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Association of 100% fruit juice consumption and 3-year weight change among postmenopausal women in the in the Women's Health Initiative

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Abstract

The association between drinking 100% fruit juice and long-term weight gain is controversial and has been investigated in few studies. We examined whether 100% fruit juice consumption was associated with weight change in a large prospective cohort of postmenopausal women. We analyzed data from 49,106 postmenopausal women in the United States enrolled in the Women's Health Initiative between 1993 and 1998. Food frequency questionnaires at baseline and year 3 assessed food and beverage intake. Body weight was measured at in-person clinic visits. We used multivariable linear regression to determine the association between change in 100% fruit juice consumption and 3-year weight change over the same time. Covariates of interest included age, demographic factors, smoking, body mass index, hormone replacement therapy, lifestyle factors,

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change in whole fruit intake, and change in sugar-sweetened beverage intake. The mean weight change was 3.2 lbs. over 3 years. In multivariable adjusted analyses, each 1 serving/day increase in 100% fruit juice intake was associated with a 3-year weight gain of 0.39 lbs. (95% confidence interval: 0.10, 0.69). In conclusion, an increase in 100% fruit juice consumption was associated with a small amount of long-term weight gain in postmenopausal women.

Introduction

American adults gain an average of 1 pound (lb.) per year, and it is a public health priority to determine which foods and beverages contribute most to this gradual weight gain.¹ Two analyses of the Nurses Health Studies (NHS) I and II and Health Professionals Follow-Up Study (HPFS) found that each 1 serving/day (1 small glass, about 6 oz.) increase in 100% fruit juice consumption was independently associated with gaining 0.31–0.49 lbs. over 4 years.^{1,2} We know of no other prospective studies on this topic in adults.³ Our objective was to confirm whether an increase in 100% fruit juice consumption is associated with weight gain in the Women's Health Initiative (WHI), which is a large prospective study of postmenopausal American women.

Methods

The design and methods of the WHI have been described elsewhere.⁴ Between 1993–1998, 122,970 postmenopausal women ages 50–79 years were enrolled into the WHI Observational Study and the comparison arm of the Dietary Modification Clinical Trial (participants received no dietary intervention). After excluding participants with missing baseline weight (n=388), year 3 weight (n=20,016), baseline 100% fruit juice intake (n=129), year 3 100% fruit juice intake (n=25,291), baseline age > 65 years (n=18,730), body mass index > 35.0 kg/m² (n=6685), and implausible energy intake (n=2425), 49,106 participants remained for inclusion in this study (Supplemental Table A1). Institutional review boards at each WHI site approved the study protocol, and all participants provided written informed consent.

The primary exposure was the change in daily 100% fruit juice consumption, measured at baseline and year 3 by a semi-quantitative food frequency questionnaire designed for the WHI and validated for measuring changes in diet over time.⁵ Participants were asked about their usual serving size (3 oz., 6 oz., or 12 oz.) and frequency of consuming all types of 100% fruit juice. Total daily 100% fruit juice consumption was estimated by multiplying the serving size by frequency. One serving of 100% fruit juice was defined as 6 oz.

The primary outcome was 3-year weight change. Study personnel measured body weight using a standardized protocol and calibrated scales. Twelve covariates of interest were assessed and included in the final models: baseline age, education level (11 levels), total household income (9 levels), race/ethnicity, baseline current smoking, baseline body mass index (BMI), baseline hormone replacement therapy status, baseline recreational physical activity level (MET-hours/week), study arm, change in the Healthy Eating Index diet quality score,⁶ change in whole fruit intake, and change in sugar-sweetened beverage (SSB) intake. Adjustment for change in total energy intake, a mediator in the relationship between change

in 100% fruit juice consumption and weight change, was included as a thirteenth covariate of interest in a separate model. Fruit juice, whole fruit, and SSB intake was standardized to 2000 kilocalories/day using the residual method.⁷

We created a linear mixed effects model to determine the association of each one serving/day increase in 100% fruit juice consumption with weight change during the same 3-year study period. Because age and BMI may modify the relationship between change in 100% fruit juice intake and long-term weight gain, we performed subgroup analyses of 5-year increments of baseline age and baseline BMI category (normal [18.5–24.9 kg/m²], overweight [25.0–29.9 kg/m²], and class I obesity [30.0–34.9 kg/m²]). We also created interaction terms between change in 100% fruit juice intake and (1) baseline age, and (2) BMI (both as continuous variables), and tested each interaction term in the adjusted linear mixed model. Finally, we conducted a sensitivity analysis using multiple imputation to estimate missing exposure data from 25,291 participants with missing year 3 exposure data for 100% fruit juice, sugar-sweetened beverages, or whole fruit. All tests were two-sided and P values < 0.05 were considered statistically significant. Data were analyzed using Stata (version 14, StataCorpLP, College Station, Texas).

Results

On average, included women at baseline were 58 years old, had a BMI of 26.2 kg/m², were predominantly white, did not smoke, and consumed less than 1 serving/day of 100% fruit juice (Table 1). Compared to included participants, participants who were excluded due to missing data were more likely to be African American or Latino, less likely to have a college degree, and less likely to use postmenopausal hormones (Supplemental Table A2). On average included participants gained 3.2 lbs. over 3 years. Estimated weight change associated with each 6-oz. serving/day increase in 100% fruit juice intake was greater in multivariable analyses, (0.39 lbs., 95% CI: 0.10, 0.69) compared to unadjusted analyses (0.15 lbs., 95% CI: -0.13, 0.44; Table 2). In multivariable analyses, each 6-oz. serving/day increase in SSB consumption was associated with a gain of 0.58 lbs. (95% CI: 0.26, 0.90), and each 1 serving/day increase in whole fruit consumption was independently associated with loss of 0.94 lbs. (95% CI: -1.17, -0.70). Results did not differ in stratified analyses of 5-year increments of baseline age or baseline BMI category, and interaction terms for change in 100% fruit juice consumption and baseline age (P=0.64) and baseline BMI (P=0.66) were not significant. Using multiple imputation to estimate missing exposure data resulted in univariate associations that were slightly decreased towards the null, but did not significantly affect multivariate associations (Supplemental Table S4).

We present results with and without adjustment for the change in total energy intake because in the WHI, there is known to be systematic underreporting of total energy intake, and estimates of total energy intake are imprecise (for example, standard deviations are large).⁸ Energy adjustment changed estimates of weight change associated with increased 100% fruit juice and whole fruit consumption only slightly. In comparison, the association between weight change and increased SSB consumption was substantially reduced after additional adjustment for total energy intake.

Conclusions

In this analysis of postmenopausal women in the WHI, an increase of one 6-oz. serving/day of 100% fruit juice was associated with a modest amount of long-term weight gain. The amount of weight gain observed in the current study (0.39 lbs. over 3-years,) was similar to the 2 other published studies on this topic.^{1,2} We assessed the relationship of change in consumption, rather than baseline consumption, with weight change because examining the change in a diet exposure over a period of 3–4 years accounts for the body's physiologic adaptations to weight change, and avoids the potential risk of reverse causation when using baseline data only.⁹

It is biologically plausible that drinking 100% fruit juice is associated with long-term weight gain. One 6-oz serving of 100% fruit juice contains 15–30 grams of sugar, 60–120 calories, little or no dietary fiber, and has a moderately high glycemic load.^{10,11} Even high-pulp 100% orange juice is not a significant source of dietary fiber.¹² Weight gain from 100% fruit juice may be mediated through both caloric and non-caloric mechanisms. Potential non-caloric mechanisms include (1) decreased satiety associated with incomplete compensation for liquid calories during subsequent meals,¹³ and (2) appetite stimulation from the post-prandial insulin response to the moderately high glycemic load of 100% fruit juice.¹⁴

This study has limitations. All observational studies, including ours, may have residual confounding due to lack of inclusion of confounding variables (e.g., obesogenic social network) or due to control for variables measured with error (e.g., total energy intake). Because of systematic underreporting of total energy intake and imprecision,⁸ adjustment for the change in total energy intake was likely biased. WHI participants may have incorrectly differentiated 100% fruit juice from <100% fruit drinks, although this was unlikely to change between baseline and year 3. Participants reported low levels of 100% fruit juice consumption: only 5% of participants had a change of ± 1 serving/day of 100% fruit juice. This study is strengthened in that the WHI is a large and diverse national sample of postmenopausal women with body weight measured at in-person clinic visits. Because resting energy expenditure slows during the postmenopausal state, which predisposes to weight gain, estimates of long-term weight gain in this study associated with increased 100% fruit juice consumption may be overestimated compared to the general US adult population and premenopausal women.¹⁵

This analysis of postmenopausal women in the Women's Health Initiative found that an increase in consumption of 100% fruit juice was associated with weight gain, while increased whole fruit consumption was associated with weight loss. These findings support the recommendations of the 2015–2020 Dietary Guidelines for Americans that adults should consume 100% fruit juice in moderation, and chose whole fruit over 100% fruit juice when possible.¹⁶

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

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Abbreviations

CI	Confidence Interval
HPFS	Health Professional’s Follow-Up Study
kcal	kilocalories
MET	Metabolic Equivalent
NHS	Nurses’ Health Study
WHI	Women’s Health Initiative

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Highlights

- Sugar-sweetened beverages are associated with weight gain, but less is known about 100% fruit juice
- We analyzed the relationship of 100% fruit juice intake and weight gain among postmenopausal women
- An increase of 1 serving/day of 100% fruit juice was associated with gaining 0.39 lbs. over 3 years

Table 1

Baseline Characteristics of 49,106 Participants in the Women's Health Initiative

Age, years	57.9 ± 4.1
Body mass index, kg/m ²	26.2 ± 4.0
Race/Ethnicity	
Asian/Pacific	3.0%
African American	7.6%
Hispanic/Latino	4.0%
White	84.0%
College degree or higher	48.0%
Annual household Income \$75,000	15.4%
Current smoking	7.1%
Current use of postmenopausal hormones	59.0%
Recreational physical activity level, MET-hours/week	4.3 ± 3.9
Daily 100% fruit juice, 6-oz. servings/day	0.67 ± 0.63
Daily sugar-sweetened beverages, 6-oz. servings/day	0.30 ± 0.54
Daily whole fruit, ½ cups	1.17 ± 0.83
Energy intake, kcal/day	1636 ± 620
Healthy Eating Index diet quality score	67.9 ± 10.5

Abbreviations: kcal (kilocalories), MET (metabolic equivalent)

All characteristics were assessed at baseline (1993–1998). Values are mean ± standard deviation (continuous variables) or percent (categorical variables). Servings/day of 100% fruit juice, sugar-sweetened beverages (regular soda and Tang®, Kool-Aid®, Hi-C®, or other <100% fruit juice drinks), and whole fruit are adjusted for energy using the residual method, and standardized to 2000 kcal/day.

The Women's Health Initiative enrolled participants between 1993–1998 throughout the United States. Eleven levels of education and nine levels of annual household income were analyzed in the linear mixed effect models, but this table dichotomizes these two variables.

Table 2

Association of a 1 serving/day Increase in 100% Fruit Juice, Whole Fruit, and Sugar-Sweetened Beverages and 3-year Weight Change in 49,106 Postmenopausal Women

	3-year Weight Change, lb. (95% CI)
100% Fruit Juice	
Unadjusted	0.19 (−0.01, 0.47)
Multivariable-Adjusted *	0.39 (0.10, 0.69)
Multivariable and Energy Adjusted **	0.33 (0.04, 0.63)
Sugar-Sweetened Beverages	
Unadjusted	0.93 (0.62, 1.24)
Multivariable-Adjusted *	0.58 (0.26, 0.90)
Multivariable and Energy Adjusted **	0.36 (0.29, 0.69)
Whole Fruit	
Unadjusted	−1.23 (−1.45, −1.02)
Multivariable-Adjusted *	−0.94 (−1.17, −0.70)
Multivariable and Energy Adjusted **	−1.01 (−1.24, −0.77)

Abbreviations: CI (confidence interval)

* Controls for the following baseline variables: age, education level, income, race/ethnicity, current smoking, BMI, hormone replacement therapy status, recreational physical activity level, and the 3-year change in 2005 Healthy Eating Index diet quality score.

** Controls for the above covariates, plus the 3-year change in total energy intake

A linear mixed effects model estimated the weight change (lb./3-years) per each 1 serving/day increase in 100% fruit juice, sugar-sweetened beverages, and whole fruit over the same 3-year period. One serving of 100% fruit juice or sugar-sweetened beverage was defined as 6 oz. One serving of whole fruit was defined as ½ cup.

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