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Research Article
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Fresh Pear Consumption is Associated with Better Nutrient Intake, Diet Quality, and Weight Parameters in Adults: National Health and Nutrition Examination Survey 2001-2010

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Abstract

No studies have examined the association of consuming fresh pears on nutrient intake or adequacy, diet quality, and cardiovascular risk factors (CVRF). The purpose of this study was to examine these association in adults (N=24,808) participating the NHANES 2001-2010. Covariate adjusted linear regression was used to compare macronutrients, diet quality, and CVRF. Diet quality was determined using the Healthy Eating Index-2010 (HEI-2010). The National Cancer Institute method was used to estimate the usual intake (UI) of nutrients. Appropriate sample weights were used. Percentages of the population below the Estimated Average Requirement (EAR) or above the Adequate Intake (AI) were determined. Consumers had higher mean intakes of total sugars and lower total, mono-, and saturated fatty acids, and added sugars than non-consumers; consumers also had higher UI for vitamin C, copper, magnesium, and potassium ($p<0.01$). Consumers had a higher percentage population meeting the EAR for vitamins A and C, copper, and magnesium; consumers had a higher percentage above the AI for fiber ($p<0.01$). HEI-2010 was higher in consumers (52.4 ± 0.4 vs 48.5 ± 0.3) ($p<0.01$). Compared to non-consumers, consumers were 35% less likely to be obese ($p<0.05$). Fresh pears should be encouraged as a component of an overall healthy diet.

Keywords: NHANES; Adults; Pears; Nutrient adequacy; Cardiovascular risk factors; Diet quality

Introduction

Fruit, which is defined by the Dietary Guidelines for Americans (DGA) as a nutrient-dense food [1] is part of a healthy diet [2]. The recommendation for fruit is age, gender, and physical activity dependent; however, for most adults the recommendation is 1½ to 2 cups per day. Fresh, frozen, canned, or dried fruit or 100% fruit juice can be used to meet the fruit recommendation [1,3]. Most Americans fail to meet this relatively modest level of fruit intake [4,5].

The DGA [1] recommend consuming fruit, which is a relatively low-energy food, in place of higher energy foods to help lower overall energy intake; however, the effect of fruit consumption on weight or weight loss is controversial [6-9]. Consumption of fruit, as part of an overall healthy diet, has been inversely associated with cardiovascular disease [6,10,11], type 2 diabetes [6,12,13], metabolic syndrome [14], and some types of cancer [6,12,13]. Often studies limited the reported associations of the health benefits to generic "fruit" or "fruit and vegetables" [6,10-13,15,16]; however, pears (and apples) have been associated with a reduced risk of stroke [16,17], type 2 diabetes [18], and cardiovascular mortality [19]. Fruit provides a wide array of nutrients, including nutrients of public health concern [1], such as dietary fiber and potassium, as well as other shortfall nutrients, like vitamins A and C and folate [20]. Many of the health benefits seen may be due to these nutrients or to the phytochemicals found in fruit, especially in pears [21-23].

Fresh pears (*Pyrus communis*) are commonly consumed in the US. In 2012, retail per capita availability of pears was ranked 9th among fruits at 2.7 pounds [9]; a limitation to the Economic Research Service's data set is that it does not give actual consumption figures. A recent study from the National Health and Nutrition Examination Survey (NHANES) ranked pears the 11th most commonly consumed fruit in the US [24]. One serving of fresh pears (166 g) provides approximately 397 kilojoules (kJ) (95 kilocalories), 16 g total sugars, 5 g dietary fiber (20% Daily Value - DV), and 193 g potassium (5 % DV). Further, pears contain virtually no total fat, saturated fatty acids (SFA), or sodium; and they have no cholesterol [20]. Pears, especially pear peels [23], are also rich sources of antioxidants, including phenolics, flavonoids, and anthocyanins [21,22], and anti-inflammatory compounds, notably total triterpenoids [22]. These phytochemicals likely contribute to the health effects reported for pears [18,19].

No epidemiologic studies have examined association of fresh pears with nutrient intake, nutrient adequacy, diet quality, or cardiovascular risk factors in adults. The purpose of this study was to examine these potential associations in a nationally representative sample of adults using the National Health and Nutrition Examination Survey (NHANES) 2001-2010 data.

Materials and Methods

Study population and analytic sample

For these analyses, data from adults 19+ years of age (y) and older

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(N=24,808) participating in the NHANES 2001-2010 were merged to increase sample size [25,26]. Excluded from the analyses were those individuals with dietary records judged to be incomplete by the National Center for Health Statistics staff (n=147) and females who were pregnant or lactating (n=1,128). This secondary analysis was without individual identifiers; therefore, no Institutional Review Board review was required [27].

Demographics and dietary information

Demographic information was determined from the NHANES interview administered in the Mobile Examination Center [28]. Intake data were obtained from What We Eat in America which collected an in-person 24-hour dietary recall interview and a telephone 24-hour dietary recall conducted three to ten days later. Both types of recalls was administered using an automated multiple-pass method [29,30]. Detailed descriptions of the dietary interview methods are provided in the NHANES Dietary Interviewers Procedure Manuals [31,32].

The USDA Food and Nutrient Database for Dietary Studies (FNDDS) [33] single food code was used to identify fresh pear consumers were 63137010. Individuals were classified as consumers if any amount of fresh pear was ingested either day of the recall. For each participant, daily total energy and nutrient intakes from foods and beverages were obtained from the total nutrient intake files of the FNDDS associated with each data release. The Vitamin D Addendum to USDA Food and Nutrient Database for Dietary Studies 3.0 [34] was used to determine vitamin D intake. Intake from supplements was not considered.

Diet quality as determined by the healthy eating index (HEI-2010)

The HEI-2010 was used to determine diet quality [35,36]. The HEI is composed of 12 sub-components; the total HEI score is the sum of the sub-component scores and has a maximum value of 100 points. A higher score correlates with higher compliance to the DGA. Nine of the sub-components address nutrient adequacy. The remaining three sub-components assess refined grains, sodium, and empty calories, which should be limited. The SAS code used to calculate HEI-2010 total score and sub-component scores was downloaded from the Center for Nutrition Policy and Promotion website [37].

Anthropometric and physiologic measures

The NHANES protocols were used to determine height, weight, and waist circumference (WC) [38]. Body mass index (BMI) was calculated as body weight (kilograms) divided by height (meters) squared [39]. Overweight was defined as a BMI between 25 and 29.9, whereas obesity was defined as a BMI ≥ 30 [39]. High waist WC was defined as >102 cm (males) or >88 cm (females). Systolic (SBP) and diastolic blood pressures (DBP) were determined using the standard NHANES protocol [40]. High density lipoprotein-cholesterol (HDL-C) was determined on non-fasted individuals [41] while LDL-C [42], triglycerides [42], blood glucose [43], and insulin [43] were determined on only fasted subjects. The homeostatic model assessment-insulin resistance (HOMA-IR) levels were calculated using insulin x glucose (mg/dL)/405 [44,45]. Other tests were also done via NHANES standard protocols: C-reactive protein [45], serum folate [46], and folate red blood cell [46]. Not all individuals had laboratory values for all tests.

Metabolic syndrome was defined using the National Heart Lung and Blood Institute Adult Treatment Panel III criteria [47]; that is having 3 or more of the following risk factors: abdominal obesity, WC>102 cm (males), >88 cm (females); hypertension, SBP ≥130 mmHg or DBP ≥85 mmHg or taking anti-hypertensive medications; HDL-C, <40 mg/dL (males), <50 mg/dL (females); high triglycerides, ≥150 mg/dL or taking anti-hyperlipidemic medications; high fasting glucose, ≥110 mg/dL or taking insulin or other hypoglycemic agents. Participants with any missing values were excluded from the analyses.

Statistical analyses

Sampling weights and the primary sampling units and strata information, as provided by NHANES [25,26], were included in all analyses using SUDAAN v11.0 (Research Triangle Institute; Raleigh, NC). Least-square means (and the standard errors of the least-square means) were calculated using PROC REGRESS of SUDAAN. For dietary fiber and micronutrients, the National Cancer Institute (NCI) Method [48] was used to estimate usual intake (UI) of selected nutrients in for assessment of nutrient adequacy. Since nutrients are consumed daily by most people, the one part model was used. The NCI SAS macros (Mixtran v1.1 and Distrib v1.1) were used to generate parameter effects after covariate adjustments and to estimate the distribution of usual intake via Monte Carlo simulation methods, respectively [48]. Covariates in this study were day of the week of the 24-hr recall [coded as weekend (Friday-Sunday) or weekday (Monday-Thursday)] and sequence of dietary recall (first or second). Software provided by NCI was used with the two days of intake using one-day sampling weights to obtain appropriate variance estimates. Balanced repeated replication (BRR) was performed to obtain standard errors (SE) and confidence intervals (CI) for the percentiles; BRR weights were constructed with Fay adjustment factor M=0.3 (perturbation factor 0.7) and further adjusted to match the initial sample weight totals within specific age/gender/ethnicity groupings for the full dataset. The Dietary Reference Intake (DRI) age groups [49] were used to present nutrient adequacy for each of the nutrients studied. Differences among pear consumers and non-consumers among the two groups were determined by computing population Z statistics generated from UI variables. The percent of the population below Estimated Average Requirement (EAR) or above the Adequate Intake (AI) [49] among pear consumers and non-consumers was similarly examined.

Linear regression was used to determine differences between fresh pear consumers and non-consumers for nutrients, HEI-2010 total and sub-component scores, and physiologic measures. Logistic regression was used to determine if fresh pear consumers had a lower odds ratio of being overweight or obese or having other adverse physiologic outcomes. For all linear and logistic regressions, covariates were age, gender, ethnicity, poverty index ratio (one of three levels: 0-1.25, 1.25-3.5, ≥3.5) [28], physical activity level (one of three levels: sedentary, moderate, and vigorous) [50], current smoking status, and alcohol consumption, which was obtained from the 24-hour dietary recall. Energy (kcals) was used for regressions in the nutrient analyses except when kcals were the dependent variable. Energy was also not used as a covariate in the HEI-2010 analyses, since HEI-2010 controls for energy. Body Mass Index was used as a covariate in the biophysical variable linear regressions except when the dependent variable was body weight, BMI, or WC. For linear regression analysis and comparison of Z values a $p<0.01$ was used; however, for the logistic analysis a p value of <0.05 was considered significant.

Results

Demographics and fresh pear consumption

Adult consumers of fresh pears were less likely to non-Hispanic black (~ 6.5 percentage units less), more likely to be older (~7 years older), less likely current-smokers (~14 percentage units less), and consumed less alcohol (about 5 g less) than non-consumers (Table 1). Mean consumption of fresh pears among consumers was 169.5 g ± 6.6 g.

Energy, macronutrient, and micronutrient intake

Adult consumers of fresh pears had similar mean energy intakes, 9104 ± 222 kJ (2176 kcal) vs 9113 ± 38 kJ (2178 kcal), compared to non-consumers (Table 2). Adult pear consumers also had lower daily mean intakes of total fat (~7 g or 8.6% less), monounsaturated fatty acids (~3 g or 9.2% less), saturated fatty acids (~4 g or 13.7% less), and added sugar (~3 tsp eq or 17% less), and higher mean daily intakes of dietary fiber (~49.7% more) and total sugars (~8.6% more) compared to non-consumers (Table 2).

Adult consumers of fresh pears also had higher UI of vitamin C (~17 mg or 19.6% more) compared to non-consumers (Table 3a). Adult consumers had higher daily UI of magnesium (~40 mg 13.6% more), copper (~0.25 mg or 19.6% more), and magnesium (~36 mg or 11% more) compared to non-consumers (Table 3a). In addition, consumers of fresh pears had higher intakes of dietary fiber (~9 g or 36% more) and potassium (~280 mg or 10.4% more) (Table 3b).

Dietary adequacy

Compared to non-consumers, a significantly lower percentage of adult fresh pear consumers had vitamin A (~29 percentage units less), vitamin C (~23 percentage units less), copper (~4 percentage units less), and magnesium (~13 percentage units less) below their EAR (Table 3a). Further, a significantly lower percentage of adult fresh pear consumers had intakes for dietary fiber (~29 percentage units less) above their AI (Table 3b).

Diet quality (healthy eating index-2010)

Adult fresh pear consumers had higher diet quality (~12 units, 26% higher) compared to non-consumers. The increased HEI-2010 score was driven by better scores for HEI-2010 subcomponents: Greens and Beans (0.6 units, 55% higher), Total Fruit (2 units, 91% higher), Whole Fruit (2.5 units, 125% higher), Whole Grains (1 unit, 48% higher), Seafood and Plant Protein (0.5 units, 26% higher), Fatty Acid Ratio (0.9 units, 18% higher), Sodium (0.7 units, 17% higher), and Empty Calories (3.4 units, 33% higher) (Table 4). For Sodium and Empty Calories higher scores denote lower intakes.

Variable	Pear Consumers (n=492)	Non-Pear Consumers (n=24,316)	P
	LSM ± SE[1]	LSM ± SE	
% Female	53.89 ± 2.79	50.80 ± 0.35	0.2725
Ethnicity			
% Non-Hispanic White	67.60 ± 3.43	71.46 ± 1.43	0.0299
% Non-Hispanic Black	4.89 ± 0.95	11.43 ± 0.77	<0.0001
% Mexican American	12.90 ± 2.28	7.74 ± 0.71	0.0308
Age (years)	53.27 ± 1.14	46.34 ± 0.25	<0.0001
Poverty Index Ratio	3.21 ± 0.12	3.01 ± 0.03	0.1155
Physical Activity			
% Sedentary Physical Activity	24.27 ± 2.61	29.06 ± 0.62	0.0735
% Moderate Physical Activity	41.15 ± 3.32	33.98 ± 0.46	0.0322
% Vigorous Physical Activity	34.58 ± 3.24	36.96 ± 0.73	0.4727
% Current Smoker	10.53 ± 1.98	24.49 ± 0.55	<0.0001
Alcohol Intake (g)	5.68 ± 0.84	11.12 ± 0.34	<0.0001
Pear Consumption (g)	169.5 ± 6.6	---	

Differences assessed using Z-Score.
[1]LSM: Least Square Means; SE: Standard Error.

Table 1: Demographics associated with pear consumption and pear consumption in adults (19+ years of age): NHANES 2001-2010.

Variable	Consumers	Non-Consumers	P
	LSM ± SE[1]	LSM ± SE	
Energy (kJ)[1]	9104 ± 222	9113 ± 38	0.9573
Energy (kcal)[1]	2176 ± 53	2178 ± 9	0.9573
Protein (gm)[2]	82.3 ± 2.8	83.2 ± 0.3	0.7428
Total fat (gm)[2]	75.3 ± 1.3	82.4 ± 0.3	<0.0001
Total monounsaturated fatty acids (gm)[2]	27.6 ± 0.6	30.4 ± 0.1	<0.0001
Total polyunsaturated fatty acids (gm)[2]	17.4 ± 0.5	17.4 ± 0.1	0.9106
Total saturated fatty acids (gm)[2]	23.4 ± 0.5	27.1 ± 0.1	<0.0001
Cholesterol (mg)[2]	265.5 ± 12.2	287.8 ± 2.1	0.0692
Dietary fiber (gm)[2]	23.9 ± 0.6	15.9 ± 0.1	<0.0001
Total sugars (gm)[2]	133.5 ± 3.0	122.9 ± 0.8	0.0011
Added Sugar (tsp eq)[2]	15.9 ± 0.6	19.2 ± 0.2	<0.0001

[1]LSM: Least Square Mean; SE: Standard Error.
[2]Adjusted for age, gender, race/ethnicity, poverty index ratio, physical activity, current smoking status, and alcohol intake.

Table 2: Energy and macronutrient intakes associated with pear consumption in adults (19+ years of age): NHANES 2001-2010.

Anthropometric and physiologic measures

Adult consumers of fresh pears had lower weights (3.6 kg) than non-consumers (Table 5) and were 35% less likely to be obese than non-consumers (p=0.0097) (Table 6). No other physiologic measures varied between consumers and non-consumers.

Discussion

This is the first published study that has examined fresh pear consumption in adults and shown its beneficial effects on nutrient intake, nutrient adequacy, diet quality, and body weight. On any given day, approximately 2% of the adult population consumed fresh pears, with the average consumption of approximately 170 g/day; this equates to 1 medium pear [20], an amount slightly above the reference amount customarily consumed of 140 g [51], or 1 cup equivalent. Thus, those consuming fresh pears met one half of the fruit recommendation for most adults [3]. This is important since the overwhelming majority of adults do not meet the recommendation for fruit consumption [4,5]. Consumption of fresh pears had a positive effect on nutrient intake since consumers had higher UI intakes of dietary fiber, vitamin C, magnesium, copper, and potassium, and higher mean intakes of total sugars; consumers of fresh pears also had lower intakes of total, monounsaturated fatty acids, saturated fatty acids, and added sugars. Consumption was also associated with higher diet quality and lower body weight than that seen in non-consumers.

Comparison of macronutrients suggested more favorable lipid intakes in fresh pear consumers than in non-consumers, presumably due to the low lipid content of fresh pears [20]. Both consumers and non-consumers had mean fat intakes within the Acceptable Macronutrient Distribution Range of 20-35% of energy, set by the Institute of Medicine [52]; however, non-consumers were near the upper range with a mean intake of 34% of energy. Mean MUFA and SFA were lower in consumers which support rat studies which showed

Variable	Pear Pop.	Usual Intake¹		Percentile					EAR	
		Mean ± SE	P	10	25	50	75	90	% Below ± SE	P
Protein (gm)	Consumer	78.0 ± 2.8	0.0866	50.8	60.3	73.1	89.9	111	1.7 ± 1.4	0.7946
	Non-Consumer	82.8 ± 0.4		51.2	62.8	79	99.3	120	2.0 ± 0.2	
Vitamin A, RAE (mcg)	Consumer	686.2 ± 32.5	0.0188	459.8	623.8	633.1	720.6	961.6	20.5 ± 2.6	<0.0001
	Non-Consumer	608.9 ± 5.6		291.8	402.6	560.8	762.5	986.8	49.5 ± 0.8	
Vitamin D² (mcg)	Consumer	4.8 ± 0.3	0.5425	0.2	2.9	4.4	6.2	8.2	96.2 ± 2.1	0.7347
	Non-Consumer	4.6 ± 0.1		1.7	2.7	4	5.9	8.2	95.5 ± 0.3	
Vitamin E³ (mg)	Consumer	8.0 ± 0.4	0.0102	4.2	5.6	7.5	9.9	12.5	88.0 ± 3.1	0.1185
	Non-Consumer	7.4 ± 0.1		4.1	5.3	6.9	9	11.2	93.0 ± 0.4	
Thiamin (mg)	Consumer	1.7 ± 0.1	0.0082	0.1	1.3	1.6	2	2.4	5.1 ± 2.9	0.6513
	Non-Consumer	1.6 ± 0.01		0.1	1.2	1.6	2	2.4	6.4 ± 0.4	
Riboflavin (mg)	Consumer	2.2 ± 0.1	0.8515	1.3	1.6	2.1	2.6	3.2	1.7 ± 1.0	0.5274
	Non-Consumer	2.2 ± 0.01		1.3	1.6	2.1	2.7	3.3	2.4 ± 0.2	
Niacin (mg)	Consumer	24.2 ± 1.0	0.0053	16.2	18.8	22.3	27.6	34.9	0.2 ± 1.1	0.1381
	Non-Consumer	24.8 ± 0.1		14.9	18.5	23.6	30	36.6	1.9 ± 0.3	
Folate, DFE (mcg)	Consumer	569.0 ± 21.3	0.2728	333.4	423.2	541.5	684.3	837	8.3 ± 2.2	0.1548
	Non-Consumer	545.3 ± 3.3		309.4	395.1	513.5	661.2	822.1	11.5 ± 0.5	
Vitamin B_{12} (mcg)	Consumer	4.8 ± 0.2	0.0507	2.3	3.2	4.5	6	7.7	6.8 ± 3.0	0.275
	Non-Consumer	5.3 ± 0.04		2.6	3.5	4.8	6.5	8.4	3.5 ± 0.3	
Vitamin C (mg)	Consumer	107.6 ± 5.7	0.0002	53.9	71.1	96.9	130.8	175.1	19.0 ± 5.3	<0.0001
	Non-Consumer	86.4 ± 1.0		31.8	48.7	75	111.5	155.2	42.5 ± 0.8	
Calcium (mg)	Consumer	906.3 ± 38.0	0.5795	489.7	643.3	850.9	1106	1387	52.6 ± 3.5	0.1402
	Non-Consumer	927.6 ± 5.9		506.4	659.2	870.2	1133	1422	47.4 ± 0.7	
Copper (mg)	Consumer	1.6 ± 0.1	<0.0001	1	1.2	1.5	1.9	2.2	1.1 ± 0.8	<0.0001
	Non-Consumer	1.3 ± 0.01		0.8	1	1.2	1.6	1.9	4.7 ± 0.4	
Magnesium (mg)	Consumer	327.6 ± 12.8	0.0005	196.2	244.9	310.2	390.5	480.2	46.7 ± 4.3	0.0028
	Non-Consumer	291.4 ± 1.6		177.3	220.5	278.6	348.5	422.3	59.8 ± 0.7	
Iron (mg)	Consumer	15.6 ± 0.6	0.9762	9.3	11.7	15	18.7	22.8	8.6 ± 1.6	0.7554
	Non-Consumer	15.6 ± 0.1		9.4	11.6	14.8	18.7	23	8.1 ± 0.3	
Phosphorus (mg)	Consumer	1312.5 ± 46.2	0.3779	822.6	1004	1245	1543	1881	1.2 ± 1.1	0.9332
	Non-Consumer	1353.6 ± 6.0		832.2	1030	1294	1617	1958	1.2 ± 0.2	
Selenium (mcg)	Consumer	110.3 ± 4.2	0.9607	67.1	83.4	104.6	130.8	159.6	0.9 ± 1.0	0.8723
	Non-Consumer	110.1 ± 0.5		68.1	83.6	105.1	131.7	159.4	0.7 ± 0.1	
Zinc (mg)	Consumer	11.3 ± 0.4	0.0537	7	8.6	10.7	13.3	16.3	16.2 ± 4.2	0.3826
	Non-Consumer	12.1 ± 0.1		7.1	8.9	11.4	14.6	18.1	12.5 ± 0.7	

Table 3a: Usual intake and estimated average intake of protein and selected micronutrient among pear consumers (n=492) and non-pear consumers (n=24,317).

Variable	Pear consumption group	Usual Intake¹		Percentile					AI	
		Mean ± SE	P	10	25	50	75	90	% Above ± SE	P
Dietary fiber (gm)	Consumer	24.7 ± 0.7	<0.0001	16.3	19.5	23.8	29	34.3	32.9 ± 3.5	<0.0001
	Non-Consumer	15.9 ± 0.1		8.9	11.6	15.1	19.3	23.8	4.1 ± 0.3	
Sodium (mg)	Consumer	3484.4 ± 66.0	0.0268	2067	2508	3100	3912	4884	99.5 ± 0.7	0.878
	Non-Consumer	3636.5 ± 10.3		2253	2757	3450	4308	5206	99.6 ± 0.1	
Potassium (mg)	Consumer	3000.2 ± 79.9	0.0004	2039	2402	2883	3461	4097	4.3 ± 1.6	0.2127
	Non-Consumer	2710.9 ± 13.5		1676	2083	2613	3236	3877	2.4 ± 0.2	
Total Choline (mg)	Consumer	321.3 ± 13.1	0.4793	218.1	254.1	303.7	368.5	448.7	3.7 ± 2.2	0.2474

Data source: Participants 19 years and older of the NHANES 2001-2010.
Adjusted for the sequence of participant's intake (Day 1 or Day 2) and a variable for weekday/weekend consumption.
Abbreviations: EAR: Estimated Average Requirement; RAE: Retinol Activity Equivalents; DFE: Dietary Folate Equivalents; AI: Adequate Intake.
[1]Excludes Supplement Use.
[2]Vitamin D (D2 + D3) (mcg).
[3]Vitamin E as α-tocopherol (mg).
Abbreviations: AI: Adequate Intake.

Table 3b: Usual intake and adequate intake of protein and selected micronutrient among adult consumers (n=492) and non-consumers (n=24,317) of pears.

that supplementing diets with pear peels had a significant positive influence on plasma lipid levels and antioxidant capacity in rats [53,54]. Our study did not show this positive influence on lipid levels, possibly because pears were consumed peeled or an insufficient amount of peal was consumed. It has also been shown that pear peels, so presumably pears, have different antioxidant capacities [21], so possibly pears with

Variable	Consumers	Non-Consumers	
	LSM ± SE	LSM ± SE	P
HEI-2010 Total Score	58.8 ± 1.2	46.7 ± 0.2	<0.0001
Component 1 (Total Vegetables)	3.2 ± 0.1	3.1 ± 0.02	0.2619
Component 2 (Greens and Beans)	1.7 ± 0.2	1.1 ± 0.02	0.001
Component 3 (Total Fruit)	4.2 ± 0.1	2.2 ± 0.03	<0.0001
Component 4 (Whole Fruit)	4.5 ± 0.1	2.0 ± 0.03	<0.0001
Component 5 (Whole Grains)	3.1 ± 0.2	2.1 ± 0.04	0.0001
Component 6 (Dairy)	4.8 ± 0.3	4.9 ± 0.1	0.67
Component 7 (Total Protein Foods)	4.2 ± 0.1	4.1 ± 0.01	0.8439
Component 8 (Seafood and Plant Protein)	2.4 ± 0.2	1.9 ± 0.02	0.0025
Component 9 (Fatty Acid Ratio)	5.8 ± 0.2	4.9 ± 0.04	0.0002
Component 10 (Sodium)	4.9 ± 0.2	4.2 ± 0.04	0.0039
Component 11 (Refined Grains)	6.5 ± 0.3	5.9 ± 0.1	0.0351
Component 12 (Empty Calories)	13.7 ± 0.4	10.3 ± 0.1	<0.0001

Data source: Participants 19 years and older of the NHANES 2001-2010.
[1]Adjusted for race/ethnicity, age, poverty income ratio, physical activity, smoker status, and alcohol.

Table 4: Healthy eating index-20101 total and component scores for consumers and non-consumers of pears.

Variable	Consumers	Non-Consumers	P
	LSM ± SE	LSM ± SE	
Weight (kg)[1]	78.1 ± 1.3	81.7 ± 0.2	0.0099
Body Mass Index (kg/m^2)[1]	27.4 ± 0.5	28.4 ± 0.1	0.043
Waist Circumference (cm)[1]	94.6 ± 1.1	97.4 ± 0.2	0.014
Apolipoprotein B (mg/dL)[2]	89.8 ± 2.1	94.9 ± 0.6	0.018
Diastolic Blood Pressure (mmHg)[2]	70.3 ± 0.8	71.3 ± 0.2	0.201
Systolic Blood Pressure (mmHg)[2]	122.4 ± 1.0	122.5 ± 0.2	0.966
C-reactive protein (mg/dL)[2]	0.3 ± 0.03	0.4 ± 0.01	0.012
Folate, RBC (ng/mL RBC)[2]	413.2 ± 22.9	390.7 ± 4.9	0.294
Folate, serum (ng/mL)[2]	17.2 ± 1.1	15.7 ± 0.2	0.165
Glucose, plasma (mg/dL)[2]	100.9 ± 1.7	103.0 ± 0.3	0.222
Glycohemoglobin (%)[2]	5.5 ± 0.1	5.5 ± 0.01	0.324
Insulin (uU/mL)[2]	11.6 ± 0.8	11.8 ± 0.2	0.798
HOMA-IR[2]	3.1 ± 0.2	3.2 ± 0.04	0.732
LDL-C (mg/dL)[2]	113.4 ± 2.9	116.9 ± 0.5	0.24
HDL-C (mg/dL)[2]	56.4 ± 1.3	53.4 ± 0.2	0.021
Triglycerides (mg/dL)[2]	133.8 ± 7.5	140.0 ± 1.9	0.434

[1]Adjusted for age, gender, race/ethnicity, poverty index ratio, physical activity level, alcohol intake, and current smoking status.
[2]Adjusted for age, gender, race/ethnicity, poverty index ratio, physical activity level, alcohol intake, current smoking status, and BMI.
Abbreviations: RBC: Red Blood Cell; HOMA-IR: Homeostatic Model Assessment-Insulin Resistance; LDL-C: Low Density Lipoprotein cholesterol; HDL-C: High Density Lipoprotein Cholesterol.

Table 5: Association of consuming pears with physiologic measures in adults participating in 2001-20010 NHANES.

the highest level were not consumed by NHANES participants.

Another important finding of this study was that, although total sugar intake was higher in fresh pear consumers when compared to non-consumers, added sugars were lower. One serving of fresh pears contains approximately 16 grams of total sugar, with approximately 66% fructose [20]. The role of fructose in weight management and weight gain is controversial. Recently, a systematic review and meta-analysis of fructose feeding trials showed that many of the studies were of poor quality, but in isocaloric trials, fructose did not contribute to weight gain when compared with other carbohydrates [55]. More studies are needed.

Dietary fiber and potassium have been identified as nutrients of public health concerns; vitamin C and magnesium have been identified as shortfall nutrients [1]. Fresh pears are an excellent source [56] of dietary fiber; the UI of dietary fiber among pear consumers was approximately equal to the DV [57] and intake was reflected in better nutrient adequacy for dietary fiber than seen in non-consumers. Fresh pears contain both soluble and insoluble fiber [58]; a recent review has shown that the dietary fiber in pears is ~30% soluble and ~70% insoluble [59]. In general, soluble fibers have positive effects on serum lipid levels [60,61] and glycemic control [62] and insoluble fibers have positive effects on laxation [63]. Our study did not show differences in lipid levels or markers of glycemic control; perhaps the amount of soluble fiber consumed was too low to see a response or the UI of fiber; although mean fiber consumption among consumers in this study nearly met the daily value of 25 g [64], did not reflect long term intake that would have affected lipid or blood glucose levels. It is also possible that fiber intake was not high enough to affect these CVRF [62].

Population studies have shown that high intake of dietary fiber is inversely related to the incidence [65] or risk [66,67] of stroke. Few studies have looked at the relationship between specific types of fruit and stroke [67]; however, this association has been studied explicitly for pears and the botanically related apple, and pears may contribute to protection against stroke [16,17,68-70]. It is not clear if the dietary fiber content of pears is associated with protection against stroke, although dietary fiber intake has been inversely related to high blood pressure,

Variable	Consumers[1]			P
	OR	LCL	UCL	
Overweight[2]	1	0.75	1.33	1
Overweight/Obese[2]	0.7	0.48	0.92	0.014
Obese[2]	0.7	0.47	0.9	0.01
Waist Circumference, Elevated[2]	0.7	0.54	1.02	0.066
Diastolic Blood Pressure,[4] Elevated[3]	1	0.71	1.31	0.814
Systolic Blood Pressure,[4] Elevated[3]	1	0.76	1.42	0.791
Glucose, Elevated[3]	0.9	0.6	1.38	0.649
Insulin, Elevated[3]	1.4	0.91	2.14	0.125
HDL-C, Reduced[3]	1.1	0.78	1.51	0.64
LDL-C, Elevated[3]	1	0.63	1.54	0.942
Triglycerides, Elevated[3]	1	0.71	1.52	0.844
Metabolic Syndrome[3]	1.2	0.78	1.18	0.408

Data source: Adults 19+ years of age participating in NHANES 2001-2010.
[1]Non-Consumers were the referent group.
[2]Adjusted for: Age, Gender, Race/Ethnicity, Poverty Index Ratio, Physical Activity Level, Smoker Status, Alcohol Consumption.
[3]Adjusted for: Age, Gender, Race/Ethnicity, Poverty Index Ratio, Physical Activity Level, Smoker Status, Alcohol Consumption, and BMI.
[4]Mean readings were used for blood pressure measurements.
Reduced HDL-cholesterol was defined as <40 mg/dL (males), <50 mg/dL (females); high triglycerides, ≥150 mg/dL or taking anti-hyperlipidemic medications; high fasting glucose, ≥ 110 mg/dL or taking insulin or other hypoglycemic agents. Elevated LDL-C ≥100 mg/dL
Metabolic syndrome was defined using the National Heart Lung and Blood Institute Adult Treatment Panel III criteria; that is having 3 or more of the following risk factors: abdominal obesity, WC>102 cm (males), >88 cm (females); hypertension, SBP ≥130 mmHg or DBP ≥85 mmHg or taking anti-hypertensive medications; HDL-cholesterol, <40 mg/dL (males), <50 mg/dL (females); high triglycerides, ≥150 mg/dL or taking anti-hyperlipidemic medications; high fasting glucose, ≥110 mg/dL or taking insulin or other hypoglycemic agents.
Abbreviations: OR: Odds Ratio; LCL: Lower Confidence level; UCL: Upper Confidence Level; HDL-C: High Density Lipoprotein Cholesterol; LDL-C: Low Density Lipoprotein Cholesterol.

Table 6: Risk of overweight and obesity and cardiovascular and metabolic syndrome risk factors in adults among consumers pears, when compared with non-consumers.

which is associated with reduced risk of stroke [71]. Our study did not show that fresh pear consumers had lower systolic or diastolic blood pressure than non-consumers, so any potential effect on stroke is unknown.

A previous NHANES study has shown that dietary fiber may be associated with lower weight in adults [72]. Since there was no difference in energy intake or level of physical activity between the fresh pear consumption and non-consumption groups, the fiber intake may have driven the lower body weights which were seen in this study.

The HEI-2010 has been shown to be a valid and reliable [35]. Mean HEI-2010 total scores, and most component scores, in fresh pear consumers were significantly higher than non-consumers suggesting that pears contributed to an overall healthy diet. Only the component scores for dairy, total protein foods, and refined grains were not higher among pear consumers, suggesting an overall healthier diet among fresh pear consumers. It should be noted however, that neither group had an especially high total score and some of the component scores could be misleading. For example, the component score for greens and beans for fresh pear consumers was only 1.7 and for non-consumers, it was 1.1, suggesting that improvements could be made by both groups. Fresh pear consumers did, however, have much higher total and whole fruit components than non-consumers, suggesting that they may come close to meeting their fruit recommendation [3].

The principal strength of this study was that it was nationally representative. The study did have several weaknesses. The sample size (number of adult pear consumers) while acceptable for these analyses, was small in terms of large epidemiologic studies. Further, 24-hour dietary recalls have several inherent limitations: they depend on memory and subjects may under- or over-report some or certain types of foods. The possibility of misclassifying someone as a fresh pear consumer or non-consumer is also a possibility. Results were also dependent on USDA nutrient content. 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 NHANES is a cross-sectional study, and the data cannot be used to draw causal relationships.

Summary and Conclusions

Fresh pear consumption among adults is 169.5 g/day. Fresh pears contributed to fiber (21% DV) and vitamin C (12% DV) intake among adult consumers. Adult pear consumers, as compared to non-consumers, had higher dietary intake and lower prevalence of inadequacy for dietary fiber, vitamin C, potassium, and magnesium and lower prevalence of inadequacy for vitamin A. Adult pear consumers, as compared to non-consumers, had higher diet quality. Adult pear consumers had a lower body weight and were less likely to be obese as compared to non-consumers. These data suggest that consumption of fresh pears should be encouraged as part of an overall healthy diet [2], since pears are nutrient-dense and can help individuals meet the fruit recommendation. Additional studies are needed to determine effects on specific CVRF.

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