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Associations of 100% Fruit Juice versus Whole Fruit with Hypertension and Diabetes Risk in Postmenopausal Women: Results from the Women's Health Initiative

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Dr. Auerbach conceived the study, completed the analysis, and led the writing. Drs. Littman, Tinker, Krieger, and Young helped design the study, contributed to analysis and interpretation of results, and critically review the manuscript for important intellectual content. Mr. Larsen completed the analysis and critically reviewed the manuscript for important intellectual content. Dr. Neuhouser conceived the study, supervised the overall project, and revised the manuscript for important intellectual content.

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Abstract

The objective of this study was to determine whether consumption of 100% fruit juice as compared to whole fruit is associated with increased risk of hypertension or diabetes. We analyzed postmenopausal women in the United States enrolled in the Women's Health Initiative between 1993 and 1998. Whole fruit and 100% fruit juice intake were assessed by baseline food frequency questionnaire. Standardized questionnaires assessed outcomes every 6–12 months during a mean 7.8 years of follow-up. Cox regression estimated hazard ratios (HR) and 95% confidence intervals (CI) for incident hypertension (n= 36,314 incident cases/80,539 total participants) and diabetes (n=11,488 incident cases/114,219 total participants). In multivariable analyses there was no significant association comparing the highest to lowest quintiles of 100% fruit juice consumption (8 ounces/day compared to none) and incident hypertension (HR 1.00, 95% CI 0.97–1.03) or diabetes (HR 0.96, 95% CI 0.90–1.03). There was also no significant association between whole fruit consumption (2.4 servings/day compared to 0.3 servings/day) and incident hypertension (HR 1.02, 95% CI 0.98–1.05) or diabetes (HR 1.03, 95% CI 0.96–1.10). Consuming moderate amounts of 100% fruit juice or whole fruit was not significantly associated with risk of hypertension or diabetes among postmenopausal US women.

Introduction

One hundred percent fruit juice is rich in nutrients, such as polyphenols, but it is also high in naturally occurring sugars and may be associated with adverse cardiometabolic health effects, such as hypertension or diabetes.[i,ii] Experts disagree on whether 100% fruit juice should be included as a harmful beverage in healthy beverage policies such as taxes on sugary beverages, food warning labels, and traffic light food labeling programs that seek to prevent obesity and diabetes.[iii,iv] Policy makers need guidance as to where 100% fruit juice falls in the health spectrum of beverage options, and to understand the cardiometabolic health effects of 100% fruit juice versus whole fruit consumption.

One hundred percent fruit juice may be associated with hypertension and diabetes through several possible biological mechanisms: (1) Increased energy intake and weight gain;[v] (2) 100% fruit juices have moderately high glycemic indices,[vi] and consumption of large portions of 100% fruit juice may cause a high postprandial insulin response that predisposes to diabetes through a mechanism independent of weight gain;[vii] (3) Metabolism of the fructose in 100% fruit juice may increase uric acid production, which is associated with both elevated blood pressure and insulin resistance.[viii,ix]

Despite the theoretical impact of a diet high in 100% fruit juice on cardiometabolic health, meta-analyses have found limited evidence that 100% fruit juice consumption is associated with changes in blood pressure or incident diabetes.[x,xi,xii] Liu et al. conducted a meta-analysis of randomized controlled trials (RCTs) analyzing the effect of consuming 4–17 oz. per day (/d) of 100% fruit juice, compared to water or non-caloric beverages, on short-term

changes in blood pressure.[10] They found slightly lower systolic blood pressure (−2.0 mmHg; 95% CI −4.5 mmHg, 0.4 mmHg) and diastolic blood pressure (−2.1 mmHg; 95% CI −3.8 mmHg, −0.4 mmHg) in the group that consumed 100% fruit juice. However, these findings may be systematically biased because the included RCTs had short follow-up durations (5–12 weeks) and participants in some RCTs had baseline chronic diseases that affect blood pressure. Regarding diabetes, two meta-analyses of prospective cohort studies found evidence that consuming 100% fruit juice was associated with a small increase in diabetes risk in adults (relative risk < 1.1), but these findings were unstable in sensitivity analyses.[11,12] Studies included in these two meta-analyses did not examine a population of postmenopausal women, who are at higher risk of diabetes compared to premenopausal women.[xiii,xiv,xv]

The question of how much 100% fruit juice adults should drink is important to consumers and policy makers. We undertook this secondary analysis of the Women's Health Initiative (WHI) to determine if consumption of fruit juice, compared to whole fruit, is associated with incident hypertension or diabetes in a large and diverse sample of postmenopausal women at higher risk for these outcomes. We selected whole fruit as a comparison group because the question of whether 100% fruit juice and whole fruit have different associations with cardiometabolic disease risk is controversial. We hypothesized that consumption of 100% fruit juice, but not whole fruit, would be associated with a small increase in hypertension and diabetes risk.

Methods

Study Design and Population

The design and methods of the WHI have been described elsewhere.[xvi] Briefly, the WHI enrolled 161,808 postmenopausal women ages 50–79 years between 1993–1998 into the WHI Observational Study (OS) and 3 RCTs. We analyzed participants in the OS (n = 93,679) and comparison arm of the Dietary Modification Clinical Trial (DM CT, n = 29,294). Participants in the comparison arm of the DM CT did not receive the low-fat, high fruit and vegetable dietary modification intervention.

Our inclusion criterion was baseline food frequency questionnaire (FFQ) completion. Our exclusion criteria were (1) Energy intake outliers on baseline FFQ (defined as ≤ 600 kcal/day or ≥ 5000 kcal/day),[xvii] (2a) baseline self-reported past or current hypertension for the analyses of incident hypertension, (2b) baseline self-reported past or current diabetes (not counting gestational diabetes) for the analyses of incident diabetes, and (3) missing answers to the two 100% fruit juice questions on the FFQ (Supplementary Tables A and B).

Exposure Assessment

Our exposure of interest was 100% fruit juice consumption, as measured by a semi-quantitative FFQ designed for the WHI.[xviii] FFQs were administered at baseline to all participants. The FFQ contained 2 separate items asking about (1) 100% orange and grapefruit juices, and (2) all other 100% fruit juice types. Participants were asked to specify their usual serving size as small (3 oz.), medium (6 oz.), or large (12 oz.), and to indicate the

frequency of intake. To increase statistical power and reduce measurement error by constraining outliers, the exposure was parametrized as quintiles of 100% fruit juice/d. Twelve percent of participants reported no 100% fruit juice consumption, and therefore we modified the first quintile to only include participants who drank no 100% fruit juice. WHI FFQ estimates are reproducible over time (the mean correlation coefficient for repeated assessment of individual nutrient or food groups is 0.76), and levels of misclassification are modest (means estimated by the FFQ for most nutrient and food groups are within 10% of means estimated by food records).[18] We standardized intake of 100% fruit juice intake and whole fruit to 2000 kilocalories (kcal)/d using the residual method.[19]

Covariate Assessment

Data on demographic characteristics, medical history, and health behaviors were collected at baseline using standardized questionnaires.[xix] Physical measurements were measured by trained and certified study personnel at baseline using standardized protocols and calibrated equipment.

Outcome Assessment

Our primary outcomes were self-reported incident hypertension or diabetes. Standardized medical history questionnaires asking about new treatment of hypertension and diabetes were completed every 6–12 months until the conclusion of these studies in March 2005. Participants were considered to have incident hypertension or diabetes if they initiated medication to treat hypertension (“pills for high blood pressure”) or diabetes (“pills or insulin shots for diabetes”). Data from a WHI data confirmation study showed that incident diabetes as measured by this question was consistent with medication inventories and fasting plasma glucose levels.[23] Nearly 80% of the participants at baseline who self-reported treatment with either insulin or oral medication for diabetes had a diabetes medication in their baseline medication inventory, and nearly 100% of women without self-reported treated diabetes had no diabetes medication in their baseline inventory.[xx] Self-reported incident hypertension has been used in other WHI analyses.[xxi]

Statistical Analysis

We used Cox proportional hazards to estimate the univariate and multivariable-adjusted hazard ratio (HR) of incident hypertension and diabetes. Time at risk was calculated from baseline to the date of first diagnosis reported on follow-up questionnaire or among those disease-free, until the participants’ last follow-up visit (April 2004 – March 2005). The proportional-hazards assumption was not rejected based on Schoenfeld residuals. The hazard ratios estimated for quintiles II – V compare the participants in each upper quintile to the participants in the first quintile. Likewise, in exploratory analyses of higher levels of consumption that expressed exposures in terms of servings/time, the higher categories of consumption are each compared to the lowest category of consumption (< 4 servings/week).

A median approach was used to examine the trend across quintiles. The median oz./d of 100% fruit juice in one quintile was assigned to all participants in that quintile. The statistical significance of the trend was tested with Cox regression using the mean intake

value as a continuous independent variable. A median approach was also used to examine the trend across the categories of consumption in exploratory analyses.

Baseline variables considered as potential confounders were age (years), education level (4 levels), race/ethnicity (Asian/Pacific, Black, Hispanic/Latino, White; categories mutually exclusive), smoking status (never, past, current), number of alcoholic drinks/week, leisure-time physical activity (metabolic equivalent [MET]-hours/week), body mass index (BMI, as a continuous variable), mean daily sodium intake (mg/d), total energy intake (kcal/d), Healthy Eating Index (HEI) score,[xxii] WHI study arm (OS or DM CT control-arm), and use of postmenopausal hormone replacement therapy (never, past, current). Selected variables derived from the FFQ that were associated with < 10% change in the regression coefficient comparing the highest to lowest quintiles for 100% fruit juice consumption were dropped from the final regression models for parsimony (alcoholic drinks/week, mean sodium/d, and HEI score). All analyses were conducted with Stata (version 14, StataCorpLP, College Station, Texas). A two-sided p-value < 0.05 was considered statistically significant for all analyses.

We performed several exploratory analyses to determine whether hypertension or diabetes risk varied between subgroups of postmenopausal women. We examined the influence of (1) stratifying by decade of age; (2) stratifying by study arm; (3) stratifying by baseline blood pressure category; (4) stratifying by race/ethnicity; (5) classifying the exposure as tertiles and quartiles; (6) performing change analysis as described Smith et al.,[xxiii] which measured change in 100% fruit juice consumption and change in incident hypertension and diabetes over the same 3-year time period; (7) using cutpoints defined by Borgi et al.[xxiv] to categorize the 100% fruit juice exposure (≤ 4 servings/week; 5–6 servings/week; 1 serving/d; 2–3 servings/d; ≥ 4 servings/d); (8) sub-classifying the exposures of 100% fruit juice and whole fruit into categories of citrus and non-citrus; and (9) restricting the analytic sample to the highest quintile of 100% fruit juice consumers.

Ethics

The WHI study protocol was approved by Institutional Review Boards (IRBs) at each participating institution, and all participants provided written informed consent.

Results

The baseline characteristics of the 80,539 participants analyzed for incident hypertension and 114,219 participants analyzed for incident diabetes are reported in Tables 1 & 2. More participants in the highest quintile of 100% fruit juice consumption (median 8 oz./d of 100% fruit juice) were older, had a normal BMI, were African American, had higher educational attainment, and had a higher HEI diet quality score.

Higher versus lower 100% fruit juice consumption was not associated with incident hypertension (Table 3) or diabetes (Table 4) over a mean individual follow-up time of 7.8 years. In multivariable-adjusted analyses comparing highest to lowest quintiles, 100% fruit juice intake was not associated with incident hypertension (HR 1.01, 95% CI 0.97–1.04) or

diabetes (HR 0.97, 95% CI 0.91–1.03). Relationships were similar in the univariate and the multivariable-adjusted models.

Higher versus lower whole fruit consumption was also not associated with incident hypertension (Table 3) or diabetes (Table 4) In multivariable-adjusted analyses comparing the highest to lowest quintiles, whole fruit intake was not associated with risk of hypertension (HR 1.01, 95% CI 0.98–1.04) or diabetes (HR 1.00, 95% CI 0.94–1.06), and associations were similar in univariate and multivariable-adjusted models. Exploratory analyses stratified by baseline age, race/ethnicity, study arm, and blood pressure did not change the results or their interpretation. Change analysis, classifying exposures as tertiles or quartiles, and restricting the analytic sample to the highest quintile of consumers also did not change our results. Exploratory analyses categorizing the exposures of 100% fruit juice and whole fruit using cut-points based on serving frequency showed an increase in hypertension risk associated with consuming ≥ 24 oz./d of 100% fruit juice vs. ≤ 4 oz./day (HR 1.29, 95% CI 1.06–1.57), and the trend of increasing serving frequency and greater hypertension risk was significant (P for trend = 0.03; Table 5). Categorizing the exposures using cut-points of serving frequency (< 4 servings/week, 5–6 servings/week, 1 serving/day, etc) otherwise yielded null associations for trend (Table 5). In exploratory analyses comparing citrus and non-citrus fruit and fruit juice, the increase in hypertension risk associated with consuming multiple servings per day of 100% fruit juice was only observed for non-citrus juices (Supplementary Table C).

Discussion

Our objective was to investigate whether 100% fruit juice consumption was associated with incident hypertension and diabetes in postmenopausal US women. Compared to no consumption of 100% fruit juice, we found no evidence that consumption of 8 oz./d of 100% fruit juice was associated with incident hypertension or diabetes. In exploratory analyses, consuming ≥ 24 oz./d of 100% fruit juice, compared to consuming ≤ 4 oz./day, was associated with increased hypertension risk (but not diabetes risk). Non-citrus fruit juices were associated with this increase in hypertension risk, while citrus fruit juices were not. We also analyzed the association of differing levels of whole fruit consumption and hypertension and diabetes risk. Compared to consuming less then 1/3 serving per day of whole fruit, consuming 2.5 servings/d whole fruit was associated not associated with incident hypertension or diabetes.

To our knowledge, this is the first longitudinal analysis of 100% fruit juice intake and hypertension risk. Previous cohort studies have examined the association of whole fruit, but not 100% fruit juice, with risk of hypertension. Borgi and colleagues analyzed 187,453 US adults for a mean follow-up time of 15.7 years.[24] They compared participants who consumed ≥ 4 servings/d of whole fruit to participants who consumed ≤ 4 servings/week of whole fruit, and found a multivariable adjusted HR of 0.92 (95% CI 0.87–0.97) for incident hypertension. When we analyzed 100% fruit juice and whole fruit dietary exposures using the same categories as Borgi et al., we found that whole fruit was associated with a similar, but non-significant decreased risk of hypertension (HR 0.94; 95% CI 0.83–1.05), and found that comparing the highest to lowest categories of 100% fruit juice consumption was

associated with an increased risk of hypertension (HR 1.29; 95% CI 1.06–1.56), with a significant increasing trend across categories (P for trend = 0.03).

Our findings that neither 100% fruit juice nor whole fruit consumption were associated with increased diabetes risk differ slightly from other cohort studies.[11,12,25,27] Muraki and colleagues analyzed 187,382 adults in the same 3 cohort studies as Borgi and colleagues over a mean follow-up time of 18.5 years. They analyzed the associations of changes in consumption over 4-year time periods of (1) 100% fruit juice, and (2) whole fruit, with diabetes risk over the same 4-year time periods.[xxv] In multivariable analyses, each 3-serving/week increment in 100% fruit juice consumption was associated with an 8% (95% CI 1.05, 1.11) increased risk of incident diabetes. Each 3-serving/week increment in whole fruit consumption was associated with a decreased risk of incident diabetes (HR 0.98, 95% CI 0.96, 0.99). Though statistically significant, the HRs found by Muraki et al. are close to a null HR of 1.0 and do not suggest a large impact.

The WHI is not well suited to study sugar-sweetened beverages (SSBs) due to low consumption of SSBs, but meta-analyses of other prospective cohort studies found that SSBs are consistently associated with increased cardiometabolic disease risk. Consumption of 1 serving/d of SSB is independently associated with gaining 1 lb/4 years among US adults, compared to gaining 0.3 lb/4 years for 100% fruit juice.[2] In meta-analyses comparing the highest versus lowest quantiles of SSB consumption, high SSB consumers had a 12% increased risk of hypertension,[xxvi] 26% increased risk of type 2 diabetes,[xxvii] and 19% increased risk of cardiovascular disease.[xxviii]

Our findings are relevant to dietary policy. The 2015–2020 Dietary Guidelines for Americans (DGA)[xxix] recommend that adults limit 100% fruit juice to 8 oz./d. These guidelines also emphasize that consuming water and whole fruit is preferred to 100% fruit juice, since 100% fruit juice contains less dietary fiber than whole fruit, and when consumed in excess, 100% fruit juice may contribute extra calories to Americans' diets. Our findings showed that consumption of 8 oz./d of 100% fruit juice was not associated with increased risk of hypertension or diabetes. Given stronger associations of SSB consumption with cardiometabolic diseases, our results do not support treating 100% fruit juice like SSBs in dietary policies.

This analysis has limitations. Exposure misclassification may be present from participants misunderstanding questions on the FFQ about 100% fruit juice versus fruit drinks such as Tang®. Despite adjusting for nine covariates, there may be residual unmeasured confounding of healthy behaviors and 100% fruit juice consumption, which could bias our associations towards the null.[16] Fruit juice consumption among WHI participants was relatively low, reducing power to examine whether higher levels of consumption are more strongly associated with risk of diabetes or hypertension. Subgroup analysis of participants with pre-diabetes was not possible. Finally, our outcome measure of incident hypertension was based on self-report, which has been used in other WHI analyses but has not been objectively validated.[24]

Conclusion

In this secondary analysis of postmenopausal US women in the WHI, consumption of 8 oz./d of 100% fruit juice was not associated with incident hypertension or diabetes. Consumption of high levels of 100% fruit juice (≥ 24 oz./d) was associated with an increased risk of hypertension, but not diabetes. Our findings that consuming moderate amounts of 100% fruit juice is not associated with hypertension and diabetes risk stand in contrast to evidence linking consumption of moderate amounts of sugar-sweetened beverages to these diseases.[5, 28–30] Our results suggest that consuming ≤ 8 oz./d of 100% fruit juice, as recommended by the Dietary Guidelines for Americans, does not increase risk of hypertension or diabetes.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Abbreviations

Adj	adjusted
BMI	body mass index
CVD	cardiovascular disease
/d	per day
HEI	Healthy Eating Index
HR	hazard ratio
HTN	hypertension
IR	incidence rate
kcal	kilocalories
MET	Metabolic Equivalent of Task
mmHg	millimeters of mercury
Oz	ounce
RCT	randomized controlled trial

Ref	reference
RR	relative risk
Serv	servings
PY	person-years

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Highlights

- We examined if drinking 100% fruit juice is linked to hypertension or diabetes risk
- Drinking 1 serving/day of 100% fruit juice did not increase risk of either disease
- Drinking 4 servings/day of 100% fruit juice increased hypertension risk (but not diabetes)

Table 1

Baseline Characteristics According to 100% Fruit Juice Consumption of 80,539 Postmenopausal US Women Analyzed for Hypertension Risk

	Modified Quintiles of 100% Fruit Juice Consumption				
	I	**II**	**III**	**IV**	**V**
Median oz./d of 100% fruit juice	**0**	**1.0**	**2.6**	**4.9**	**8.0**
Range oz./d of 100% fruit juice	**0**	**0.06–1.7**	**1.8–3.7**	**3.8–6.5**	**6.6–36.8**
N	**10,317**	**17,556**	**17,555**	**17,556**	**17,555**
Age, years					
50–59	37.1%	41.7%	36.8%	33.8%	35.7%
60–69	44.3%	42.6%	43.7%	44.1%	42.7%
70–79	18.5%	15.8%	19.5%	22.1%	21.6%
BMI category, kg/m^2					
Normal (18.5 – 24.9)	40.0%	37.6%	41.3%	43.6%	47.9%
Overweight (25.0 – 29.9)	34.6%	35.7%	34.7%	34.7%	32.7%
Obese (> 30.0)	23.9%	25.9%	22.6%	20.6%	16.2%
Blood pressure, mmHg					
Systolic	122 ± 16	122 ± 16	123 ± 16	123 ± 16	123 ± 16
Diastolic	73 ± 9	74 ± 9	73 ± 9	73 ± 9	73 ± 9
Race/Ethnicity					
Asian/Pacific	2.6%	2.5%	2.7%	2.7%	2.4%
Black	3.9%	4.2%	6.0%	6.6%	7.2%
Hispanic/Latino	3.8%	4.2%	4.4%	3.6%	3.2%
White	88.1%	87.6%	85.4%	85.8%	85.9%
Education					
< High school diploma	5.1%	4.2%	4.3%	3.6%	3.5%
High school diploma	18.1%	15.9%	15.9%	15.1%	13.0%
School after high school	37.8%	36.8%	36.8%	36.4%	34.1%
College degree or higher	39.1%	43.1%	43.0%	44.9%	49.5%
Smoking					
Never	50.9%	50.7%	51.8%	51.6%	51.3%

	Modified Quintiles of 100% Fruit Juice Consumption				
	I	II	III	IV	V
Past	41.9%	42.1%	41.2%	41.5%	41.9%
Current	7.3%	7.1%	7.1%	6.9%	6.8%
Use of postmenopausal hormones					
Never	43.7%	43.6%	44.7%	44.1%	44.8%
Past	15.9%	16.4%	16.4%	16.2%	15.1%
Current	40.4%	40.0%	38.9%	39.7%	40.1%
Recreational physical activity level, MET-hours/week	12.2 ± 13.5	11.6 ± 13.3	12.1 ± 13.8	11.9 ± 13.5	12.1 ± 13.6
Energy intake, Kcal/day	1492 ± 593	1778 ± 680	1545 ± 596	1621 ± 606	1612 ± 576
2005 HEI diet quality score	66.7 ± 11.9	65.5 ± 11.3	67.7 ± 10.4	69.1 ± 9.8	71.0 ± 9.1

All characteristics were assessed at baseline (1993–1998). Values are mean ± SD (continuous variables) or percent (categorical variables). Not all categories sum to 100% due to rounding of data within some categories. Servings/d of 100% fruit juice are adjusted for energy using the residual method, and standardized to 2000 kcal/d. The Women's Health Initiative enrolled participants between 1993–1998 throughout the United States.

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Table 2

Baseline Characteristics According to 100% Fruit Juice Consumption of 114,219 Postmenopausal US Women Analyzed for Diabetes Risk

	Modified Quintiles of 100% Fruit Juice Consumption				
	I	II	III	IV	V
Median oz./d of 100% fruit juice	**0**	**1.0**	**2.7**	**5.1**	**8.0**
Range oz./d of 100% fruit juice	**0**	**0.06–1.7**	**1.8–3.8**	**3.9–6.5**	**6.6–36.8**
N	**14,008**	**25,053**	**25,053**	**25,053**	**25,052**
Age, years					
50–59	33.7%	38.2%	32.9%	30.1%	31.6%
60–69	45.1%	44.0%	44.6%	45.3%	43.8%
70–79	21.2%	17.8%	22.5%	24.6%	24.6%
BMI category, kg/m^2					
Normal (18.5 – 24.9)	35.7%	32.9%	37.6%	38.8%	42.1%
Overweight (25.0 – 29.9)	34.6%	35.2%	35.3%	34.7%	33.7%
Obese (> 30.0)	28.4%	31.0%	26.6%	25.5%	23.3%
Blood pressure, mmHg					
Systolic	126 ± 18	126 ± 17	127 ± 18	127 ± 18	127 ± 18
Diastolic	75 ± 9	75 ± 9	75 ± 9	75 ± 9	75 ± 9
Race/Ethnicity					
Asian/Pacific	2.5%	2.6%	2.8%	2.6%	2.5%
Black	4.6%	5.6%	7.7%	8.8%	10.2%
Hispanic/Latino	3.4%	3.9%	3.9%	3.3%	3.1%
White	87.9%	86.3%	83.9%	84.0%	82.8%
Education					
< High school diploma	5.3%	4.6%	4.8%	4.2%	4.1%
High school diploma	19.0%	16.6%	16.8%	16.1%	13.9%
School after high school	38.5%	37.6%	37.7%	37.1%	35.3%
College degree or higher	37.2 %	41.2%	40.6%	42.7%	46.7%
Smoking					
Never	51.1%	51.3%	51.6%	51.4%	51.7%

	Modified Quintiles of 100% Fruit Juice Consumption				
	I	II	III	IV	V
Past	41.9%	41.7%	41.3%	41.4%	41.4%
Current	7.0%	7.0%	7.1%	7.2%	6.9%
Use of postmenopausal hormones					
Never	43.6%	43.8%	44.7%	44.2%	44.6%
Past	15.9%	16.4%	16.1%	16.4%	15.6%
Current	40.4%	39.8%	39.2%	39.5%	39.8%
Recreational physical activity level, MET-hours/week	12.1 ± 13.5	11.8 ±13.3	12.1 ± 13.7	11.9 ± 13.5	12.1 ± 13.5
Energy intake, Kcal/day	1493 ± 597	1770 ± 690	1556 ± 599	1634 ± 614	1610 ± 596
2005 HEI diet quality score	66.4 ± 11.8	65.3 ± 11.4	67.6 ± 10.5	68.9 ± 9.9	70.9 ± 9.2

All characteristics were assessed at baseline (1993–1998). Values are mean ± SD (continuous variables) or percent (categorical variables). Not all categories sum to 100% due to rounding of data within some categories. Servings/d of 100% fruit juice are adjusted for energy using the residual method, and standardized to 2000 kcal/d. The Women's Health Initiative enrolled participants between 1993–1998 throughout the United States.

Table 3

Associations of 100% Fruit Juice and Whole Fruit Consumption with Hypertension Risk in 80,539 Postmenopausal US Women

Hypertension Risk According to 100% Fruit Juice Consumption						
	Modified Quintiles of 100% Fruit Juice Consumption					
	I	**II**	**III**	**IV**	**V**	**P for Trend**
Median oz./d	**0**	**1.0**	**2.6**	**4.9**	**7.8**	
Person-years of follow-up	58,299	100,796	100,614	99,971	99,467	
Number of incident cases	5994	10,087	9971	10,036	10,114	
Incidence rate, per 1000 person-years	103	100	99.1	100	102	
Multivariable-adjusted * hazard ratio (95% CI)	1.0 (ref)	0.98 (0.94–1.01)	0.97 (0.94–1.01)	0.98 (0.94–1.01)	1.01 (0.97–1.04)	0.21

Hypertension Risk According to Whole Fruit Consumption						
	Quintiles of 100% Whole Fruit Consumption					
	I	**II**	**III**	**IV**	**V**	**P for Trend**
Median servings/d	**0.3**	**0.7**	**0.9**	**1.6**	**2.4**	
Person-years of follow-up	92,241	91,812	91,647	91,953	91,494	
Number of incident cases	9244	9239	9263	9214	9242	
Incidence rate, per 1000 person-years	100	101	101	100	101	
Multivariable-adjusted * hazard ratio (95% CI)	1.0 (ref)	1.00 (0.97–1.04)	1.01 (0.98–1.04)	1.00 (0.97–1.03)	1.01 (0.98–1.04)	0.91

Abbreviations: CI (confidence interval), /d (per day), P (probability)

* Adjusted for age, education level, race/ethnicity, smoking status, physical activity, body mass index, hormone replacement therapy status, study arm, and total energy intake. Univariate and multivariable-adjusted models yielded nearly identical hazard ratios and 95% confidence intervals.

Hazard ratios estimated for quintiles II – V compare the participants in each upper quintile to the participants in the first quintile.

The Women's Health Initiative enrolled participants between 1993–1998 throughout the United States.

Table 4

Associations of 100% Fruit Juice and Whole Fruit Consumption and Diabetes Risk in 114,219 Postmenopausal US Women

Diabetes Risk According to 100% Fruit Juice Consumption						
	Modified Quintiles of 100% Fruit Juice Consumption					
	I	**II**	**III**	**IV**	**V**	**P for Trend**
Median oz./d	**0**	**1.0**	**2.7**	**5.1**	**8.0**	
Person-years of follow-up	102,874	183,543	183,980	183,210	184,126	
Number of incident cases	1435	2529	2522	2541	2461	
Incidence rate, per 1000 person-years	13.9	13.8	13.7	13.9	13.4	
Multivariable-adjusted * hazard ratio (95% CI)	1.0 (ref)	0.98 (0.92, 1.04)	0.99 (0.93–1.05)	1.00 (0.93–1.07)	0.97 (0.91–1.03)	0.17

Diabetes Risk According to Whole Fruit Consumption						
	Quintiles of 100% Whole Fruit Consumption					
	I	**II**	**III**	**IV**	**V**	**P for Trend**
Median servings/d	**0.3**	**0.6**	**0.9**	**1.6**	**2.4**	
Person-years of follow-up	167,457	167,857	167,421	167,277	167,721	
Number of incident cases	2329	2406	2255	2217	2281	
Incidence rate, per 1000 person-years	13.9	14.4	13.4	13.2	13.6	
Multivariable-adjusted * hazard ratio (95% CI)	1.0 (ref)	1.03 (0.97–1.10)	0.97 (0.91–1.03)	0.95 (0.89–1.01)	1.00 (0.94–1.06)	0.34

Abbreviations: CI (confidence interval), /d (per day), P (probability)

* Adjusted for age, education level, race/ethnicity, smoking status, physical activity, body mass index, hormone replacement therapy status, study arm, and total energy intake. Univariate and multivariable-adjusted models yielded nearly identical hazard ratios and 95% confidence intervals.

Hazard ratios estimated for quintiles II – V compare the participants in each upper quintile to the participants in the first quintile.

The Women's Health Initiative enrolled participants between 1993–1998 throughout the United States.

Table 5

Exploratory Analysis: Exposures Defined Using Cut-points

Incidence of Hypertension Between 1993 and 2005 According to 100% Fruit Juice and Whole Fruit Consumption in 80,539 Postmenopausal US Women						
	100% Fruit Juice			Whole Fruit		
	N	IR, per 1000 PY	Multivariable Adj HR (95% CI)	N	IR, per 1000 PY	Multivariable Adj HR (95% CI)
≤ 4 serv/week	42,854	2.8	1.0 (ref)	19,651	2.7	1.0 (ref)
5–6 serv/week	16,530	2.7	0.99 (0.97–1.01)	23,933	2.8	1.02 (1.00–1.04)
1 serv/day	17,905	2.8	1.02 (0.99–1.04)	23,530	2.8	1.01 (0.98–1.05)
2–3 serv/day	2647	2.9	1.04 (0.99–1.10)	12,397	2.8	1.02 (0.98–1.05)
≥ 4 serv/day	159	3.4	1.29 (1.06–1.56)	584	2.6	0.94 (0.83–1.05)
P for Trend	0.03			0.76		

Incidence of Diabetes Between 1993 and 2005 According to 100% Fruit Juice and Whole Fruit Consumption in 114,219 Postmenopausal US Women						
	100% Fruit Juice			Whole Fruit		
	N	IR, per 1000 PY	Multivariable Adj HR (95% CI)	N	IR, per 1000 PY	Multivariable Adj HR (95% CI)
≤ 4 serv/week	59,226	13.8	1.0 (ref)	28,633	13.8	1.0 (ref)
5–6 serv/week	24,010	13.9	1.01 (0.97–1.07)	34,213	14.1	1.03 (0.97–1.08)
1 serv/day	26,142	13.5	0.97 (0.93–1.02)	32,771	13.4	1.00 (0.94–1.06)
2–3 serv/day	3972	13.4	0.97 (0.87–1.08)	17,180	13.5	1.04 (0.96–1.11)
≥ 4 serv/day	253	10.5	0.82 (0.53–1.27)	806	13.3	0.93 (0.73–1.18)
P for Trend	0.18			0.28		

Abbreviations: adj (adjusted), HR (hazard ratio), IR (incidence rate), PY (person-years), serv (servings)

*Adjusted for age, education level, race/ethnicity, smoking status, physical activity, BMI, hormone replacement therapy status, study arm, and total energy intake.

Hazard ratios compare participants in higher categories of consumption (5–6 serv/week, 1 serv/day, etc) to participants in the lowest category of consumption (< 4 servings/week).

One serving of 100% fruit juice was defined as 6 ounces. The Women's Health Initiative enrolled participants between 1993–1998 throughout the United States.