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Soy consumption is not protective against diabetes in Hawaii: The Multiethnic Cohort

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Abstract

Based on the hypothesis that soy consumption may improve glucose tolerance, we examined the association of soy intake with diabetes risk in the Hawaii component of the Multiethnic Cohort. Among 29,719 Caucasian, 35,141 Japanese American, and 10,484 Native Hawaiian men and women, 8,564 incident diabetes cases were identified during 14 years of follow-up. Cox regression was used to calculate hazard ratios while adjusting for known confounders with stratifications by sex, ethnicity, and weight status. We observed no protective effect of soy food consumption on diabetes risk in this population, which has a wide range of soy intakes though lower than in Asian populations. Indeed, higher soy food intake was associated with a weakly elevated diabetes risk across ethnic groups; the higher risk was limited to overweight and obese individuals. The current findings do not support a protective effect of modest levels of soy food consumption against diabetes.

Keywords

Diabetes mellitus type 2; ethnicity; soy foods; obesity; prospective study

Introduction

The prevalence of diabetes varies considerably by ethnicity. In the Multiethnic Cohort (MEC) study, Native Hawaiians and Japanese Americans had a 2-fold higher risk than Caucasians (Maskarinec *et al.* 2009). In addition to a strong effect of body weight, dietary composition is thought to affect risk (Erber *et al.* 2010). Legume intake, in particular soy, may be protective against diabetes because of its ability to improve glucose tolerance and lower insulin resistance, its dietary fiber content, and/or the estrogenic effects of isoflavones (Jayagopal *et al.* 2002; Bhathena & Velasquez 2002; Kwon *et al.* 2010). However, the limited number of studies in Western and Asian populations show inconsistent findings (Meyer *et al.* 2000; Feskens *et al.* 1995; Villegas *et al.* 2008; Nanri *et al.* 2010). In the present analysis, we examined the association of soy food consumption with diabetes risk in the Hawaii component of the MEC.

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Conflict of Interest

The authors declare no conflict of interest.

Materials and Methods

The MEC is a population-based prospective cohort established in 1993–1996; it consists of men and women aged 45–75 years in Hawaii and California (Kolonel *et al.* 2000). Participants entered the cohort by completing a 26-page, self-administered questionnaire that included a validated food frequency questionnaire (FFQ) and questions about demographics, medical history, anthropometric measures, and lifestyle factors (Stram *et al.* 2000). The Institutional Review Boards at the University of Hawaii and Kaiser Permanente Hawaii approved the study.

We calculated food and nutrient intakes as g/day using an ethnicity-specific food composition database. Soy intake estimated from reported consumption of tofu, miso soup, and vegetarian-meat products was categorized into low, moderate, and high (<5, 5-<10,≥ 10 g/day).

In the Hawaii component of the MEC, comprised of 103,898 primarily Caucasian, Japanese American, and Native Hawaiian participants, we were able to identify incident diabetes cases through linkages with health plans in addition to follow-up questionnaires (Maskarinec *et al.* 2009). After excluding 10,028 self-reported cases at baseline, 8,797 participants of other ethnicities, 812 unconfirmed cases, 8,917 individuals with missing covariates, dietary information, or follow-up information, 75,344 participants were part of the analysis.

Using the SAS software, version 9.2 (SAS Institute, Cary, NC, USA), Cox regression was applied to calculate hazard ratios (HR) and 95% confidence intervals (CI). The models were stratified by age at cohort entry and adjusted for ethnicity, body mass index (BMI), physical activity (quintiles of Metabolic Equivalent of Tasks), education (≤12, 12-<15, and ≥15 years), energy intake (log-transformed), smoking status (never, past, and current), and intakes of alcohol (quintiles), dietary fiber (log-transformed), and processed red meat (log-transformed) (Hopping *et al.* 2010; Erber *et al.* 2010; Steinbrecher *et al.* 2010). We also performed stratified analyses by sex, ethnicity, and weight status. Ethnic-specific cut-offs for overweight and obesity were applied: 25 and 30 kg/m^2 for Caucasians and Native Hawaiians and 23 and 27.5 kg/m^2 for Japanese Americans (WHO expert consultation 2004).

Results

During 14 years of follow-up, 8,564 incident diabetes cases were identified. The estimated soy intake varied greatly by ethnicity (p <0.0001) (Table 1): Japanese American men and women had the highest median intakes (14.5 g/day for both), followed by Hawaiians (7.6 and 8.1 g/day), whereas the median intake for Caucasians was 0. We observed a weakly elevated diabetes risk with soy intake in all men and women (Table 2); moderate and high soy intakes were associated with a 10–18% higher risk (p_{trend} <0.001) as compared to low intake. Although interaction terms of soy intake with ethnicity and weight status were not statistically significant, we examined the risk by subgroup. In Caucasian and Native Hawaiian but not Japanese American women, there was a monotonic increase in risk with higher intakes. A similar pattern across all ethnic groups was seen in men, though the association for Caucasians was weaker than in women. After stratification by adiposity, no relation with soy intake was observed in normal weight individuals, but the elevated risk persisted in overweight and obese men and in overweight women.

Discussion

Unlike previous studies (Nanri *et al.* 2010; Villegas *et al.* 2008), we observed no protective effect of soy food consumption on diabetes risk. On the contrary, the risk was slightly elevated with higher soy food intake across sex and ethnic groups. The higher risk was limited to overweight and obese individuals, whereas a Japanese study described a protective effect among overweight women (Nanri *et al.* 2010). Despite a wide range of soy food consumption, mean daily intake was considerably lower in the MEC than in Asian populations, 23 g among Japanese Americans as compared to 88 g in Japan (Nanri *et al.* 2010). The high soy intake of Asian populations reflects their traditional diets that differ substantially from a more Westernized dietary pattern in Hawaii and may have influenced the results in combination with the higher BMI in the MEC than in China (Villegas *et al.* 2008) and Japan (Nanri *et al.* 2010).

Strengths of our study include its prospective design, the long follow-up time, a validated FFQ (Stram *et al.* 2000), the availability of many confounders, the identification of cases by linkage with health plans (Maskarinec *et al.* 2009), and the relatively high soy intakes as compared to other Western populations. Potential weaknesses that may partly explain the inconsistent findings are the low soy intake among our cohort as compared to Asian populations as well as the limited number of soy foods items in the FFQ, which may have led to underreporting of soy foods. For example, in the Chinese study (Villegas *et al.* 2008), only soy beans and soy milk were associated with diabetes, but these foods were not assessed in the MEC because they are not as commonly consumed in Hawaii as tofu. Although the slightly increased risk among overweight/obese individuals may have been due to chance, residual confounding, or other dietary or lifestyle factors correlated with soy food consumption, it may also indicate a differential metabolic effect of soy foods by adiposity.

The findings in this multiethnic population do not support a protective effect of soy foods against diabetes development in a population with relatively low soy food consumption.

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Table 1

Baseline characteristics of the Hawaii component of the Multiethnic Cohort Study[1]

Characteristics	Men			Women		
	Caucasian	Native Hawaiian	Japanese American	Caucasian	Native Hawaiian	Japanese American
	N=15,096	N=4,561	N=16,555	N=14,623	N=5,923	N=18,586
Age (years)						
45–54	44.8%	50.5%	32.8%	47.2%	53.3%	32.5%
55–64	27.7%	29.2%	28.0%	26.7%	28.2%	30.5%
≥65	27.5%	20.3%	39.2%	26.1%	18.5%	37.0%
Education (years)						
≤12	19.0%	47.5%	39.0%	23.2%	52.3%	41.0%
13–15	29.0%	31.9%	28.8%	34.3%	30.2%	28.2%
>15	52.0%	20.6%	32.2%	42.5%	17.5%	30.8%
BMI (kg/m^2)[2]						
Normal	47.1%	26.7%	30.9%	62.4%	38.5%	55.9%
Overweight	40.6%	44.2%	51.8%	25.1%	33.5%	32.9%
Obese	12.3%	29.1%	17.3%	12.5%	28.0%	11.2%
Smoking status						
Never	32.7%	32.8%	30.3%	43.5%	45.0%	69.3%
Past	50.9%	44.7%	54.2%	39.9%	31.2%	21.5%
Current	16.4%	22.5%	15.5%	16.6%	23.8%	9.2%
Physical activity (METs)[3]	1.6 (1.4, 1.8)	1.7 (1.5, 1.9)	1.6 (1.5, 1.8)	1.6 (1.4, 1.8)	1.6 (1.4, 1.8)	1.6 (1.4, 1.7)
Total energy (kJ/day)	9042 (6996, 11673)	10623 (7770, 14364)	9046 (7071, 11477)	7138 (5573, 9184)	8619 (6289, 11841)	7146 (5602, 9134)
Soy (g/day)[4]	0.0 (0.0, 4.8)	7.6 (3.0, 15.1)	14.5 (8.1, 31.1)	0.0 (0.0, 4.2)	8.1 (3.2, 15.1)	14.5 (8.1, 31.1)
Processed red meat (g/day)	13.9 (6.6, 24.9)	23.5 (12.5, 38.9)	17.5 (9.4, 28.6)	7.0 (3.2, 13.8)	15.9 (7.6, 27.3)	10.7 (5.2, 18.1)
Dietary fiber (g/day)	22.7 (16.3, 31.4)	20.8 (14.1, 30.6)	19.2 (13.6, 27.1)	21.1 (15.0, 29.2)	21.2 (14.0, 32.0)	19.5 (13.8, 27.5)
Alcohol (g/day)	8.2 (0.0, 29.1)	3.2 (0.0, 18.2)	1.5 (0.0, 15.6)	1.8 (0.0, 12.9)	0.0 (0.0, 2.2)	0.0 (0.0, 0.0)

[1] Data are presented as median (interquartile range) or percentages.

[2] Defined as <25, 25-<30, and 30+ for Caucasians and Hawaiians and <23, 23-<27.5, and 27.5+ kg/m^2 for Japanese Americans.

[3] METs: Metabolic equivalent of tasks.

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[4]Soy intake estimated from tofu, miso soup and vegetarian-meat consumption.

Table 2

Diabetes risk by soy food intake

Soy intake (g/day)	Category	Men				Women			
		Cases (N)	Non-Cases (N)	HR (95% CI)[1]	*p* for trend	Cases (N)	Non-Cases (N)	HR (95% CI)[1]	*p* for trend
< 5		1,496	14,432	1.00		1,178	15,112	1.00	
5–10	All	837	5,004	1.10 (1.01–1.21)	<0.001	830	6,164	1.14 (1.03–1.25)	< 0.001
≥ 10		2,218	12,225	1.18 (1.09–1.29)		2,005	13,843	1.18 (1.08–1.29)	
< 5		786	10,546	1.00		509	10,703	1.00	
5–10	Caucasian	135	1,436	1.24 (1.03–1.49)	0.009	96	1,436	1.37 (1.09–1.71)	< 0.001
≥ 10		157	2,036	1.22 (1.02–1.46)		107	1,772	1.44 (1.16–1.80)	
< 5		301	1,576	1.00		338	1,994	1.00	
5–10	Hawaiian	171	851	1.03 (0.85–1.25)	0.004	213	1,185	1.02 (0.85–1.21)	0.03
≥ 10		324	1,338	1.29 (1.08–1.53)		390	1,803	1.19 (1.02–1.40)	
< 5		409	2,310	1.00		331	2,415	1.00	
5–10	Japanese American	531	2,717	1.11 (0.97–1.26)	0.04	521	3,543	1.11 (0.97–1.28)	0.17
≥ 10		1,737	8,851	1.14 (1.01–1.28)		1,508	10,268	1.11 (0.98–1.26)	
< 5		234	6,302	1.00		244	9,100	1.00	
5–10	Normal[2]	123	1,854	1.04 (0.81–1.32)	0.63	177	3,523	1.02 (0.83–1.27)	0.12
≥ 10		353	4,586	1.05 (0.85–1.31)		541	8,220	1.15 (0.94–1.40)	
< 5		690	6,290	1.00		423	4,134	1.00	
5–10	Overweight[2]	401	2,347	1.17 (1.02–1.33)	0.001	322	1,858	1.17 (0.99–1.36)	0.003
≥ 10		1,090	5,891	1.23 (1.09–1.38)		837	4,180	1.25 (1.08–1.45)	
< 5		572	1,840	1.00		511	1,878	1.00	
5–10	Obese[2]	313	803	1.09 (0.94–1.27)	0.002	331	783	1.14 (0.98–1.32)	0.10
≥ 10		775	1,748	1.23 (1.08–1.40)		627	1,443	1.13 (0.98–1.30)	

[1] Hazard ratio and 95% confidence interval adjusted for ethnicity, BMI, physical activity, education, total energy, smoking status, alcohol, dietary fiber, & processed red meat intake.

[2] Defined as <25, 25-<30, and 30+ kg/m^2 for Caucasians and Hawaiians and <23, 23-<27.5, and 27.5+ kg/m^2 for Japanese Americans.