly different, $P < 0.001$. WWEIA, What We Eat in America.

snacks. In 1 study, a higher percentage of adults who met recommendations for FV intake consumed vegetables raw or alone (not as an ingredient) and a smaller proportion obtained vegetables from other forms, which included mixed dishes (40). Consuming salad was also associated with better nutrient intakes than in salad nonreporters (41), as well as higher total FV intake and greater odds of meeting FV recommendations among adults (42). Dietary guidance promotes these behaviors as strategies for making FVs "half the plate" and these results show their potential impact on total FV intake.

The differences in total FV intakes between the variety levels were generally not a result of portion sizes. When consumed, the mean amounts of individual FVs were not different between levels. For instance, among the low, moderate, and high levels, the mean CE amount consumed among individuals who reported apples (including applesauce and dried apples) was 1.6, 1.5, and 1.5 and the mean CE intake of tomatoes (including raw and cooked, but not sauce) was 0.3, 0.4, and 0.4 CE, respectively (data not shown). However, it should be noted that the ranges in total FV intake among the 3 levels were wide with some

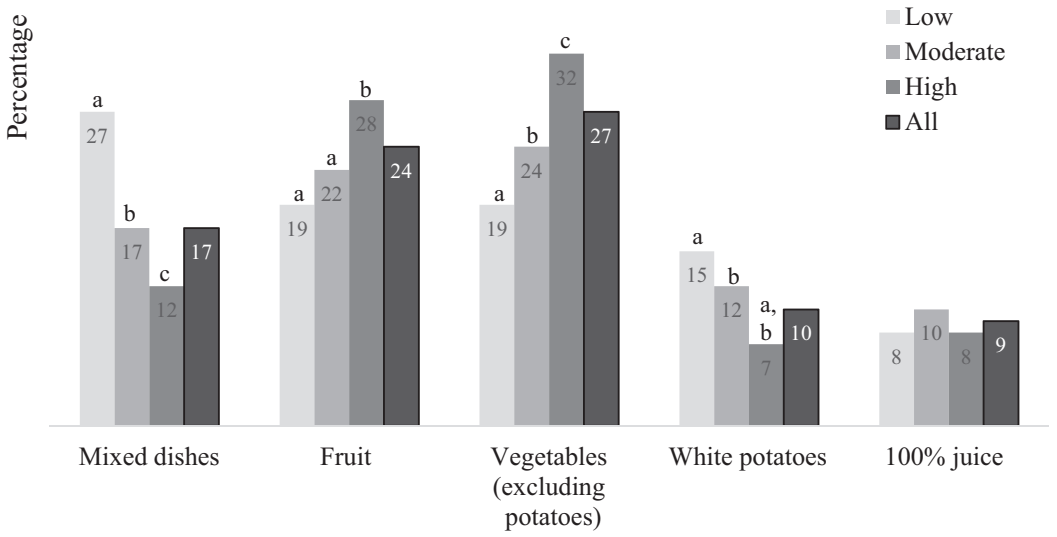

FIGURE 3 Percentage contribution of WWEIA food categories to intake of fruit and vegetables by variety level, WWEIA, NHANES 2013–2016. Within each food category, values with different letters are significantly different, $P < 0.001$. WWEIA, What We Eat in America.

overlapping of amounts consumed. Criteria used for counting variety allowed some items consumed in smaller amounts to be included. We chose to count small amounts toward variety because some food items that are frequently consumed such as salads may include a variety of different FVs. In addition, the FV intakes of the bottom percentile of individuals within the low, moderate, and high variety levels were 0.21, 0.78, and 1.37 CE, respectively. Thus, only a small number of individuals in the low variety level had very low intakes. Extreme total FV intakes among those at the high end of the ranges were due to consumption of large amounts of 1 or 2 items, such as smoothies. Some mixed items such as smoothies were counted as 1 item but may contain >1 fruit and/or vegetable, so variety may have been underestimated by the method used in this study, particularly among those in the low and moderate levels. However, the number of these instances is small, and not likely to influence the observed relations between variety and FV intake.

The increases in energy intake among the low to high levels were not accounted for solely by the higher number of FVs. As FV variety increased, there was a corresponding increase in the total number of food items, and higher percentages reported intake from all food categories. Dietary variety within food groups has been positively associated with higher energy intake, which appears to be related to the variety of energy-dense foods consumed including sweets, snacks, entrées, condiments, and carbohydrates (43). High intake of these energy-dense foods together with low vegetable variety was positively associated with body fatness, whereas having a higher variety of vegetable intake was inversely associated (43, 44). In this study, mean amounts consumed from the condiments, snacks and sweets, and sweetened beverages food categories were also higher among those in the high than among those in the moderate and low levels. But those in the high level included a significantly higher proportion of individuals who were normal weight and a lower proportion of obese. It is not possible to draw inferences from these results because 1 d of dietary intake data is not sufficient to evaluate relations between energy intake and body weight. More research would be required to understand these discrepancies.

Despite differences in energy intake between variety levels, limited research does not support that increasing FV intake through greater variety and/or amounts has a major effect on energy intake or body weight. In a meta-analysis of studies that promoted increased FV consumption without specifically decreasing intake of other foods, weight gain was not observed in the short term. In fact, results suggested there may be a small weight loss or reduced weight gain with increased FV consumption. There was also no difference in energy intake when comparing low with high FV intake (45). A meta-analysis of similar intervention studies also found no difference in energy intake between the intervention and control groups (46). These analyses included studies that measured intake over the course of an intervention period, so estimates may have been a better reflection of energy intake and body weight changes.

Encouraging variety to promote increased vegetable consumption is not original. However, few studies have reported about the effectiveness of this message. Several studies found that although participants were aware of the 5-a-day fruit and vegetable message in the United Kingdom, there was less understanding of the need for a variety of FVs (47, 48) as well as confusion about how to incorporate variety of FVs in the diet (48). Intervention studies that have promoted variety by encouraging intake of different colors of FVs each day showed modest increases in intake among parents and children (49), low-income young adults (50), and older adults (28). It is noteworthy that among those in the high variety level, mean intakes per 1000 kcal of fruit (0.9 CE) and of vegetables (1.24 CE) met the targets in Healthy People 2020 (0.93 and 1.16 CE, respectively) (51). Innovative messages are needed to effectively communicate what it means to consume a variety of FVs and practical ways to do it.

A strength of this study is that results are from a nationally representative sample, and thus are generalizable to the civilian noninstitutionalized population of US adults. These nationally representative estimates result from the NHANES sample design (33) and the application of dietary sample weights (31, 32), which include an adjustment for day of the week as well as adjustments for the basic probability of selection and for nonresponse. However, there are several limitations to consider when interpreting the results. As previously mentioned, the criteria used to count variety may have incorrectly classified some individuals in the low and moderate levels. Mixed dishes were counted as 1 item whereas they may have included more. Also, a single 24-h intake per sample person is only a snapshot of FV intake by US adults on any given day of the year, but it does not address the long-term or usual consumption of FV. However, 1 d of dietary intake is adequate for estimating mean intake among groups and comparing mean intake between groups (52) and it is satisfactory for describing the dietary intake of the population.

In conclusion, greater variety of FVs in the diet is associated with higher total FV intake. Those with more variety tended to consume whole FVs more frequently, resulting in greater intakes. These results show the beneficial impact on FV intake of including a variety of FV items each day, and support suggestions for boosting intake by choosing FVs at snacks, adding FVs to mixed dishes, and including vegetable side dishes and salads at meals.

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