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Canned Vegetable and Fruit Consumption Is Associated with Changes in Nutrient Intake and Higher Diet Quality in Children and Adults: National Health and Nutrition Examination Survey 2001-2010

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Canned Vegetable and Fruit Consumption is Associated with Changes in Nutrient Intake and Higher Diet Quality in Children and Adults: National Health and Nutrition Examination Survey 2001-2010

ABSTRACT

Background: Canned vegetables and fruit (CV+CF) are ubiquitous throughout the food supply. Yet information regarding their specific contribution to nutrient intake and health measures is lacking.

Objective: The objective of this study was to examine the association of CV+CF with nutrient intake, diet quality, anthropometric indicators of overweight/obesity and blood pressure in a nationally representative population.

Design and participants: A secondary analysis of cross-sectional data from 17,344 children and 24,807 adults in the National Health and Nutrition Examination Survey 2001-2010 was conducted. A dataset was developed that distinguished CV+CF consumers from non-consumers.

Main outcome measures: Diet quality was calculated using the Healthy Eating Index (HEI)-2010.

Statistical analyses: Regression analysis determined differences between groups.

Results: About 11% of the population consumed CV+CF on a given day. Compared to non-consumers, child (n=2,066) and adult (n=2,746) CV+CF consumers ate more energy, and energy adjusted dietary fiber, total sugar, choline, and potassium, and less fat and saturated fat. Child consumers also ate more energy adjusted protein, vitamin A, calcium and magnesium. Child and adult consumers and non-consumers had comparable energy adjusted sodium and added sugar intakes. Compared to non-consumers, the total HEI-2010 score was higher ($P<0.001$) in child (45.8 ± 0.5 vs. 43.3 ± 0.3) and adult consumers (49.0 ± 0.4 vs. 47.4 ± 0.3). Covariate adjusted

body weight, body mass index, waist circumference and blood pressure were comparable in both of the child and adult groups.

Conclusions: Results suggest CV+CF consumption was associated with improved intake of select nutrients, a higher quality diet, and comparable adiposity measures and blood pressure.

INTRODUCTION

The 2010 Dietary Guidelines for Americans (DGA)[1] recommend maintenance of caloric balance to achieve and sustain a healthy weight. The Guidelines also recommend increased consumption of nutrient-dense foods and beverages (such as vegetables, fruits, whole grains, low- or fat-free milk products, lean proteins, eggs, beans and peas, and nuts and seeds), while limiting consumption of foods that provide too much sodium, solid fats, and added sugars.[1] Consuming a healthful diet, in general, and consuming vegetables and fruits, in particular, helps to provide adequate dietary intake of "nutrients of concern" – vitamin D, calcium, potassium, and dietary fiber,[1] and nutrients identified by the Dietary Guidelines Advisory Committee as "tenuous for adult men and women" – vitamins A, C, E, and K, choline, and magnesium.[2] Consumption of vegetables and fruits is also associated with health benefits.[1] Longitudinal studies suggest that a greater intake of vegetables and/or fruits may protect against adiposity in children and adolescents.[3] In adults, there is a modest inverse association between vegetable and fruit intake and body weight,[4] and myocardial infarction and stroke.[5] Some vegetables and fruits may reduce the risk of breast, lung, colorectal or prostate cancer.[1]

The recommended intake for vegetables and fruits depends on age, sex and physical activity and ranges from 1 to 3 cups per day for vegetables and from 1 to 2 cups per day for fruits.[6] All vegetables and fruits, including 100% vegetable and fruit juices count towards

intake. Vegetables and fruits may be canned, fresh, frozen, or dried/dehydrated; they may be consumed raw or cooked; and they may be whole, cut-up, mashed or pureed.[6] Although the majority of vegetables and fruits consumed by Americans are fresh,[7] the Academy of Nutrition and Dietetics (AND) promotes the total diet approach to healthy eating,[8] a position supportive of the 2010 DGA. Noting that most Americans fail to meet DGA recommendations for vegetables and fruits,[9-12] the Academy encourages food and nutrition practitioners to recommend, along with fresh forms, inclusion of frozen, canned, and dried forms of vegetables and fruits, which have similar nutrient profiles,[13-15] but may offer consumers additional benefits with respect to cost, seasonality, storage, and transport.[8,13]

Studies have examined associations of whole vegetables and fruits,[16-18] individual vegetables and fruits,[19-22] dried fruits,[23] and 100% fruit juices[24-25] with nutritional or health outcomes. Little is known about the overall effect that consumption of canned vegetables and fruit (CV+CF) has on nutrient intake, dietary quality, and health measures. The purpose of this study was to determine, using National Health and Nutrition Examination Survey (NHANES) 2001-2010, the association of CV+CF with nutrient intake, diet quality, anthropometric indicators of overweight/obesity and blood pressure.

METHODS

Study Population

This study involved analyses of cross-sectional data from US children aged 2 to 18 years (17,344) and adults aged ≥19 years (24,807) participating in the 2001-2002, 2003-2004, 2005-2006, 2007-2008 and 2009-2010 NHANES. The data from these five cycles were merged to increase sample size. The study population was limited to participants with complete, reliable 24-hour dietary recall data. Pregnant or lactating females were excluded. Details of NHANES

study design, implementation, datasets, analytic considerations, and other documentation are available online.[26-30] As described therein, following administration of a series of questionnaires in a detailed in-home interview, participants visit a Mobile Examination Center where in-person health examinations and a dietary interview, commonly referred to as the What We Eat in America (WWEIA) component of the NHANES was conducted. All participants or proxies provided written informed consent and the Research Ethics Review Board at the National Center for Health Statistics approved the survey protocol.[31]

Collection of Dietary Intake Data

Dietary intake data were obtained from multi-pass, in-person, 24-hour dietary recall interviews, conducted by experienced interviewers with the use of a computer-assisted dietary interview system.[32-33] For the years when two 24-hour recalls were publicly available, only the first day of the dietary recall data were used. Parents/guardians of children aged 2 to 5 years provided the dietary recalls, and assisted children aged 6 to 11 years. Children aged 12 to 18 years self-reported intake. Descriptions of interview methods are available in the NHANES Dietary Interviewer's Training Manual, which includes pictures of the computer-assisted dietary interview system screens, measurement guides, and charts used to collect dietary information.[34]

Canned Vegetable and Fruit Consumption and Nutrient Intake Data

The USDA Food and Nutrient Database for Dietary Studies is updated for each 2-year cycle of What We Eat in America. The versions corresponding to NHANES 2001-2002, 2003-2004, 2005-2006, 2007-2008 and 2009-2010[35-39] were used to code, process, and analyze these data for nutrient content. Almost 7,000 foods from all food groups, including their source (e.g., from fresh, frozen or canned) and method of preparation (e.g., cooked or raw; with added salt) were included. Each food is identified by a unique 8-digit code. The first digit identifies one of

the nine major food groups. In this initial examination of intake of CV+CF, we focused on canned food products available in traditional metal cans. As such, canned vegetables were defined as all items, including tomatoes, beginning with the food code 7 that were listed as "cooked, from canned" (i.e., beans, string, green, cooked, from canned), "canned" (i.e., corn, yellow, canned), or "from canned" (i.e., corn, yellow, from canned, cream style). Spaghetti sauce, tomato sauce, tomato paste, and black olives were included as canned vegetables. Canned fruits were comprised of all items beginning with the food code 6 that were listed as either "cooked or canned" (i.e., peach, cooked or canned), or "canned or frozen" (i.e., orange, mandarin, canned or frozen). The only fruit included as canned that was not listed as such was cranberries, which was listed as "NS as to raw, cooked, or canned" (in addition to being listed as "cooked or canned"). Exclusions to the CV+CF category included all fruit and vegetable juices (listed as canned, bottled or in a carton or as juice), all soups (even if listed as canned), and all mixed dishes containing vegetables. Salsa, pickles, relish, all legumes, and applesauce were also excluded. Participants were classified as CV+CF consumers based on their reported consumption of at least one item classified as a canned vegetable or a canned fruit. We focused analyses on energy, macronutrients (protein, total fat, saturated fat, monounsaturated fat, dietary fiber, total sugars, and added sugars) and nutrients mentioned in the 2010 DGA as over consumed or possibly a concern for under consumption for at least some population groups (vitamin A, vitamin D, choline, folate, calcium, iron, sodium, and potassium). Additionally we calculated the molar ratio of sodium and potassium.

The Healthy Eating Index-2010

The Healthy Eating Index (HEI) was used to determine diet quality.[40-42] The HEI-2010 is an updated version that reflects the 2010 DGA and includes 12 components. Nine components

assess dietary adequacy (Total Fruit; Whole Fruit; Total Vegetables; Greens and Beans; Whole Grains; Dairy; Total Protein Foods; Seafood and Plant Proteins; and Fatty Acids Ratio) and three assess dietary components that should be consumed in moderation [Refined Grains; Sodium; and Empty Calories (energy from solid fats, alcohol, and added sugars; SoFAAS)]. Higher intake for the adequacy components and lower intake for the moderation components indicate better compliance with the DGA and result in higher scores. The total score (which has a maximum value of 100) is a measure of overall diet quality in terms of dietary intake per 1,000 kcal.[43] The SAS code used to calculate HEI-2010 scores was downloaded from the Center for Nutrition Policy and Promotion website.[44]

Anthropometric and Physiologic Measures

Measurements of standing height, weight, and waist circumference were taken in the Mobile Examination Center by trained staff, according to NHANES protocol.[45] Body mass index was calculated as body weight (in kilograms) divided by height (in meters squared) (kg/m^2).[46] Waist circumference was measured at the mid-axillary line of the body to the nearest 0.1 cm.[45] The average of multiple blood pressure measurements were taken in a sitting position using typically the right arm for those $\geq$ 8 years.[47]

Demographics and Physical Activity

Demographic information, including age, sex, race/ethnicity, poverty income ratio (PIR), physical activity, smoking status, and alcohol consumption was collected during household interviews. For race/ethnicity, all individuals were included in the analyses, but since NHANES only has nationally representative data for non-Hispanic white, non-Hispanic black, and Mexican Americans for data prior to 2007, these classifications were the ones used in this study. The PIR is the ratio of income (before taxes, excluding capital gains and non-cash benefits such as SNAP)

to the family's appropriate poverty threshold. A PIR value < 1.00 means the family is below the official poverty threshold. Physical activity was classified as sedentary, moderate activity or active based on self-report. Subjects reporting 7 "days active at least 60 minutes in the past 7 days" or responding affirmatively to the two questions about vigorous recreational or work related activity were classified as being active; subjects reporting between 4 and 6 "days active at least 60 minutes in the past 7 days" or responding affirmatively to the two questions about moderate recreational or work related activity were classified as having moderate activity; all others were classified as sedentary.

Statistical Analysis

Sample-weighted data were used in all analyses, performed with SAS (version 9.2, 2010, SAS Institute, Cary, NC) and SUDAAN (version 11.0.1, 2014, Research Triangle Institute, Research Triangle Park, NC) to adjust the variance for the complex sample design. Regression analyses of intakes from the first dietary recall were conducted to assess differences in CV+CF consumer and non-consumers; analyses of energy intake and HEI-2010 and sub-components included the following covariates: age, sex and race/ethnicity. For analyses of nutrient intakes, molar ratio of sodium and potassium, and food group intakes, energy was also included in regression models (energy adjustment helps to ensure differences reported are not just due to consuming more food/calories). Regression analyses of anthropometric and physiological parameters (body weight, body mass index, and waist size in children and adults; diastolic and systolic blood pressure in adults) included age (years), sex and race/ethnicity as covariates. For all analyses, $P < 0.01$ was used to assess statistical significance.

RESULTS

Among the total sample (weighted population percentage), 2,066 children (13.4%) and 2,746 (11.1%) adults consumed CV+CF. Table 1 presents the distribution of respondents based on sex, race/ethnicity, age, PIR, physical activity, smoking status and alcohol intake. Children who consumed CV+CF were more likely to be younger. Adult CV+CF consumers were more likely to be female, older (by about 5 years), and less likely to be physically active. Adult consumers were more likely to be white and less likely to be Mexican American.

Mean daily consumption of CV+CF was 103 ± 2.9 g (or 0.5 ± 0.02 cup equivalents) among children and 122.2 ± 3.3 g (or 0.7 ± 0.02 cup equivalents) among adults (data not shown). The 10 most commonly consumed CV+CF in all subjects (ranked from most to least consumptions) were string beans, corn, peaches, fruit cocktail, spaghetti sauce, pineapple, tomatoes (including sauce), green peas, pears, and olives. The 10 most commonly consumed non-canned fruits and vegetables in all subjects (ranked similarly, and excluding tomato ketchup, potato chips, and salsa) were lettuce, orange juice (all types and kinds), tomatoes, bananas, apples, white potatoes (French fries), onions, apple juice, carrots and oranges.

As compared to non-consumers, child CV+CF consumers on a given day had significantly higher intakes of total energy (5.8%), protein (3.7%), total sugar (4.7%), dietary fiber (7.7%), vitamin A (11.3%), total choline (5.3%), calcium (5%), magnesium (3.1%) and potassium (5.8%) (Table 2). Among adults, consumers had significantly higher intakes of total energy (4.5%), total sugar (7.1%), dietary fiber (7.6%), total choline (3.8%), and potassium (4.8%). As compared to non-consumers, child and adult CV+CF consumers had significantly lower intakes of total fat, saturated fat, and monounsaturated fat (4.9%, 3.5% and 5.6% for children and 3.3%, 4.3%, 4.8% for adults, respectively) and comparable intakes of added sugar

and sodium. The molar ratio of sodium to potassium was significantly lower in both children and adult CV+CF consumers as compared to non-consumers.

As measured by the HEI-2010, child CV+CF consumers had a significantly higher diet quality (approximately 2.4 units) compared to non-consumers on a given day. Better scores for Total Vegetable (about 27.4% higher), Total Fruit (about 14% higher), Whole Fruit (about 33.3% higher), Dairy (about 6.1% higher), and Empty Calories (about 6.6% higher) drove the higher total HEI-2010 score in child CV+CF consumers as compared to non-consumers (Table 3). Adult CV+CF consumers, as compared to non-consumers, had a significantly higher diet quality (approximately 1.7 units). Higher scores for Total Vegetables (about 18.5% higher), Total Fruit (about 17.5% higher), Whole Fruit (about 31.3% higher), and Refined Grains (about 6.2% higher) drove the higher total HEI-2010 score (Table 3).

There was no association of CV+CF with any anthropometric measures (body weight, body mass index, and waist circumference) or physiological variables (systolic and diastolic blood pressure) evaluated in children or in adults (data not shown).

DISCUSSION

These data show that the low percentage (~12%) of child and adult CV+CF consumers in the NHANES 2001-2010, as compared to non-consumers, had higher intakes of selected nutrients (dietary fiber, choline, and potassium in both children and adults and vitamin A, calcium, and magnesium in children only) on a given day. Additionally, both child and adult CV+CF consumers had small, but statistically significant higher HEI total scores as compared to non-consumers.

Since the Academy promotes the total diet approach to healthy eating, it is useful to examine the HEI, which is a measure of dietary quality. In this study, CV+CF consumption was

associated with better overall diet quality, as indicated by higher total HEI-2010 scores in child and adult consumers, as compared to non-consumers. Significantly higher Total Vegetables, Total Fruit, and Whole Fruit scores helped drive the higher total HEI score, and support the contention that CV+CF make important contributions towards total vegetable and fruit intake. Since HEI scores were also higher for Dairy and Empty Calories in child CV+CF consumers, and for Refined Grains in adult CV+CF consumers, attributing higher total HEI scores to CV+CF intake alone would be incorrect.

In the HEI, since food mixtures are broken down into their constituent components, the Total Vegetables score includes vegetables found in soups and mixed dishes. However, in this analysis, all soups (including canned tomato and vegetable) and all mixed dishes comprised of at least one vegetable (such as pizza which contains tomato sauce) were excluded from the CV+CF category. Thus, using the current dataset, the higher Total Vegetables score among CV+CF consumers does not appear to be due to increased consumption of canned soup or other canned vegetable containing mixed dishes. Rather, the higher Total Vegetables score appears to be a result of higher canned vegetable intake.

In the HEI, the Total Fruit score includes fruit juice, whereas the Whole Fruit score does not. Since all fruit juices were excluded from the CV+CF database in this analysis, the higher Total Fruit score among CV+CF consumers was not the result of increased fruit juice consumption. Rather, the higher Total Fruit score indicates that canned fruits – excluding juice – contributed to higher fruit intake. Inclusion of canned orange, apple, pineapple, tomato, or other types of 100% juices in the CV+CF database would mean a higher Total Fruit score among CV+CF consumers, and a lower Total Fruit score among non-consumers, further increasing the difference in the Total Fruit score between CV+CF consumers and non-consumers.

In a recent report using a large multi-ethnic cohort, HEI scores were inversely associated with mortality from all causes, cardiovascular diseases and cancer in adult men and women when comparing the lowest to the highest quintile of HEI scores.[48] Few studies have evaluated the relationship of HEI with health effects in children.

Although intake of dietary fiber (a "nutrient of concern") was higher in consumers, dietary fiber intake in the population studied was only about half of the recommended level. Increasing dietary fiber is important as fiber may help to lower blood pressure and serum cholesterol levels, and improve glycemic control.[49] Those with high dietary fiber intakes appear to be at significantly lower risk for developing coronary heart disease, stroke, hypertension, diabetes, obesity, and certain gastrointestinal diseases.[49] Keast et al. reported that fruits were the major contributor (10.4%) to American children's dietary fiber intake.[50] Increasing the proportion of fruit that is eaten as whole, rather than as juice, can help all Americans consume more fiber. In addition, beans (legumes) and peas, other vegetables, whole grain foods, and nuts are good sources of dietary fiber.[1] Efforts to increase dietary fiber intake by recommending consumption of all types of vegetables and fruits, including canned varieties, as well as legumes, whole grain foods, and nuts is warranted.

Sodium and potassium (another "nutrient of concern") play important roles with respect to blood pressure. As dietary sodium levels increase, so does blood pressure.[51] Dietary potassium can blunt the adverse effects of sodium on blood pressure, especially at higher levels of sodium intake.[51] It is possible that the ratio of sodium-to-potassium identifies risk better than either electrolyte alone.[52] Both children and adult consumers of CV+CF had lower molar ratios of sodium to potassium as compared to non-consumers. The DGA recommend reducing sodium intake to ≤2,300 mg (based on age or presence of disease), and increasing intake of potassium-

rich foods as part of the DASH (Dietary Approaches to Stop Hypertension) Eating Plan.[1]

The body needs sodium in relatively small quantities. Sodium is primarily consumed as salt; about 90% comes from salt added during food processing, not from home cooking or at the table.[51] Yeast breads, chicken and chicken mixed dishes, pizza, pasta and pasta dishes, and cold cuts contribute 30% of sodium to American's diets.[53] Canned vegetables contribute less than 2% of total sodium intake[53] and canned fruits do not contribute dietary sodium. White and sweet potatoes, fruit and vegetable juices, tomato paste, beans, and plain nonfat or low-fat yogurt provide the most potassium per standard food portion;[1] these foods should thus be recommended.

In this study, CV+CF consumers did not consume more sodium than non-consumers. However, potassium intake of CV+CF consumers was higher, despite the exclusion of 100% fruit juices (including canned varieties which provide between ~250 and ~700 mg/potassium per cup; prune juice and carrot juice provide about 700 mg/cup while tomato and orange juice provide about 500 mg/cup and apple juice provides 250 mg/cup)[1] from the CV+CF category. Since consumption of 100% juice was associated with increased potassium intake,[24] it is possible that exclusion of 100% juice from the CV+CF category may have underestimated the potassium intake among CV+CF consumers and overestimated the potassium intake among non-consumers. Regardless, the optimal sodium-to-potassium ratio is unknown, and when examined in the Mobile Examination Center, blood pressure was comparable in child and adult CV+CF consumers and non-consumers. Further, in the current study, sodium intake among all groups exceeded 3,000 mg/day, and potassium intake failed to meet recommended intake levels.[1] Vegetables and fruits, including canned, fresh, frozen and dried forms, and moderate amounts of 100% fruit juice, may help Americans meet potassium requirements without increasing their sodium intake.

Child and adult CV+CF consumers, as compared to non-consumers, had higher total sugar intakes. Rather than focusing on total sugar intake, the DGA recommends limiting intake of added sugars, which provide energy without nutrients.[1] Soda/energy/sports drinks, grain-based desserts, and fruit drinks contribute almost 60% of added-sugar energy to Americans' diets.[54] Although fresh fruits do not contribute to added sugar intake, some syrup-packed frozen or canned fruits may contribute. In this study, since added sugar intake was similar between CV+CF consumers and non-consumers, the contribution of canned fruits to added sugar intake appears to be insignificant. This is likely due to the fact that for canned fruits, the majority of consumption reports (55%) were for "drained solids" or fruits canned "in light or medium syrup." Of the remaining 45% of reports, 23% were for fruits "NS as to sweetened or unsweetened," and 12% were for "juice packed" or "unsweetened, water packed fruit." Only 10% of reports were for fruit "in sugar or heavy syrup." In addition, most canned fruits (including peaches, mixed fruit, pears, and apricots) available to children in the National School Lunch Program are packed in unsweetened fruit juice, lightly sweetened fruit juice(s) and water, lightly sweetened fruit juice, or extra light syrup.[55]

The DGA emphasize limiting intake of saturated and *trans* fatty acids (collectively known as solid fats). In this study, child and adult CV+CF consumers consumed less saturated fat (and less total fat) as compared to non-consumers. Pizza, grain-based desserts, whole milk, regular cheese, sausages, franks, bacon and ribs contribute 44.1% of calories from solid fats to diets of American children.[56] Consuming more fresh, canned, or frozen fruits and vegetables, which contain no fat, can help Americans consume diets low in solid fats, as long as solid fats are not added to these foods during preparation or consumption.

Despite the positive associations of CV+CF to the nutrient intake and diet quality of Americans, overall intake of fruits and vegetables remains low.[9-12] Continued efforts are needed to promote dietary consumption of all types, kinds and forms of fruits and vegetables, as recommended by the Academy's total diet approach.[8] Meengs et al. reported that in a laboratory setting, increasing vegetable variety offered at a single meal increased the quantity of vegetables consumed at that meal.[57] Keim et al. reported that low-income women who consumed the greatest variety of vegetables had better diet quality indexes and more healthful attitudes about food and eating, and chose to spend more money on food, including vegetables.[58] Incorporation of a combination of canned, fresh, frozen and dried varieties of vegetables into meals may help increase variety, and thus intake. This may be especially important among low-income individuals who may not be able to afford to purchase, cook, or store fresh vegetables. In adults, vegetable costs depend on items selected, and careful budgeting using lower-cost vegetables can reduce these costs.[59,60] In children, since the Healthy Hunger-Free Kids Act of 2010 has mandated that a greater amount and variety of fruits and vegetables be served in the National School Lunch and School Breakfast Programs,[61] fresh, frozen and canned vegetables and fruits available to schools at a low cost can help children increase their vegetable and fruit intake, and provide important nutrients.

Finally, in this study, there was no association of CV+CF with any of the anthropometric (body weight, body mass index, and waist size) or physiological measures (systolic and diastolic blood pressure) evaluated in children or in adults. Unless total fruit and vegetable intake increases (to the point of displacing more calorically dense foods, or displacing foods high in sodium), and the contribution of CV+CF to total fruit and vegetable intake also increases, there will be a limited impact of CV+CF intake on these health measures. Additionally, a relationship

with anthropometric or physiological measures may not have been able to be discerned given the observational nature of NHANES and errors inherent in measuring food/nutrient intakes.

Limitations

The major limitation of this study is that results may have been influenced by determination of which foods were included in or excluded from the CV+CF category. In this study, "canned" was defined as "in a can." Other forms of canned vegetables and fruits (e.g., those in jars, coated cardboard, plastic or metallized bags, cups or containers, etc.) were not considered "canned." Canned soups, canned mixed dishes containing vegetables (such as stews), and other mixed dishes prepared with canned vegetables or canned fruits (such as pizza or baked goods) were also excluded from the CV+CF category. Exclusion of these items likely resulted in an underestimation of the true contribution of CV+CF to American's diets. In addition, there might be random misclassification of CV+CF in the large number of vegetables and fruits reported by NHANES respondents that are non-specified in the USDA nutrient database with respect to whether they are frozen, canned or fresh (as was the case with cranberries, which was listed as "NS as to raw, cooked or canned" and which was classified as "canned" in this study). But depending on consumption patterns, misclassification may have little to no measurable effect (e.g., in this study, only 14 people reported eating this cranberry item). Future USDA food coding should nevertheless strive to delineate fresh, canned/jarred, and frozen vegetables and fruits.

As with other NHANES studies, the cross-sectional design means that results cannot show causal relationships. Since dietary intake is based on 24-hour dietary recalls that depend on memory, subjects may have under- or over-reported some or certain types of foods. Of relevance to this study, subjects may have failed to correctly identify the form of food (e.g.,

fresh, frozen or canned) consumed. Results were also dependent on USDA nutrient content and food group equivalent data.

While numerous covariates were used in regression analyses, residual confounding may still exist and as such, associations reported may also be due to other unknown differences in consumers and non-consumers. Finally, the formula used to calculate the HEI-2010 scores did not account for the fact that some HEI-2010 components are consumed on an episodic basis (i.e., whole grains and greens and beans). Thus, HEI-2010 scores might be lower than reported.

CONCLUSIONS

Results of this cross-sectional study using NHANES 2001-2010 data suggest that improved intake of select nutrients, specifically higher energy adjusted dietary fiber and potassium intakes, and higher diet quality, especially due to higher intakes of vegetables and fruits, are associated with CV+CF intake in a large population. In support of the Academy's total diet approach to healthy eating and the 2010 DGA, nutrition and health-care professionals should continue to encourage consumption of all forms – whether they are canned, fresh, frozen and dried – of vegetables and fruits as part of a healthful diet.

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Table 1. Demographics of children 2-18 years (n=17,344) and adults ≥19 years (n=24,807) participating in NHANES 2001-2010 by canned vegetable and fruit consumption[a]

Variable	Children aged 2 to 18 years			Adults aged ≥19 years		
	Non-Consumers (n=15,278)	Consumers (n=2,066)	P-Value	Non-Consumers (n=22,061)	Consumers (n=2,746)	P-Value
	Mean ± SE	Mean ± SE		Mean ± SE	Mean ± SE	
Sex (%)						
Female	48.9 ± 0.67	52.1 ± 0.7	0.074	50.4 ± 0.4	54.3 ± 0.4	<0.001
Race/Ethnicity (%)						
Non-Hispanic white	60.1 ± 1.6	63.0 ± 1.6	0.288	70.7 ± 1.5	77.0 ± 1.5	0.003
Non-Hispanic black	13.8 ± 0.9	18.0 ± 0.9	0.012	11.2 ± 0.8	12.2 ± 0.8	0.443
Mexican American	13.5 ± 1.0	10.3 ± 1.0	0.043	8.3 ± 0.7	4.4 ± 0.7	<0.001
Age (Years)	10.3 ± 0.08	8.6 ± 0.1	<0.001	45.9 ± 0.3	50.9 ± 0.3	<0.001
Poverty Income Ratio ≤1.3 (%)	31.3 ± 1.0	37.0 ± 1.0	0.016	20.9 ± 0.7	22.1 ± 0.7	0.381
Physical Activity (%)						
Sedentary	12.6 ± 0.4	13.5 ± 0.4	0.417	28.6 ± 0.6	32.2 ± 0.6	0.004
Moderate	19.1 ± 0.6	19.4 ± 0.6	0.904	33.9 ± 0.5	36.1 ± 0.5	0.096
Active	65.7 ± 0.7	65.2 ± 0.7	0.732	37.8 ± 0.7	31.7 ± 0.7	<0.001
Smoker, current (%)				24.5 ± 0.6	22.0 ± 0.6	0.053
Alcohol (g)				11.2 ± 0.3	9.4 ± 0.8	0.030

[a] Data are presented as means ± SEM

Table 2. Adjusted mean nutrient intake in children 2-18 years and adults ≥19 years by canned vegetable and fruit consumption: NHANES 2001-2010[a,b]

	Children aged 2 to 18 years			Adults aged ≥19 years		
Nutrient	Non-consumers n=15,278	Consumers n=2,066	P value	Non-Consumers (n=22,061)	Consumers (n=2,746)	P value
Food energy (kcal)	1981 ± 10	2097 ± 27	<0.001	2166 ± 10	2263 ± 27	<0.001
Protein (g)	69.4 ± 0.3	71.9 ± 0.6	<0.001	82.9 ± 0.3	84.5 ± 0.6	0.012
Total fat (g)	73.9 ± 0.3	70.3 ± 0.7	<0.001	82.2 ± 0.3	79.7 ± 0.7	<0.001
Saturated fat (g)	26.0 ± 0.1	25.1 ± 0.3	0.004	27.2 ± 0.1	25.9 ± 0.3	<0.001
MUFA (g)	27.1 ± 0.1	25.6 ± 0.3	<0.001	30.4 ± 0.1	28.9 ± 0.3	<0.001
Cholesterol (mg)	223 ± 2	220 ± 5	0.549	287 ± 2	289 ± 6	0.748
Total sugars (g)	136 ± 1	143 ± 2	0.001	122 ± 1	131 ± 2	<0.001
Added sugar (tsp. eq)	21.2 ± 0.2	20.9 ± 0.4	0.522	19.3 ± 0.3	20.1 ± 0.3	0.029
Dietary fiber (g)	12.8 ± 0.1	13.8 ± 0.2	<0.001	16.0 ± 0.2	17.2 ± 0.2	<0.001
Vitamin A (μg RAE)	573 ± 7	639 ± 17	<0.001	619 ± 8	637 ± 12	0.164
Vitamin D (mcg)	5.9 ± 0.1	6.2 ± 0.2	0.057	4.7 ± 0.1	4.9 ± 0.1	0.280
Folate, DFE (μg)	534 ± 5	539 ± 13	0.700	544 ± 5	550 ± 8	0.497
Total choline (mg)	249 ± 2	262 ± 4	0.004	332 ± 2	345 ± 5	0.003
Calcium (mg)	1004 ± 8	1054 ± 16	0.007	933 ± 6	919 ± 14	0.348
Magnesium (mg)	229 ± 1	236 ± 2	0.006	293 ± 2	298 ± 3	0.130
Iron (mg)	14.5 ± 0.1	14.4 ± 0.2	0.616	15.6 ± 0.1	15.8 ± 0.2	0.253
Sodium (mg)	3144 ± 15	3190 ± 26	0.124	3615 ± 11	3682 ± 30	0.053
Potassium (mg)	2210 ± 15	2338 ± 26	<0.001	2713 ± 14	2842 ± 23	<0.001
Sodium-potassium ratio	1.55 ± 0.01	1.46 ± 0.02	<0.001	1.45 ± 0.01	1.38 ± 0.02	<0.001

[a] Data are presented as least square means (LSM) ± standard errors (SE).

[b] Covariates for nutrients are sex, race/ethnicity, age (years), and energy (kcals). Covariates for energy are sex, race/ethnicity, and age (years). LSM represent adjustment for covariates.

Table 3. Adjusted mean Healthy Eating Index-2010 (HEI-2010) component scores in children 2-18 years and adults ≥19 years by canned vegetable and fruit consumption: NHANES 2001-2010[a,b]

HEI-2010 component score (maximum)	Children aged 2 to 18 years			Adults aged ≥19 years		
	Non-Consumers (n=15,278)	Consumers (n=2,066)	P Value	Non-Consumers (n=22,061)	Consumers (n=2,746)	P Value
	LSM ± SE	LSM ± SE		LSM ± SE	LSM ± SE	
Total HEI-2010 (100)	43.3 ± 0.3	45.8 ± 0.5	<0.001	47.4 ± 0.3	49.0 ± 0.35	<0.001
Total Vegetables (5)	2.1 ± 0.03	2.7 ± 0.05	<0.001	3.0 ± 0.02	3.5 ± 0.04	<0.001
Greens and Beans (5)	0.6 ± 0.02	0.6 ± 0.05	0.097	1.2 ± 0.03	1.1 ± 0.06	0.507
Total Fruit (5)	2.4 ± 0.04	2.8 ± 0.08	<0.001	2.1 ± 0.03	2.5 ± 0.06	<0.001
Whole Fruit (5)	1.9 ± 0.04	2.6 ± 0.08	<0.001	2.0 ± 0.03	2.6 ± 0.05	<0.001
Whole Grains (10)	1.8 ± 0.04	1.8 ± 0.10	0.734	2.2 ± 0.05	2.2 ± 0.08	0.970
Dairy (10)	6.8 ± 0.05	7.3 ± 0.13	0.003	5.0 ± 0.05	4.8 ± 0.10	0.054
Total Protein Foods (5)	3.5 ± 0.02	3.6 ± 0.06	0.155	4.1 ± 0.01	4.2 ± 0.05	0.094
Seafood and Plant Protein (5)	1.4 ± 0.03	1.3 ± 0.07	0.116	1.9 ± 0.02	1.8 ± 0.06	0.078
Fatty Acids (10)[c]	3.8 ± 0.05	3.6 ± 0.12	0.093	4.9 ± 0.04	5.0 ± 0.12	0.328
Sodium (10)	5.1 ± 0.06	4.8 ± 0.10	0.038	4.3 ± 0.04	4.0 ± 0.09	0.016
Refined Grains (10)	5.1 ± 0.06	5.4 ± 0.14	0.029	5.9 ± 0.05	6.3 ± 0.09	<0.001
Empty Calories (20)[d]	8.9 ± 0.11	9.5 ± 0.22	0.009	10.7 ± 0.12	10.9 ± 0.14	0.389

[a] Data are presented as least-square means (LSM) ± SE.
[b] Covariates include sex, race/ethnicity, and age (years). LSM represent adjustment for covariates.
[c] Ratio of polyunsaturated fatty acids and monounsaturated fatty acids to saturated fatty acids.
[d] Calories from solid fats, alcohol, and added sugars; threshold for counting alcohol is 13 g/1,000 kcal.