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Dietary calcium from dairy and non-dairy sources and risk of symptomatic kidney stones

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Abstract

Purpose—Because of high correlations between dairy intake and total dietary calcium, previously reported associations between lower calcium intake and increased kidney stone risk represent de facto associations between milk products and risk. We sought to examine associations between dietary calcium from non-dairy and dairy sources and symptomatic nephrolithiasis.

Materials and Methods—We conducted prospective studies in the Health Professionals Follow-up Study (HPFS; N=30,762 men), the Nurses' Health Study I (NHS I; N=94,164 women), and the Nurses' Health Study II (NHS II; N=101,701 women). We excluded men ≥ 60 years old because we previously reported inverse associations between calcium intake and risk only in men < 60. Food frequency questionnaires assessed calcium intake every four years. We used Cox proportional hazards regression to adjust for age, BMI, supplemental calcium, diet, and other factors.

Results—We documented 5,270 incident kidney stones over a combined 56 years of follow-up. For participants in the highest compared to lowest quintile of non-dairy dietary calcium, the multivariable relative risks of kidney stones were 0.71 (95% CI 0.56–0.92; P for trend 0.007) for HPFS, 0.82 (0.69–0.98; P trend 0.08) for NHS I, and 0.74 (0.63–0.87; P trend 0.002) for NHS II. The multivariable relative risks comparing highest to lowest quintile of dairy calcium were 0.77 (0.63–0.95; P trend 0.01) for HPFS, 0.83 (0.69–0.99; P trend 0.05) for NHS I, and 0.76 (0.65–0.88; P trend 0.001) for NHS II.

Conclusions—Higher dietary calcium from either non-dairy or dairy sources is independently associated with lower kidney stone risk.

Keywords

Kidney stones; calcium; dietary risk factors

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INTRODUCTION

Lower dietary calcium is an established risk factor for calcium kidney stone formation. In observational studies, we and others previously reported prospective independent associations between lower dietary calcium and increased risk of incident kidney stones.[1–4] In a randomized trial of 120 men with calcium oxalate stone disease and idiopathic hypercalciuria, Borghi compared the effects of a low calcium (400 mg/d) diet to a higher calcium diet (1200 mg/d) also restricted in sodium (1200 mg/d) and animal protein (52 g/d).[5] Study participants on the higher calcium diet had a 51% lower risk of recurrent nephrolithiasis than their low-calcium counterparts. The mechanism whereby higher calcium intake may decrease stone risk is unclear; it is possible that more calcium in the intestinal lumen results in lower intestinal absorption (and thus lower urinary excretion) of oxalate.[6, 7]

Despite these data, the relations between dietary calcium and kidney stone formation require elucidation. Because of the large contribution of milk products to non-supplemental calcium intake in Western populations, large-scale observational studies to date reporting associations between dietary calcium and stone risk have, to a large extent, delineated associations between dairy intake and risk. Furthermore, in contrast to dietary calcium, higher supplemental calcium intake has been associated with increased, rather than decreased, risk of kidney stone formation.[1, 8] Taken together, these points suggest the important possibility that milk products may contain an unknown factor that inhibits calcium stone formation. To date, no study has examined the association between non-dairy dietary calcium and kidney stone risk.

To examine the independent associations between non-dairy dietary calcium, dairy calcium, and risk of incident symptomatic kidney stones, we conducted prospective analyses in three large cohorts: the Health Professionals Follow-up Study (HPFS) and the Nurses' Health Studies I and II (NHS I and II).

MATERIALS and METHODS

Study populations

In 1986, 51,529 male dentists, optometrists, osteopaths, pharmacists, podiatrists, and veterinarians between the ages of 40 and 75 years enrolled in HPFS by completing and returning an initial questionnaire that provided detailed information on diet, medical history, and medications. This cohort, like NHS I and NHS II, is followed by biennial mailed questionnaires, which include inquiries about newly diagnosed diseases such as kidney stones. We limited the analysis to men who completed at least one dietary questionnaire and excluded participants with a history of kidney stones before 1986. We excluded men ≥ 60 years old because we previously reported inverse associations between calcium intake and stone risk only in HPFS participants < 60.[9] A total of 30,762 men remained in the study group.

In 1976, 121,700 female registered nurses between the ages of 30 and 55 years enrolled in NHS I. Since we first asked NHS I participants about their lifetime history of kidney stones in 1992, the current analysis was limited to women who answered questionnaires in 1992 or

later. For this study we started follow-up in 1986. After excluding women with kidney stones before 1986, our study population included 94,164 NHS I participants.

In 1989, 116,430 female registered nurses between the age of 25 and 42 years enrolled in NHS II. Dietary information was first collected from this cohort in 1991. We limited the analysis to women who completed at least one dietary questionnaire and excluded participants with a history of kidney stones before 1991. A total of 101,701 NHS II participants remained in the study group.

Assessment of diet

The baseline semiquantitative food-frequency questionnaires asked about the annual average use of more than 130 individual foods and 22 beverages. Subsequently, a version of this food-frequency questionnaire (FFQ) has been mailed to study participants every 4 years. Intakes of dietary factors were computed from the reported frequency of consumption of each specified unit of food and, with the exception of oxalate, from United States Department of Agriculture data on the content of the relevant nutrient in specified portions. The oxalate content of the majority of foods on the FFQ, as well as frequently consumed write-in foods, was measured by capillary electrophoresis in the laboratory of Dr Ross Holmes. This assay has been described in detail elsewhere.[10, 11] Nutrient values were adjusted for total caloric intake to determine the nutrient composition of the diet independent of the total amount of food eaten. Adjustment was performed using a regression model, with total caloric intake as the independent variable and absolute nutrient intake as the dependent variable.[12, 13]

The intake of mineral and vitamin supplements (such as calcium and vitamin D) in multivitamins or isolated form was determined by the brand, type, and frequency of reported use. The reproducibility and validity of the FFQs in the HPFS and NHS I have been documented.[14, 15]

Assessment of non-dietary covariates

For each cohort, information on age, weight and height was obtained on the baseline questionnaire, and age and weight were updated every two years. Body mass index (BMI) was calculated as the weight in kilograms divided by the square of height in meters. Information on thiazide diuretics was updated every two years in HPFS and NHS II. In NHS I, thiazide use was determined in 1980, 1982, and then every six years until 1994, when biennial updates started.

Assessment of incident kidney stones

The primary outcome was an incident kidney stone accompanied by pain or hematuria. The participants reported on the interval diagnosis of kidney stones every two years. Any study participant who reported a new kidney stone on the biennial questionnaire was sent an additional questionnaire to determine the date of occurrence and the symptoms from the stone. In HPFS, we obtained medical records from 582 men who reported a kidney stone and the diagnosis was confirmed in 95%. There were 148 records that contained a stone composition report and 127 men (86%) had a stone that contained ≥ 50% calcium oxalate. In

NHS I, we obtained medical records from 194 women who reported a kidney stone and 96% of the records confirmed the diagnosis. There were 78 records that contained a stone composition report and 60 women (77%) had a stone that contained ≥ 50% calcium oxalate. In NHS II, we obtained medical records from 858 women who reported a kidney stone and 98% of the records confirmed the diagnosis. There were 243 records that contained a stone composition report and 191 women (79%) had a stone that contained ≥ 50% calcium oxalate.

Statistical analysis

The study design was prospective; information on diet was collected before the diagnosis of the kidney stone. The relative risk was used as the measure of association between dairy and non-dairy dietary calcium and incident kidney stones. Dairy and non-dairy dietary calcium were divided into quintiles, and the lowest quintiles served as the referent groups. The Mantel extension test was used to evaluate linear trends across categories of intake.

Dietary exposures were updated every four years. We allocated person-time of follow-up according to exposure status at the start of each follow-up period. If complete information on diet was missing at the start of a time period, the participant was excluded from that time period. For HPFS, person-time was counted from the date of the return of the 1986 questionnaire to the date of a kidney stone or death or to January 31, 2006, whichever came first. For NHS I, person-time was counted from the date of the return of the 1986 questionnaire to the date of a kidney stone or death or to May 31, 2006. For NHS II, person-time was counted from the date of the return of the 1991 questionnaire to the date of a kidney stone or death or to May 31, 2007.

We adjusted our analyses for potentially confounding variables using Cox proportional hazards regression. The confounding variables considered were age (continuous), BMI (six categories), history of diabetes, history of hypertension, use of thiazide diuretics (yes or no), family history of kidney stones (yes or no; HPFS and NHS II), fluid intake (in quintiles), alcohol intake (seven categories), calcium supplement use (0 mg/d, 1 to 100 mg/d, 101 to 500 mg/d, and ≥ 500 mg/d), and intakes of animal protein, potassium, sodium, vitamin C, sodium, oxalate, magnesium, and caffeine (all in quintiles). We calculated 95% confidence intervals for all relative risks. All P values are two tailed.

All data were analyzed by using SAS software, version 9.2 (SAS Institute Inc., Cary, North Carolina). The research protocol for this study was reviewed and approved by the institutional review board of Brigham and Women’s Hospital.

RESULTS

Over a combined 56 years of follow-up, we documented 5,270 new symptomatic kidney stones in the three cohorts. In HPFS (men), NHS I (older women), and NHS II (younger women), there were 1,133, 1,806, and 2,331 incident kidney stones, respectively.

At baseline, study participants with higher non-dairy dietary calcium were older, were more likely to have a history of diabetes, were more likely to use thiazide diuretics (NHS I and

NHS II only), and consumed more supplemental and less dairy calcium (Table 1). NHS I participants with higher non-dairy dietary calcium had higher BMI and were more likely to have a history of hypertension. At baseline, the fraction of dietary calcium from non-dairy sources (calculated as mean non-dairy dietary calcium/mean total dietary calcium) was 41% for HPFS, 46% for NHS I, and 38% for NHS II. However, the Spearman correlation coefficients between energy-adjusted dairy calcium and total dietary calcium were 0.95 in HPFS, 0.97 in NHS I, and 0.96 in NHS II. In contrast, the correlation coefficients between energy-adjusted non-dairy dietary calcium and total dietary calcium were 0.23 in HPFS, 0.20 in NHS I, and 0.13 in NHS II.

Higher dietary calcium from either non-dairy or dairy sources was associated independently with a lower risk of incident kidney stones in all 3 cohorts (Tables 2 and 3). The multivariable relative risks in the highest as compared to the lowest quintile of non-dairy dietary calcium were 0.71 (95% confidence interval 0.56 to 0.92; P for trend 0.007) for HPFS, 0.82 (95% confidence interval 0.69 to 0.98; P for trend 0.08) for NHS I, and 0.74 (95% confidence interval 0.63 to 0.87; P for trend 0.002) for NHS II. The multivariable relative risks in the highest as compared to lowest quintile of dairy calcium were 0.77 (95% confidence interval 0.63 to 0.95; P for trend 0.01) for HPFS, 0.83 (95% confidence interval 0.69 to 0.99; P for trend 0.05) for NHS I, and 0.76 (95% confidence interval 0.65 to 0.88; P for trend 0.001) for NHS II.

We also performed analyses stratified by intakes (above and below the median) of total vitamin D, total dietary calcium, and oxalate. The magnitude of the associations between higher non-dairy dietary calcium and dairy calcium and lower kidney stone risk were similar in participants with higher and lower vitamin D intake, higher and lower dietary calcium, and higher and lower oxalate. Additional multivariable adjustment for menopause, as well as analyses restricted to postmenopausal women in NHS I, yielded similar results to the primary analyses.

DISCUSSION

In men and women, higher dietary calcium from either non-dairy or dairy sources is associated with lower risk of incident symptomatic kidney stones. This inverse association is independent of age, body size, dietary factors, intake of fluid and supplemental calcium, thiazide use, and other kidney stone risk factors.

Because of the high correlation between total dietary calcium and dairy intake in Western populations, previous large-scale observational studies of dietary calcium and kidney stone risk represent, de facto, studies of milk products and risk. In Borghi's randomized trial comparing the effects of a higher to a low calcium diet on recurrent calcium oxalate stone formation, calcium restriction was achieved by avoiding dairy (i.e., milk, yogurt, and cheese).[5] The data from our current study allows us to dismiss the important possibility that dairy products were solely responsible for previously observed associations between higher dietary calcium and lower risk of incident kidney stones.

Our results do not provide insight into why dietary calcium may exert different effects on kidney stone risk than supplemental calcium. Supplemental calcium use, in these cohorts and others, is associated with a nominal *increase* in kidney stone formation.[1, 8] For example, participants in the Women's Health Initiative (WHI) taking 1000 mg of supplemental calcium and 400 IU of vitamin D_3 daily were 17% more likely to have a kidney stone than participants in the placebo group.[8] Because feeding studies suggest that orally administered calcium can reduce intestinal oxalate absorption (and subsequent renal oxalate excretion),[6, 7] it is reasonable to speculate that the effect of supplemental calcium on kidney stone risk depends on whether supplements are taken with or between meals.

Our study has limitations. First, we did not have kidney stone composition reports from all stone formers. Thus, we could not determine whether associations between non-dairy dietary calcium and risk varied by stone type. However, the majority of stone composition reports in each cohort show kidney stones containing ≥ 50% calcium oxalate. Second, as with any observational study, we cannot rule out the possibility of confounding by unknown or unmeasured factors associated with stone risk. Third, data from the validated FFQ can only approximate actual nutrient intake. However, we expect that potential misclassification of dietary intake would be random with respect to subsequent risk of symptomatic nephrolithiasis. Finally, the results of our study may not be generalizable. Only a small fraction of our study population is non-white, and we do not have data on stone formation in men aged less than 40 years.

CONCLUSIONS

Higher dietary calcium, regardless of source, is independently associated with a lower risk of symptomatic kidney stones in 3 large cohorts of free-living individuals. Restriction of dietary calcium should not be recommended as a means of calcium kidney stone prevention.

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REFERENCES

1. Curhan G, Willett W, Speizer F, et al. Comparison of dietary calcium with supplemental calcium and other nutrients as factors affecting the risk for kidney stones in women. Ann Intern Med. 1997; 126:497. [PubMed: 9092314]
2. Curhan GC, Willett WC, Knight EL, et al. Dietary factors and the risk of incident kidney stones in younger women (Nurses' Health Study II). Arch Intern Med. 2004; 164:885. [PubMed: 15111375]
3. Curhan GC, Willett WC, Rimm EB, et al. A prospective study of dietary calcium and other nutrients and the risk of symptomatic kidney stones. N Engl J Med. 1993; 328:833. [PubMed: 8441427]
4. Sorensen MD, Kahn AJ, Reiner AP, et al. Impact of nutritional factors on incident kidney stone formation: a report from the WHI OS. J Urol. 2012; 187:1645. [PubMed: 22425103]
5. Borghi L, Schianchi T, Meschi T, et al. Comparison of two diets for the prevention of recurrent stones in idiopathic hypercalciuria. N Engl J Med. 2002; 346:77. [PubMed: 11784873]
6. Hess B, Jost C, Zipperle L, et al. High-calcium intake abolishes hyperoxaluria and reduces urinary crystallization during a 20-fold normal oxalate load in humans. Nephrol Dial Transplant. 1998; 13:2241. [PubMed: 9761503]

7. Holmes RP, Assimos DG. The impact of dietary oxalate on kidney stone formation. Urol Res. 2004; 32:311. [PubMed: 15221245]
8. Jackson RD, LaCroix AZ, Gass M, et al. Calcium plus vitamin D supplementation and the risk of fractures. N Engl J Med. 2006; 354:669. [PubMed: 16481635]
9. Taylor EN, Stampfer MJ, Curhan GC. Dietary factors and the risk of incident kidney stones in men: new insights after 14 years of follow-up. J Am Soc Nephrol. 2004; 15:3225. [PubMed: 15579526]
10. Holmes R, Kennedy M. Estimation of the oxalate content of foods and daily oxalate intake. Kidney Int. 2000; 57:1662. [PubMed: 10760101]
11. Taylor EN, Curhan GC. Oxalate intake and the risk for nephrolithiasis. J Am Soc Nephrol. 2007; 18:2198. [PubMed: 17538185]
12. Willett WC, Stampfer MJ. Total energy intake: implications for epidemiologic analyses. Am J Epidemiol. 1986; 124:17. [PubMed: 3521261]
13. Willett, WC. Nutritional Epidemiology. 2nd ed ed. New York: Oxford University Press; 1998. p. 273-298.
14. Rimm EB, Giovannucci EL, Stampfer MJ, et al. Reproducibility and validity of an expanded self-administered semiquantitative food frequency questionnaire among male health professionals. Am J Epidemiol. 1992; 135:1114. [PubMed: 1632423]
15. Willett WC, Sampson L, Stampfer MJ, et al. Reproducibility and validity of a semiquantitative food frequency questionnaire. Am J Epidemiol. 1985; 122:51. [PubMed: 4014201]

Table 1

Age-standardized characteristics of men < 60 years of age (HPFS), older women (NHS I), and younger women (NHS II) according to energy-adjusted non-dairy dietary calcium at baseline.*

	Quintile of non-dairy dietary calcium					
	Q1	Q2	Q3	Q4	Q5	P for trend
HPFS						
Age, y	48.2	48.6	49.1	49.4	49.2	<0.001
Body mass index, kg/m^2	25.6	25.6	25.6	25.5	25.3	<0.001
Hypertension (%)	16.7	16.7	16.2	16.4	16.6	0.66
Thiazide use (%)	5.8	6.0	5.4	6.0	5.3	0.22
Diabetes Mellitus (%)	0.9	1.5	2.0	2.2	2.7	<0.001
Supplemental calcium, mg/d	56	70	79	99	134	<0.001
Dairy calcium, mg/d	475	491	474	464	432	<0.001
Non-dairy dietary calcium, mg/d	238	289	318	351	434	<0.001
NHS I						
Age, y	51.9	52.4	52.7	52.9	53.1	<0.001
Body mass index, kg/m^2	24.7	25.0	25.2	25.5	25.7	<0.001
Hypertension (%)	23.2	23.2	24.4	26.0	27.0	<0.001
Thiazide use (%)	11.0	11.9	12.5	13.3	14.9	<0.001
Diabetes Mellitus (%)	1.8	2.6	3.3	4.1	5.1	<0.001
Supplemental calcium, mg/d	307	336	360	381	413	<0.001
Dairy calcium, mg/d	437	452	448	437	414	<0.001
Non-dairy dietary calcium, mg/d	262	304	329	357	419	<0.001
NHS II						
Age, y	35.7	36.0	36.2	36.3	36.4	<0.001
Body mass index, kg/m^2	24.6	24.5	24.6	24.7	24.6	0.28
Hypertension (%)	6.3	5.6	6.2	6.4	6.9	0.02
Thiazide use (%)	1.3	1.5	1.8	2.0	2.0	<0.001
Diabetes Mellitus (%)	0.5	0.7	0.9	1.1	1.5	<0.001
Supplemental calcium, mg/d	103	113	124	137	165	<0.001

	Quintile of non-dairy dietary calcium					
	Q1	**Q2**	**Q3**	**Q4**	**Q5**	**P for trend**
Dairy calcium, mg/d	617	609	584	555	513	<0.001
Non-dairy dietary calcium, mg/d	253	302	332	364	440	<0.001

* Mean values were derived from responses to the 1986 (HPFS and NHS I) and 1991 (NHS II) questionnaires.

Note: Nutrient values were adjusted for caloric intake. Supplemental calcium also includes calcium from multivitamin preparations.

HPFS: Health Professionals Follow-up Study
NHS: Nurses' Health Study

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Table 2

Relative risk of incident kidney stones in men < 60 years of age (HPFS) and women (NHS I and NHS II) by quintile of non-dairy dietary calcium.

	Quintile 1	Quintile 2	Quintile 3	Quintile 4	Quintile 5	P for trend
HPFS						
Quintile median* (mg/day)	262	310	345	384	460	
Cases	280	277	229	210	137	
Person-years	64,948	63,521	61,905	61,165	60,006	
Age-adjusted RR (95% CI)	1.0	1.01 (0.86–1.20)	0.86 (0.72–1.03)	0.80 (0.67–0.96)	0.53 (0.43–0.65)	<0.001
Multivariate RR+ (95% CI)	1.0	1.10 (0.93–1.31)	0.99 (0.82–1.20)	0.99 (0.80–1.21)	0.71 (0.56–0.92)	0.007
NHS I						
Quintile median* (mg/day)	272	315	345	378	441	
Cases	444	375	367	323	297	
Person-years	286,868	287,835	288,285	288,964	289,611	
Age-adjusted RR (95% CI)	1.0	0.85 (0.74–0.98)	0.84 (0.73–0.96)	0.74 (0.64–0.85)	0.68 (0.59–0.79)	<0.001
Multivariate RR+ (95% CI)	1.0	0.89 (0.78–1.03)	0.92 (0.79–1.07)	0.85 (0.72–1.00)	0.82 (0.69–0.98)	0.08
NHS II						
Quintile median* (mg/day)	256	302	334	371	439	
Cases	627	462	487	397	358	
Person-years	256,151	257,286	258,443	258,750	259,144	
Age-adjusted RR (95% CI)	1.0	0.75 (0.66–0.84)	0.78 (0.70–0.88)	0.65 (0.57–0.73)	0.58 (0.51–0.66)	<0.001
Multivariate RR+ (95% CI)	1.0	0.81 (0.72–0.92)	0.89 (0.79–1.02)	0.78 (0.67–0.90)	0.74 (0.63–0.87)	0.002

*For illustrative purposes, non-dairy dietary calcium values were derived from responses to the 1994 (men and older women) and 1995 (younger women) dietary questionnaires. Updated period-specific values were used in the prospective analyses.

+Results are adjusted for age, BMI (six categories), history of diabetes, history of hypertension, use of thiazide diuretics (yes or no), family history of kidney stones (yes or no; HPFS and NHS II), fluid intake (in quintiles), alcohol use (seven categories), calcium supplement use (four categories), and intakes of dairy calcium, animal protein, potassium, sodium, vitamin C, sodium, oxalate, magnesium, and caffeine (all in quintiles).

HPFS: Health Professionals Follow-up Study
NHS: Nurses' Health Study

Table 3

Relative risk of incident kidney stones in men < 60 years of age (HPFS) and women (NHS I and NHS II) by quintile of dairy calcium intake.

	Quintile 1	Quintile 2	Quintile 3	Quintile 4	Quintile 5	P for trend
HPFS						
Quintile median* (mg/day)	151	272	385	528	839	
Cases	252	261	214	216	190	
Person-years	61,397	64,447	62,981	62,671	60,048	
Age-adjusted RR (95% CI)	1.0	0.98 (0.82–1.16)	0.82 (0.69–0.99)	0.83 (0.70–1.00)	0.77 (0.64–0.93)	0.002
Multivariate RR+ (95% CI)	1.0	0.95 (0.79–1.13)	0.79 (0.66–0.95)	0.80 (0.67–0.97)	0.77 (0.63–0.95)	0.01
NHS I						
Quintile median* (mg/day)	143	266	377	523	816	
Cases	400	411	351	363	281	
Person-years	284,583	287,508	289,352	289,877	290,242	
Age-adjusted RR (95% CI)	1.0	1.01 (0.88–1.16)	0.86 (0.75–1.00)	0.89 (0.77–1.03)	0.70 (0.60–0.82)	<0.001
Multivariate RR+ (95% CI)	1.0	1.02 (0.89–1.18)	0.91 (0.78–1.05)	0.97 (0.84–1.13)	0.83 (0.69–0.99)	0.05
NHS II						
Quintile median* (mg/day)	181	319	446	615	937	
Cases	559	500	443	444	385	
Person-years	254,554	256,792	258,225	259,369	260,835	
Age-adjusted RR (95% CI)	1.0	0.89 (0.79–1.01)	0.79 (0.70–0.89)	0.79 (0.69–0.89)	0.68 (0.60–0.77)	<0.001
Multivariate RR+ (95% CI)	1.0	0.91 (0.81–1.03)	0.83 (0.73–0.95)	0.85 (0.74–0.97)	0.76 (0.65–0.88)	0.001

*For illustrative purposes, dairy calcium values were derived from responses to the 1994 (men and older women) and 1995 (younger women) dietary questionnaires. Updated period-specific values were used in the prospective analyses.

+Results are adjusted for age, BMI (six categories), history of diabetes, history of hypertension, use of thiazide diuretics (yes or no), family history of kidney stones (yes or no; HPFS and NHS II), fluid intake (in quintiles), alcohol use (seven categories), calcium supplement use (four categories), and intakes of non-dairy dietary calcium, animal protein, potassium, sodium, vitamin C, sodium, oxalate, magnesium, and caffeine (all in quintiles).

HPFS: Health Professionals Follow-up Study
NHS: Nurses' Health Study