Published in final edited form as:

Int Urogynecol J. 2013 April ; 24(4): 605–612. doi:10.1007/s00192-012-1914-9.

ACIDIC FRUIT INTAKE IN RELATION TO INCIDENCE AND PROGRESSION OF URINARY INCONTINENCE

Mary K. Townsend, ScD^{1,*}, Elizabeth E. Devore, ScD^{1,*}, Neil M. Resnick, MD², and Francine Grodstein, ScD^{1,3}

¹Channing Laboratory, Department of Medicine, Brigham & Women's Hospital and Harvard Medical School, Boston, MA

²Department of Geriatric Medicine, University of Pittsburgh Medical Center, Pittsburgh, PA

³Department of Epidemiology, Harvard School of Public Health, Boston, MA

Abstract

Introduction and hypothesis—Acidic fruits are commonly cited in the lay press as potential bladder irritants that may promote urinary incontinence (UI), but no epidemiologic studies have examined this issue. We hypothesized that higher intake of acidic fruits might be related to greater risk of UI incidence and progression in women.

Methods—In one set of analyses, we included women without UI at study baseline in the Nurses' Health Studies (NHS), with 34,144 women aged 54–79 in NHS I and 31,024 women aged 37–54 in NHS II. These cohorts were established among women living in the United States. Incident UI was ascertained over four years of follow up, and acidic fruit consumption was measured by food frequency questionnaire prior to UI onset. In a second set of analyses, we examined UI progression over two years of follow up among 11,764 women in NHS I and 11,299 women in NHS II with existing UI. Multivariable-adjusted relative risks were calculated for the associations of acidic fruit intake and UI incidence and progression.

Results—We found no relation between acidic fruit intake and risk of developing UI, including urgency, mixed, and stress UI. In addition, there was no association between consumption of acidic fruits and UI progression, regardless of UI type.

Conclusion—No associations were detected between acidic fruit intake and UI in this large, prospective study of women. These data have implications for the development of evidence-based dietary guidelines around acidic fruits and UI, particularly because acidic fruits likely have many health benefits.

Keywords

aging; cohort studies; diet; epidemiology; urinary incontinence

Corresponding author: Elizabeth Devore, 181 Longwood Avenue, Room 452, Boston, MA 02115; phone: 617-525-2090; fax: 617-525-2008; nheed@channing.harvard.edu.

*M.K. Townsend and E.E. Devore contributed equally to this manuscript.

Author contributions: Townsend MK (data analysis, manuscript editing), Devore EE (manuscript writing/editing), Resnick NM (manuscript editing), Grodstein F (project development, data collection, manuscript editing).

Financial disclaimer/conflict of interest: None.

The authors report no conflicts of interest.

INTRODUCTION

Both the World Health Organization and United States Department of Agriculture recommend fruit and vegetable consumption for health maintenance.[1, 2] In particular, higher intakes of fruits and vegetables have been linked to a decreased risk of major chronic diseases, particularly cardiovascular and cerebrovascular diseases.[3] However, citrus fruits and tomatoes are commonly cited in the lay press as potential bladder irritants, [4, 5] which are thought to result in a greater propensity for urinary incontinence – a common and burdensome condition for women.[6, 7] Yet, epidemiologic data are virtually non-existent in regard to the association between acidic fruit intake and urinary incontinence (UI). Thus, we prospectively evaluated the consumption of acidic fruits and UI incidence among approximately 65,000 women, aged 37–79 years, in the Nurses' Health Studies (NHS) I and II. We further examined the association of acidic fruit intake and UI progression in a sample of approximately 23,000 women with moderate levels of existing UI in these cohorts. We hypothesized that higher intake of acidic fruits might be related to greater risk of UI incidence or progression in women.

MATERIALS AND METHODS

In 1976, NHS I was established when 121,700 female nurses, aged 30–55 years and living in the United States, returned a mailed questionnaire about their health and lifestyle[8]. In 1989, NHS II began when 116,430 female nurses in the United States, ranging in age from 25 to 42, returned a similar questionnaire[9]. Biennial questionnaires are used to update this information, with follow up approximately 90% complete to date in both cohorts. A food frequency questionnaire was added to NHS I in 1980 and to NHS II in 1991 and repeated approximately every four years. In addition, questions on UI were included on the 2000, 2002, and 2004 NHS I questionnaires and 2001, 2003, and 2005 NHS II questionnaires. The institutional review board of Brigham and Women's Hospital (Boston, Massachusetts) approved these studies.

ASCERTAINMENT OF URINARY INCONTINENCE

To ascertain UI, women in both cohorts were asked, "During the last 12 months, how often have you leaked or lost control of your urine?" Response categories were never, less than once per month, two to three times per month, about once per week, and almost every day. Of women who reported urinary symptoms, we asked the following: "When you lose your urine, how much usually leaks?" Women could indicate a few drops, enough to wet your underwear, enough to wet your outer clothing, and enough to wet the floor. These questions have been previously validated.[10–13] In a random sample of 200 NHS I participants, we previously established that women's responses to these questions are highly reliable.[14]

INCIDENCE OF URINARY INCONTINENCE

To study new onset of UI, we defined baseline as 2000 in NHS I and 2001 in NHS II ("incidence baseline"), the first follow up as 2002 in NHS I and 2003 in NHS II ("first incidence follow up"), and the second follow up as 2004 in NHS I and 2005 in NHS II ("second incidence follow up"). Ninety-three percent of women who provided UI information at incidence baseline also reported UI information at least once during follow up, and were included in the incidence analyses. We excluded 40,807 NHS I participants and 43,926 NHS II participants with prevalent UI at incidence baseline, which was defined as UI at least once per month or UI less than once per month of quantities at least enough to wet the underwear. We also removed women from our analysis if they were missing data on acidic fruit intake or key potential confounders, including BMI, parity, and caffeine, at the start of either two-year follow-up period. Furthermore, women who reported major

neurologic conditions (stroke, multiple sclerosis, Parkinson's disease, or amyotrophic lateral sclerosis) or functional limitations (difficulty climbing a flight of stairs, walking one block, bathing or dressing) were excluded because these ailments might hinder a woman's ability to reach the bathroom in a timely manner, and thus contribute to UI (as suggested by previous epidemiologic studies)[15, 16], and might also result in dietary changes. After these exclusions, there were 65,168 remaining women (34,144 in NHS I and 31,024 in NHS II) in our sample for incidence analyses.

For UI incidence, we defined cases as: 1) women who reported UI at least once per month at the first or second incidence follow up ("any UI"), and 2) women who reported UI at least once per week at the first or second incidence follow up ("frequent UI"). In addition, we used a supplemental questionnaire in both cohorts to assess incontinence type among women with frequent incontinence at the first incidence follow up, as we thought that these women were more likely to accurately report circumstances surrounding UI onset compared to women with less frequent incontinence. The questions about UI type have been previously validated.[17, 18] Due to the large number of women with incident frequent UI in NHS I, the supplemental questionnaire was sent to a random sample of 80% of these cases (n=2,183); the response rate was 84%. In NHS II, the supplemental questionnaire was sent to virtually all incident cases of frequent UI (n=1,224; 19 cases did not receive this questionnaire because they were identified after it was mailed) and 79% responded. Information on UI type was collected directly from the main NHS questionnaires rather than from a supplementary questionnaire during the second incidence follow up.

We defined urgency UI as primarily leaking accompanied by an urge to urinate or a sudden feeling of bladder fullness; stress UI as leaking primarily with coughing, sneezing, lifting things, laughing, or exercise; and mixed UI when the occurrence of urgency and stress UI was reported to be equally common. There were 187 cases of frequent UI that did not meet any of these definitions and were therefore excluded from our analyses of UI type.

PROGRESSION OF URINARY INCONTINENCE

To study the progression of existing UI, we defined baseline as 2002 in NHS I and 2003 in NHS II ("progression baseline") and follow up as 2004 in NHS I and 2005 in NHS II ("progression follow up"). We defined 2002–2004 in NHS I and 2003–2005 in NHS II as the timeframe for progression analyses because 2004 in NHS I and 2005 in NHS II were the first years that UI type information was ascertained for all women reporting UI (i.e., UI type was only measured among women with incident frequent UI in 2002 in NHS I and 2003 in NHS II). This choice of timeframe enabled analyses of associations between acidic fruit intake and progression of specific UI types.

Ninety-two percent of women who provided UI information at progression baseline also provided UI information at progression follow up. Women who: 1) provided incontinence information at progression baseline and follow up, 2) reported UI 1–3 times per month ("moderate UI") at progression baseline, 3) did not have missing data on acidic fruit intake or potential confounders, and 4) did not report major neurologic conditions or functional limitations (as described previously for incidence analyses) were included in progression analyses (n=11,764 in NHS I and 11,299 in NHS II). We defined cases of UI progression as women who reported moderate UI at progression baseline and frequent UI at progression follow up ("UI progression").

ASCERTAINMENT OF ACIDIC FRUIT INTAKE

A validated semi-quantitative food frequency questionnaire (FFQ) was used to ascertain dietary habits beginning in 1980 in NHS I and 1991 in NHS II; it was repeated

approximately every four years in each cohort.[19] Food items were specified in common units or portion sizes (e.g. one small glass of orange or grapefruit juice, or one tomato) and participants were asked how often, on average, they consumed each food item over the previous year. Nine response options ranged from “almost never” to “6 times per day”. We considered acidic fruit intake to be consumption of fruits with a pH of 4.6 or less, as defined by the U.S. Food and Drug Administration, as well as the corresponding fruit juices.[20] For each participant, we calculated total energy intake by multiplying the consumption frequency and energy content of each food (determined using the Harvard University Food Composition Database, and updated regularly), and summing these values across the diet. In a validation study, high correlations were observed for intakes of major acidic fruits comparing the FFQ assessment to four, one-week dietary records collected over one year. [21] In particular, correlation coefficients (corrected for within-person variation in dietary records) were 0.74 for oranges, 0.84 for orange or grapefruit juice, and 0.73 for tomatoes on the FFQ versus diet records.

STATISTICAL ANALYSIS

Our primary exposure was total acidic fruit intake, although we secondarily considered intakes of specific categories, including citrus fruit, plums/grapes, apples, berries, and tomatoes/tomato products. For incidence analyses, we considered participants’ most recent intake of acidic fruits reported on the questionnaire prior to the development of UI. Because acidic fruit is considered a bladder irritant, our main interest was examining associations with incident urgency and mixed UI.[4, 5]. Analyses of UI incidence over four years included women with at least one report of UI status at the first or second incidence follow up; therefore, we calculated multivariable-adjusted relative risks of incident UI, estimated by hazard ratios, across quintiles of acidic fruit intake using Cox proportional hazard models[22]. Quintiles were created by dividing the ranked data into fifths. Cox proportional hazard models were used because they allow changes in participant follow-up status (e.g., missing data on the first, but not the second, follow-up questionnaire) and thus take advantage of all available data. Models were stratified by age (in months) and two-year time period (necessary for incidence analyses), and we considered covariates that were identified from the existing literature as potential risk factors for UI: parity, body-mass index, cigarette smoking, race, type 2 diabetes, total fluid intake, and physical activity. The status of these covariates was updated at follow up.

For analyses of UI progression over two years, we considered acidic fruit intake reported at progression baseline in relation to progression risk; again, urgency and mixed UI were primary outcomes. Because we restricted these analyses to women with UI data at baseline and progression follow up (i.e., women with uniform follow up), we calculated multivariable-adjusted relative risks of UI progression, estimated by odds ratios, across quintiles of acidic fruit intake using logistic regression models. Covariates considered for logistic regression models were identical to those described above for UI incidence models.

After calculating cohort-specific relative risks of UI incidence and progression, we combined the log relative risks (RR), weighted by the inverse of their variances, using a random effects model for meta-analysis; between-study heterogeneity was tested by the Q statistic.[23] We calculated 95% confidence intervals (CI) for all relative risk estimates, and conducted tests of linear trend using an ordinal variable representing the median value of each exposure quintile.

RESULTS

In analyses of UI incidence, NHS I participants were ages 54 to 79 years and NHS II participants were ages 37 to 54 years. Acidic fruit intake was slightly greater in NHS I

compared to NHS II (median=2.6 versus 2.1 servings/day), and the largest food contributors were tomatoes and orange juice in both cohorts. Overall, characteristics of participants were similar across quintiles of acidic fruit intake in both cohorts (Table 1). However, with increasing quintiles of acidic fruit intake, women had greater levels of physical activity and, as might be expected, higher total energy consumption. These trends were similar among women included in our progression analyses (results not shown in tables).

No clear association was evident between higher intake of acidic fruits and risk of incident frequent incontinence in NHS I (p-trend=0.07) or NHS II (p-trend=0.9), and there was no statistical difference in results between the two cohorts (Q statistic=0.88, p-heterogeneity=0.3) (Table 2). When the cohorts were combined, there was no overall association between acidic fruit intake and frequent UI (p-trend=0.1), and specifically no difference in frequent UI risk comparing the highest and lowest quintiles of acidic fruit consumption (RR=0.91, 95% CI=0.81–1.02), after adjusting for numerous potential confounding variables. For urgency UI, we found that intake of acidic fruits was not associated with risk in either NHS I (p-trend=0.5) or NHS II (p-trend=0.6), and these associations were similar between cohorts (Q statistic=0.70, p-heterogeneity=0.4). When we combined data in the two cohorts, there was no overall association between acidic fruits and urgency UI risk (p-trend=0.8), and the risk of urgency UI was similar comparing the highest versus lowest quintiles of acidic fruit intake (RR=1.07, 95% CI=0.76–1.50). Findings were similar when we considered any UI (i.e., leaking at least once per week), stress UI, and mixed UI as outcomes of interest.

Furthermore, acidic fruit intake was not related to risk of UI progression among women with moderate UI at baseline in NHS I (p-trend=0.9) or NHS II (p-trend=0.6) (Table 3); this association did not differ between the two cohorts (Q statistic=0.06, p-heterogeneity=0.8). In models including women from both cohorts, acidic fruit consumption was not associated with progression risk (p-trend=0.7); for example, the relative risk of UI progression was 1.00 (95% CI=0.89–1.11) comparing the top versus bottom quintiles of acidic fruit intake. In addition, we found no association between acidic fruit consumption and risk of urgency UI progression in either NHS I (p-trend=0.3) or NHS II (p-trend=0.1), and the association did not differ between these cohorts (Q-statistic=0.61, p-heterogeneity=0.4). Combined results for the two cohorts also showed no relation between acidic fruit intake and urgency UI progression (p-trend=0.1), with a similar risk in the highest and lowest quintiles of intake (RR=1.09, 95% CI=0.91–1.32). Again, there were no associations for any UI, stress UI, or mixed UI progression.

In secondary analyses, we found no associations of specific acidic fruit categories (citrus fruit, plums/grapes, apples, berries, and tomatoes/tomato products) with risk of incident UI or UI progression in either NHS I or NHS II (results not shown in tables). For example, in combined cohort analyses, there was no evidence that consumption of citrus fruit or tomatoes/tomato products was related to an increased risk of frequent UI (for citrus fruit: p-trend=0.01; RR=0.91, 95% CI=0.82–1.00 comparing the highest versus lowest quintiles; for tomatoes/tomato products: p-trend=0.7; RR=1.00, 95% CI=0.90–1.11 comparing extreme quintiles) or an increased risk of UI progression (for citrus fruit: p-trend=0.8; RR=1.01, 95% CI=0.89–1.15 comparing extreme quintiles; tomatoes/tomato products: p-trend=1.0; RR=0.98, 95% CI=0.82–1.17 comparing extreme quintiles).

DISCUSSION

We found no association of acidic fruit intake to initial development or progression of urinary incontinence in this large, prospective study of women. Although the lay literature classifies citrus fruits and tomatoes as bladder irritants, and thus especially a potential risk

factor for urgency UI, higher intakes of acidic fruits were not associated with UI overall, or urgency UI in particular. These findings provide the first substantial epidemiologic evidence that restrictions on acidic fruits, including citrus fruits and tomatoes, may not be necessary for women who are concerned about incontinence.

Previous epidemiologic studies of acidic fruits and UI are virtually non-existent. A single prospective study (n=6,424 women) reported that overall fruit intake was not related to risk of overactive bladder, and higher fruit consumption appeared to be associated with a slight, but non-significant, decrease in risk of stress incontinence (p-trend=0.05; OR=0.78, 95% CI=0.53–1.12 for fruit consumption 5 times/day versus <2 times/day).[24] A specific analysis of acidic fruits was not conducted in that report; however, the study is consistent with the results of our analysis, which provides no indication that fruits contribute to urinary incontinence in women. Moreover, existing evidence suggests that most fruits and vegetables, including the vast majority of acidic fruits examined in our analysis, increase urine pH due to their high content of carbonate, sodium, and potassium.[25, 26] Thus, although the fruits themselves are acidic and therefore are thought to be bladder irritants, their alkalinizing effects on urine could explain the lack of association between acidic fruit intake and urinary incontinence in this study.

The strengths of our study include its large, prospective design, use of validated instruments for measuring dietary intake and urinary symptoms, and availability of data on many potential confounding variables. Some limitations should also be considered when interpreting our results. First, dietary information was self reported in NHS I and II, and we expect that a certain amount of reporting error led to some random misclassification of acidic fruit intake. However, the validation of our FFQ demonstrated very good ascertainment of the primary fruits of interest for these analyses.[21] Moreover, we have previously identified strong relations of fruit intake and major health outcomes in the NHS cohorts, indicating that our data on fruit intake are adequate to detect associations of interest. [27, 28] Second, our FFQ could not distinguish women who consumed large quantities of acidic fruits at once versus smaller quantities spread throughout the day; thus, we could not examine whether different consumption patterns may result in different UI risks. Third, women who experienced early symptoms of incontinence may have reduced their acidic fruit consumption to help alleviate these symptoms. This source of bias would tend to induce an association between higher fruit consumption and reduced risk of incident UI, but is not likely to explain our generally null results. Finally, women who are diagnosed with certain chronic diseases (e.g. coronary artery disease) may increase their acidic fruit intake as part of an effort to adopt a healthy lifestyle, while medications taken for such conditions (e.g. diuretics) may independently lead to urinary incontinence. However, inclusion of these women would have tended to bias our results in favor of an association between higher consumption of acidic fruits and increased risk of incontinence. Because we found no relation of acidic fruits and incontinence, this possibility is not likely to have substantially influenced our results.

In summary, there was no evidence in our study to suggest an association of acidic fruit intake, including citrus fruits and tomatoes, with UI incidence or progression in this first large, prospective study of acidic fruits. These findings may be important for helping to establish evidence-based dietary recommendations around acidic fruits and UI, particularly given the many likely health benefits of fruit intake.[2, 3]

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

Financial support for this research was provided by the National Institutes of Health (DK62438, CA87969, CA50385).

References

1. World Health Organization. Global strategy on diet, physical activity and health: promoting fruit and vegetable consumption around the world. [cited 2012 May 11]; Available from: <http://www.who.int/dietphysicalactivity/fruit/en/index2.html>
2. United States Department of Agriculture. Dietary Guidelines for Americans. 2010. [cited 2011 March 7]; Available from: www.cnpp.usda.gov/
3. Hung HC, et al. Fruit and vegetable intake and risk of major chronic disease. *J Natl Cancer Inst.* 2004; 96(21):1577–84. [PubMed: 15523086]
4. National Association for Continence. Diet and Daily Habits: Can this affect your bladder or bowel control?. [cited 2011 Feb 17]; Available from: <http://www.nafc.org/>
5. Web, MD. Foods that make you gotta go. [cited 2011 August 11]
6. Grodstein F, et al. Association of age, race, and obstetric history with urinary symptoms among women in the Nurses' Health Study. *Am J Obstet Gynecol.* 2003; 189(2):428–34. [PubMed: 14520212]
7. Townsend MK, et al. Incidence and remission of urinary incontinence in middle-aged women. *Am J Obstet Gynecol.* 2007; 197(2):167, e1–5. [PubMed: 17689637]
8. Colditz GA, Manson JE, Hankinson SE. The Nurses' Health Study: 20-year contribution to the understanding of health among women. *Journal of women's health / the official publication of the Society for the Advancement of Women's Health Research.* 1997; 6(1):49–62.
9. Townsend MK, et al. Postmenopausal hormone therapy and incident urinary incontinence in middle-aged women. *American journal of obstetrics and gynecology.* 2009; 200(1):86, e1–5. [PubMed: 19019333]
10. Diokno AC, et al. Medical correlates of urinary incontinence in the elderly. *Urology.* 1990; 36(2): 129–38. [PubMed: 2385880]
11. Herzog AR, Fultz NH. Prevalence and incidence of urinary incontinence in community-dwelling populations. *Journal of the American Geriatrics Society.* 1990; 38(3):273–81. [PubMed: 2179368]
12. Sandvik H, et al. Validation of a severity index in female urinary incontinence and its implementation in an epidemiological survey. *Journal of epidemiology and community health.* 1993; 47(6):497–9. [PubMed: 8120507]
13. Avery KN, et al. Questionnaires to assess urinary and anal incontinence: review and recommendations. *The Journal of urology.* 2007; 177(1):39–49. [PubMed: 17161997]
14. Lifford KL, et al. Type 2 diabetes mellitus and risk of developing urinary incontinence. *J Am Geriatr Soc.* 2005; 53(11):1851–7. [PubMed: 16274364]
15. Huang AJ, et al. Urinary incontinence in older community-dwelling women: the role of cognitive and physical function decline. *Obstetrics and gynecology.* 2007; 109(4):909–16. [PubMed: 17400853]
16. Jenkins KR, Fultz NH. Functional impairment as a risk factor for urinary incontinence among older Americans. *Neurourology and urodynamics.* 2005; 24(1):51–5. [PubMed: 15578629]
17. Diokno AC, et al. Urodynamic tests for female geriatric urinary incontinence. *Urology.* 1990; 36(5):431–9. [PubMed: 2238302]
18. Diokno A, Yuhico M Jr. Preference, compliance and initial outcome of therapeutic options chosen by female patients with urinary incontinence. *The Journal of urology.* 1995; 154(5):1727–30. discussion 1731. [PubMed: 7563333]
19. Willett WC, et al. Reproducibility and validity of a semiquantitative food frequency questionnaire. *Am J Epidemiol.* 1985; 122(1):51–65. [PubMed: 4014201]
20. United States Food and Drug Administration. Instructions for Establishment Registration and Processing Filing for Acidified and Low-Acid Canned Foods. [cited 2010 Feb 17]; Available from: <http://www.fda.gov/>

21. Salvini S, et al. Food-based validation of a dietary questionnaire: the effects of week-to-week variation in food consumption. *Int J Epidemiol.* 1989; 18(4):858–67. [PubMed: 2621022]
22. Cox, DR.; Oakes, D. The analysis of survival data. Chapman and Hall; London: 1984.
23. DerSimonian R, Laird N. Meta-analysis in clinical trials. *Control Clin Trials.* 1986; 7(3):177–88. [PubMed: 3802833]
24. Dallosso HM, et al. The association of diet and other lifestyle factors with overactive bladder and stress incontinence: a longitudinal study in women. *BJU Int.* 2003; 92(1):69–77. [PubMed: 12823386]
25. Remer T, Manz F. Potential renal acid load of foods and its influence on urine pH. *J Am Diet Assoc.* 1995; 95(7):791–7. [PubMed: 7797810]
26. Welch AA, et al. Urine pH is an indicator of dietary acid-base load, fruit and vegetables and meat intakes: results from the European Prospective Investigation into Cancer and Nutrition (EPIC)-Norfolk population study. *Br J Nutr.* 2008; 99(6):1335–43. [PubMed: 18042305]
27. Joshipura KJ, et al. Fruit and vegetable intake in relation to risk of ischemic stroke. *JAMA.* 1999; 282(13):1233–9. [PubMed: 10517425]
28. Joshipura KJ, et al. The effect of fruit and vegetable intake on risk for coronary heart disease. *Ann Intern Med.* 2001; 134(12):1106–14. [PubMed: 11412050]

Baseline characteristics^a among women at risk of incident urinary incontinence in NHS I and II, according to selected cohort specific quintiles of acidic fruit intake

Table 1

Characteristics	Acidic fruit intake (quintiles)									
	NHS I					NHS II				
	Quintile 1	Quintile 3	Quintile 5	Quintile 1	Quintile 3	Quintile 5	Quintile 1	Quintile 3	Quintile 5	Quintile 5
Mean acidic fruit intake, servings/day	1.1	2.7	5.4	0.9	2.2	4.6				
Mean age, years	64.7	65.6	65.8	45.8	46.0	46.2				
Mean body-mass index, kg/m ²	26.1	25.8	25.5	25.6	25.4	25.2				
Mean physical activity, MET-hrs/wk ^b	14.8	19.4	24.8	18.3	22.4	29.2				
Mean caffeine intake, mg/day	226	206	201	218	220	209				
Mean total energy intake, kcal/day	1406	1708	2111	1464	1809	2217				
Race, %										
White	97.3	97.8	97.3	95.6	97.3	96.9				
Black	1.5	1.3	1.8	1.6	1.0	1.0				
Asian	1.0	0.6	0.8	2.2	1.1	1.3				
Other/missing	0.2	0.3	0.1	0.6	0.6	0.8				
Parity, %										
0	6.1	6.2	6.5	24.5	20.3	20.7				
1-2	37.3	35.7	35.7	51.7	51.5	51.1				
3	56.6	58.1	57.8	23.8	28.2	28.2				
Cigarette smoking, %										
Never	40.5	45.5	49.3	65.8	67.3	70.3				
Past	44.4	46.8	45.2	23.1	25.5	25.3				
Current, cigarettes per day										
1-14	7.3	4.3	3.7	5.7	4.4	3.0				
15-24	6.0	2.8	1.4	3.9	2.3	1.2				
25	1.8	0.6	0.4	1.5	0.5	0.2				
History of diabetes, %	7.2	6.4	5.8	1.9	1.8	2.1				

NHS = Nurses' Health Study

^aBaseline is 2000 in NHS I and 2001 in NHS II.

b_2 A metabolic-equivalent task-hour (MET-hr) is proportional to the amount of energy spent sitting quietly for one hour.

Table 2

Multivariable-adjusted relative risks (RR) (95% confidence intervals [CI])^a of incident urinary incontinence (2000–2004 in NHS I and 2001–2005 in NHS II) across quintiles of acidic fruit intake

Outcome	Quintile 1	Quintile 2	Quintile 3	Quintile 4	Quintile 5	p-trend
NHS I						
Frequent UI ^b						
Cases	673	637	579	549	440	
RR (95% CI)	1.00 (reference)	0.99 (0.88–1.10)	0.97 (0.86–1.09)	1.00 (0.88–1.13)	0.86 (0.75–0.99)	0.07
Urgency UI ^c						
Cases	112	125	129	87	98	
RR (95% CI)	1.00 (reference)	1.17 (0.89–1.52)	1.25 (0.95–1.64)	0.96 (0.70–1.30)	1.22 (0.89–1.67)	0.5
NHS II						
Frequent UI ^b						
Cases	365	347	267	298	267	
RR (95% CI)	1.00 (reference)	1.00 (0.85–1.16)	0.84 (0.71–0.99)	1.01 (0.86–1.20)	0.98 (0.81–1.17)	0.9
Urgency UI ^c						
Cases	59	58	31	48	38	
RR (95% CI)	1.00 (reference)	1.10 (0.75–1.62)	0.67 (0.42–1.06)	1.11 (0.72–1.70)	0.86 (0.53–1.37)	0.6
Combined ^d						
Frequent UI ^b						
Cases	1038	984	846	847	707	
RR (95% CI)	1.00 (reference)	0.99 (0.90–1.08)	0.91 (0.79–1.05)	1.00 (0.91–1.11)	0.91 (0.81–1.02)	0.1 ^e
Urgency UI ^c						
Cases	171	183	160	135	136	
RR (95% CI)	1.00 (reference)	1.15 (0.92–1.43)	0.94 (0.51–1.73)	1.01 (0.78–1.29)	1.07 (0.76–1.50)	0.8 ^f

CI=confidence interval; NHS = Nurses' Health Study; RR=relative risk

^aRelative risks are adjusted for age, total energy intake (quintiles), body-mass index (continuous), parity (0, 1–2, 3 live births), cigarette smoking (never, past, current: 1–14, 15–24, 25 cigarettes/day), race (white, black, Asian, other/missing), physical activity (continuous), total caffeine intake (continuous), and diabetes.

- ^b Frequent UI is defined as incontinence at least once per week.
- ^c Urgency UI is defined as primarily leaking accompanied by an urge to urinate or a sudden feeling of bladder fullness.
- ^d Cohort-specific RRs were combined using random effects meta-analysis.
- ^e Q-statistic=0.88, p-heterogeneity=0.3
- ^f Q-statistic=0.70, p-heterogeneity=0.4

Table 3

Multivariable-adjusted relative risks (RR) (95% confidence intervals[CI])^a of urinary incontinence progression among women with existing incontinence (2002–2004 in NHS I and 2003–2005 in NHS II) across quintiles of acidic fruit intake

Outcome	Quintile 1	Quintile 2	Quintile 3	Quintile 4	Quintile 5	p-trend
NHS I						
All progression ^b						
Cases	513	483	526	504	559	
RR (95% CI)	1.00 (reference)	0.92 (0.79–1.06)	0.96 (0.83–1.11)	0.90 (0.78–1.05)	1.00 (0.85–1.16)	0.9
Urgency UI progression ^c						
Cases	184	155	172	194	206	
RR (95% CI)	1.00 (reference)	0.83 (0.66–1.04)	0.87 (0.70–1.09)	0.97 (0.77–1.22)	1.03 (0.82–1.31)	0.3
NHS II						
All progression ^b						
Cases	573	496	492	484	502	
RR (95% CI)	1.00 (reference)	0.90 (0.78–1.04)	0.87 (0.75–1.00)	0.94 (0.81–1.09)	1.00 (0.86–1.17)	0.6
Urgency UI progression ^c						
Cases	107	90	92	105	106	
RR (95% CI)	1.00 (reference)	0.93 (0.69–1.25)	0.94 (0.70–1.27)	1.19 (0.881–1.61)	1.22 (0.88–1.68)	0.1
Combined ^d						
All progression ^b						
Cases	1086	979	1018	988	1061	
RR (95% CI)	1.00 (reference)	0.91 (0.82–1.00)	0.91 (0.82–1.01)	0.92 (0.83–1.02)	1.00 (0.89–1.11)	0.7 ^e
Urgency UI progression ^c						
Cases	291	245	264	299	312	
RR (95% CI)	1.00 (reference)	0.86 (0.72–1.04)	0.90 (0.75–1.07)	1.04 (0.86–1.26)	1.09 (0.91–1.32)	0.1 ^f

CI=confidence interval; NHS = Nurses' Health Study; RR=relative risk

^aRelative risks are adjusted for age, total energy intake (quintiles), body-mass index (continuous), parity (0, 1–2, 3 live births), cigarette smoking (never, past, current: 1–14, 15–24, 25 cigarettes/day), race (white, black, Asian, other/missing), physical activity (continuous), total caffeine intake (continuous), and diabetes.

^b UI progression was defined among women with moderate incontinence (leaking 1–3 times per month) in 2002 in NHS I and 2003 in NHS II, and frequent incontinence (leaking at least once per week) in 2004 in NHS I and 2005 in NHS II.

^c Progression of UI urgency was defined among women with moderate incontinence in 2002 in NHS I and 2003 in NHS II, and frequent urgency incontinence in 2004 in NHS I and 2005 in NHS II.

^d Cohort-specific RRs were combined using random effects meta-analysis.

^e Q-statistic=0.06, p-heterogeneity=0.8

^f Q-statistic=0.61, p-heterogeneity=0.4