

Embargoed for 4 PM EDT, Monday, June 26, 2006

## Influence of Saturated Fat and Linolenic Acid on the Association Between Intake of Dairy Products and Blood Pressure

Luc Djoussé, James S. Pankow, Steven C. Hunt, Gerardo Heiss, Michael A. Province, Edmond K. Kabagambe, R. Curtis Ellison

**Abstract**—Data on the association between dairy consumption and blood pressure have been inconsistent. We sought to examine the relation between dairy consumption and prevalent hypertension (HTN) among 4797 participants of the National Heart, Lung, and Blood Institute Family Heart Study. We used generalized estimating equations to estimate prevalence odds ratios of HTN across categories of dairy consumption. From the lowest to the highest sex-, age-, and energy-adjusted quartile of dairy consumption, there was an inverse association between dairy intake and prevalent HTN: odds ratios (95% CIs) were 1.0 (reference), 0.82 (0.64 to 1.05), 0.68 (0.53 to 0.89), and 0.62 (0.45 to 0.84), respectively, in a model adjusting for age, sex, energy intake, field center, body mass index, dietary linolenic acid, saturated and monounsaturated fat, sodium intake, potassium, caffeine, fiber, and fruits and vegetables ( $P$  for trend=0.002). This association was independent of calcium intake and was mainly observed among subjects consuming fewer calories from saturated fat ( $P$  for interaction=0.014). Dairy consumption was inversely associated with systolic ( $P$  for trend=0.003) but not diastolic ( $P$  for trend=0.09) blood pressure. Although subjects consuming  $\geq 2$  servings per day of dairy products and higher total linolenic acid had the lowest prevalence odds of HTN, there was no evidence for interaction between linolenic acid and dairy consumption on HTN ( $P$  for interaction=0.65). In conclusion, our data indicate an inverse association between dairy consumption and prevalent HTN that was independent of dietary calcium, mainly among individuals consuming less saturated fat. This suggests that consumption of low-fat dairy products might be more beneficial for preventing HTN. (*Hypertension*. 2006;48:1-2.)

**Key Words:** hypertension, detection and control ■ epidemiology ■ diet ■ blood pressure

Hypertension is highly prevalent in the United States and is a major cause of morbidity and mortality.<sup>1-3</sup> Other than pharmacological interventions, lifestyle and dietary interventions are important to lower blood pressure.<sup>4-6</sup> Current nonpharmacological recommendations for lowering blood pressure include exercise, weight loss, and a diet rich in fruits and vegetables, potassium, magnesium, and calcium.<sup>1,6</sup> However, data on the effects of dietary calcium on blood pressure have been inconsistent. Both noninterventional studies<sup>7-9</sup> and randomized clinical trials<sup>10-15</sup> have yielded conflicting results on the effects of calcium intake on blood pressure and weight loss (from null effects to protective effects).

Dairy products, such as cheese, yogurt, and milk, are excellent sources of calcium. Previous studies assessing the effects of dairy products on blood pressure have also been inconsistent.<sup>11,16</sup> Because some of these dairy products may also contain substantial amounts of saturated fats, it might be

possible that the intake of saturated fats might offset some of the beneficial effects of dairy products. Limited data are available on the effects of  $\alpha$ -linolenic acid (ALA) on blood pressure. A few studies have reported an inverse association between dietary ALA<sup>17</sup> or adipose-tissue ALA<sup>18</sup> and blood pressure. However, it is not known whether ALA and dairy products exert additive or more than additive effects on blood pressure.

The current project sought to examine the association between dairy products and prevalent hypertension (HTN) and blood pressure and whether such an association is modified by the amount of saturated fatty acids consumed among 4797 participants of the National Heart, Lung, and Blood Institute (NHLBI) Family Heart Study. In addition, we also examined whether there was an interaction between saturated fat and total linolenic acid on the dairy-blood pressure relation.

Received March 31, 2006; first decision April 19, 2006; revision accepted May 19, 2006.

From the Division of Aging (L.D.), Department of Medicine, Brigham and Women's Hospital and Harvard Medical School, Boston, Mass; Division of Epidemiology and Community Health (J.S.P.), University of Minnesota, Minneapolis; Cardiovascular Genetics (S.C.H.), University of Utah, Salt Lake; Department of Epidemiology (G.H.), University of North Carolina, Chapel Hill, NC; Division of Biostatistics (M.A.P.), Washington University, St Louis, Mo; Department of Epidemiology (E.K.K.), University of Alabama at Birmingham; and the Section of Preventive Medicine and Epidemiology (R.C.E.), Boston University, Boston, Mass.

Correspondence to Luc Djoussé, Division of Aging, Brigham and Women's Hospital and Harvard Medical School, 1620 Tremont St, 3rd Floor; Boston, MA 02120. E-mail ldjousse@rics.bwh.harvard.edu

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*Hypertension* is available at <http://www.hypertensionaha.org>

DOI: 10.1161/01.HYP.0000229668.73501.e8

## Methods

### Study Population

The NHLBI Family Heart Study is a multicenter, population-based study designed to identify and evaluate genetic and nongenetic determinants of coronary heart disease (CHD), preclinical atherosclerosis, and cardiovascular risk factors. A detailed description of the NHLBI Family Heart Study has been published elsewhere.<sup>19</sup> Briefly, families in the study had been chosen randomly (a random group) or based on a higher-than-expected risk of CHD (a high-risk group) from previously established population-based cohort studies in Framingham, Mass; Forsyth County, NC; northwest suburbs of Minneapolis, Minn; and Salt Lake City, Utah. A family risk score relating the family's age- and sex-specific incidence of CHD to that expected in the general population<sup>20</sup> was used to identify families for the high-risk group. During a clinic visit at one of the field centers, a detailed medical and lifestyle history was obtained through interview, and laboratory measurements were done. Of a total 4971 subjects, we excluded 174 individuals without food frequency data. From the remaining 4959 participants with complete data on dairy consumption, we excluded 162 subjects because of probable errors on food frequency questionnaires (answers on the food frequency questionnaire judged by the interviewer as unreliable or >18 items left blank on the dietary questionnaires or energy intake outside a priori ranges [acceptance range=3347.2 to 17 572.8 kJ for men<sup>21</sup> and 2510.4 to 14 644 kJ for women<sup>22</sup>]). Thus, current analyses are based on 4797 participants (from both random and high-risk groups) with complete data on diet and blood pressure. Each participant gave informed consent, and the study protocol was reviewed and approved by each of the participating institutions.

### Assessment of Dairy Consumption

Dairy consumption was assessed through a staff-administered semi-quantitative food frequency questionnaire.<sup>23</sup> The reproducibility and validity of this food frequency questionnaire have been documented elsewhere.<sup>21,24</sup> Specifically, information on intake frequency of 8 ounces of low-fat milk (item Q1), 8 ounces of whole milk (item Q2), 1 cup yogurt (item Q3), half a cup of cottage cheese (item Q5), and 1 slice of other types of cheese (item Q6) was recorded. Possible responses were never, 1 to 3 servings per month, 1 serving per month, 2 to 4 servings per week, 5 to 6 servings per week, 1 serving per day, 2 to 3 servings per day, 4 to 6 servings per day, and  $\geq 7$  servings per day. Total dairy intake was computed as the sum of all 5 items.

### Other Dietary Data

Data on other dietary factors were obtained through a food frequency questionnaire as described above. The intake of specific nutrients (eg, calcium, magnesium, sodium, potassium, and caffeine) was computed by multiplying the frequency of consumption of an item by the nutrient content of specified portions. Composition values for nutrients were obtained from the Harvard University Food Composition Database derived from US Department of Agriculture sources<sup>25</sup> and manufacturer information. The frequency of fruit and vegetable consumption was obtained from a food frequency questionnaire.

### Blood Pressure Measurement and Prevalent HTN

Resting blood pressure was measured 3 times on seated participants after a 5-minute rest using a random 0 sphygmomanometer by trained and certified technicians. The appropriate cuff size was determined by the arm circumference. For arm circumference <240 mm, 240 to 320 mm, 321 to 240 mm, and >240 mm, a pediatric, regular, large, and thigh cuff size was used, respectively. For analyses, the average systolic blood pressure (SBP) and diastolic blood pressure (DBP) from the second and third measurements were used. We used the Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (JNC VII) classification<sup>1</sup> to define HTN (stages 1 or 2, SBP

of  $\geq 140$  mm Hg or DBP of  $\geq 90$  mm Hg) or if the subject reported that he/she was currently taking medications for HTN.

### Other Variables

Information on cigarette smoking, alcohol intake, education, and level of physical activity during the previous year was obtained by interview during the clinic visit. Diabetes mellitus was present if a subject was taking hypoglycemic agents, if a physician had told him/her that he/she has diabetes mellitus, or if fasting glucose levels were >7.0 mmol/L. Prevalent CHD was assessed by self-reported history of myocardial infarction, percutaneous transluminal coronary angioplasty, or coronary artery bypass graft.

### Statistical Analyses

Because energy intake and dietary patterns differ by gender and age, we created gender-, age-, and energy-adjusted quartiles of dairy consumption. Specifically, within each gender, we created deciles of age categories, and within each of the 10 age groups, we created deciles of energy intake. Finally, within each gender, we created quartiles of dairy intake within each of the 100 age- and energy-specific categories. We conducted gender-specific analyses, but because we observed an inverse association in both genders and there was no statistical interaction between gender and dairy consumption ( $P=0.60$ ), we present combined data for men and women. Because subjects were not independent, we used generalized estimating equations to compute adjusted odds ratios (ORs) for prevalent HTN and adjusted mean blood pressure across quartiles of dairy consumption. The multivariable model controlled for age (deciles), gender, energy intake (deciles), body mass index, field center, total linolenic acid, saturated and monounsaturated fat, sodium, potassium, magnesium, caffeine, fiber, fruit and vegetable intake, education (3 groups), current alcohol intake (yes/no), current smoking (yes/no), and history of CHD and diabetes mellitus (yes/no). Additional adjustment for CHD risk group, physical activity, long-chain omega-3 fatty acids, polyunsaturated fatty acids, and dietary calcium had little effects on the point estimates (data not shown). We evaluated interactions by including the main effects and product terms in the regression model and compared model with and model without the interaction terms using partial likelihood ratio tests. For 3-way interaction, we also included 2-way product terms and main effects in the regression model. To test whether saturated fat modified the observed association, we used the median energy from saturated fat (11.2%) as the cut point to dichotomize saturated fat intake. Similarly, to assess whether dietary total linolenic acid modified the observed association, we used the median intake of linolenic acid (0.68 g per day) to dichotomize linolenic acid intake. All of the analyses were performed using PC SAS (version 9.1).

## Results

### Subject Characteristics

Of the 4797 participants, the mean age was  $52.2 \pm 13.7$  years (range, 25 to 94 years), 45% were men, and 4% were black. Table 1 presents baseline characteristics of the studied population. Higher consumption of dairy products was associated with higher educational attainment; higher intake of fruits and vegetables, total linolenic acid, energy from saturated fat, magnesium, sodium, and potassium; lower consumption of caffeine; and lower percentage of current drinkers and smokers.

### Dairy Consumption and Prevalent HTN

We observed an inverse association between dairy consumption and prevalent HTN. In a multivariable model adjusting for age (deciles), gender, education (3 groups), energy intake (deciles), field center, body mass index, linolenic acid, saturated and monounsaturated fat (% energy), sodium, po-

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**TABLE 1. Characteristics Among 4797 Participants in the NHLBI Family Heart Study**

Characteristic	Gender-, Age-, and Energy-Adjusted Quartiles of Dairy Consumption (servings per day)			
	Q1 (low)	Q2	Q3	Q4 (high)
Mean [median]	0.5 [0.4] (n=1123)	1.2 [1.1] (n=1227)	2.0 [1.8] (n=1269)	3.5 [3.1] (n=1178)
Age, y	52.2±13.6	52.2±13.6	52.3±14.0	52.1±13.7
Gender, % male	44.4	46.4	45.2	45.4
Body mass index, kg/m <sup>2</sup>	27.5±5.6	27.8±5.4	27.4±5.4	27.7±5.7
Exercise, min/day	29.5±40.0	30.1±39.0	30.7±38.1	27.7±32.7
Fruits and vegetables, servings/day	3.2±1.8	3.3±1.7	3.5±1.8	3.4±1.8
Energy intake, kJ/day	7302±2566	7291±2542	7331±2600	7348±2642
Dietary cholesterol, g/day	0.24±0.14	0.24±0.12	0.24±0.13	0.24±0.13
Energy from linolenic acid, %	0.37	0.39	0.38	0.40
Energy from EPA/DHA, %	0.13	0.11	0.13	0.11
Energy from saturated fat, %	10.4	11.1	11.2	12.2
Energy from monounsaturated fat, %	12.3	12.3	11.8	11.5
Magnesium, g/day	0.24±0.09	0.25±0.09	0.27±0.10	0.29±0.10
Sodium, g/day	1.48±0.57	1.58±0.61	1.63±0.63	1.73±0.67
Potassium, g/day	2.59±0.93	2.68±0.96	2.83±1.01	2.93±1.04
Calcium intake, g/day	0.45±0.19	0.64±0.24	0.84±0.32	1.2±0.52
Caffeine, g/day	0.25±0.29	0.22±0.26	0.21±0.25	0.17±0.25
Dietary fiber, g/day	18.1±9.1	18.0±8.4	18.4±8.6	16.8±7.6
Systolic blood pressure, mm Hg	119.2±19.3	117.7±17.8	117.1±17.5	116.3±18.1
Diastolic blood pressure, mm Hg	69.6±10.7	69.2±10.1	69.2±10.1	69.0±9.9
High-risk group, %	50.8	51.4	48.5	50.3
College education, %	61.1	63.9	66.8	65.8
Diabetes mellitus, %	2.8	2.4	2.1	3.0
Use of blood pressure drugs, %	3.6	2.4	2.9	2.3
CHD, %	11.5	11.3	10.5	10.6
Current smoker, %	19.9	15.7	13.1	11.2
Current alcohol use, %	58.4	55.8	56.6	45.6

tassium, magnesium, caffeine, fiber, fruits and vegetable, smoking, alcohol consumption, and history of CHD and diabetes, subjects in the highest quartile of dairy consumption had a 36% lower prevalence odds of HTN compared with those in

the lowest quartile ( $P$  for linear trend=0.001; Table 2).  $T_2$  Additional adjustment for dietary calcium made the inverse association between dairy and HTN slightly stronger: ORs of 1.0, 0.82 (95% CI, 0.63 to 1.06), 0.69 (95% CI,

**TABLE 2. Prevalence ORs (95% CIs) of HTN According to Dairy Consumption for 4797 Participants in the NHLBI Family Heart Study**

Gender-, Age-, and Energy-Adjusted Quartiles of Dairy Consumption (Median Daily Servings)	Cases/N	Crude Model	Model 1*	Model 2†
Q1 (0.4) low	196/1123	1.0	1.0	1.0
Q2 (1.1)	193/1227	0.88 (0.71 to 1.10)	0.82 (0.64 to 1.05)	0.83 (0.64 to 1.07)
Q3 (1.8)	178/1269	0.77 (0.61 to 0.97)	0.68 (0.53 to 0.89)	0.71 (0.54 to 0.93)
Q4 (3.1) high	157/1178	0.73 (0.57 to 0.92)	0.62 (0.45 to 0.84)	0.64 (0.46 to 0.90)
$P$ for linear trend		0.01	0.002	0.01

HTN was defined as stages 1 and 2 of JNC VII or current treatment for high blood pressure.

\*Adjusted for age (deciles), gender, field center, body mass index, energy intake (deciles), total linolenic acid, saturated and monounsaturated fat, intake of sodium, potassium, caffeine, fiber, fruit, and vegetable using generalized estimating equations.

†Variables in model 1 plus additional adjustment for magnesium, education (3 groups), current drinking (yes/no), current smoking (yes/no), and history of CHD and diabetes mellitus.

**TABLE 3. Prevalence ORs (95% CIs) of HTN According to Dairy and Saturated Fat Consumption in the NHLBI Family Heart Study**

Sex-, Age-, and Energy-Adjusted Quartiles of Dairy Consumption (Median Daily Servings)	Energy From Saturated Fat <11.2%		Energy From Saturated Fat ≥11.2%	
	Cases/N	Odds ORs (95% CI)*	Cases/N	ORs (95% CI)*
Q1 (0.4) low	131/677	1.0	65/446	1.0
Q2 (1.1)	109/626	0.76 (0.55 to 1.05)	84/601	0.94 (0.63 to 1.41)
Q3 (1.8)	84/628	0.53 (0.37 to 0.78)	94/641	1.03 (0.68 to 1.57)
Q4 (3.1) high	63/460	0.46 (0.29 to 0.74)	94/718	0.94 (0.55 to 1.60)
<i>P</i> for linear trend		0.001		0.89
<i>P</i> for interaction†			0.014	

HTN was defined as stages 1 and 2 of JNC VII or current treatment for high blood pressure. Median energy from saturated fat in the population was 11.2%.

\*Adjusted for age, gender, field center, body mass index, energy intake, linolenic acid, saturated and monounsaturated fat, sodium intake, potassium, magnesium, caffeine, fiber, fruit and vegetable, education (3 groups), current drinking (yes/no), current smoking (yes/no), and history of CHD and diabetes mellitus using generalized estimating equations.

†*P* value for interaction obtained using dairy consumption as a continuous variable.

0.52 to 0.92), and 0.61 (95% CI, 0.40 to 0.93) from the lowest to the highest quartile of dairy consumption, respectively (*P* for trend=0.02). To evaluate the influence of saturated fat intake on this association, we repeated these analyses stratified by energy from saturated fat (using median intake as cut point). Although no association between dairy intake and HTN was seen among subjects whose saturated fat intake was above the median (11.2%), we observed a stronger inverse association between dairy and HTN among subjects consuming <11.2% saturated fat. Multivariable ORs were 1.0 (reference), 0.76, 0.53, and 0.46 from the lowest to the highest quartile of dairy intake, respectively (*P* for trend=0.001; Table 3). The *P* value for interaction was statistically significant between saturated fat and dairy intake on HTN (*P*=0.014). The inverse association between dairy products and HTN was observed across all of the field centers (*P* for interaction between center and dairy product=0.4).

### Dietary Calcium and HTN

There was an inverse association between calcium intake and prevalent HTN. From the lowest to the highest quartile of calcium intake, multivariable ORs (95% CI) for HTN were 1.0, 0.76 (0.59 to 0.98), 0.71 (0.53 to 0.94), and 0.68 (0.48 to 0.95), respectively (*P* for trend=0.02). Additional adjustment for dairy intake (quartiles) eliminated the observed associa-

tion with corresponding ORs (95% CI) of 1.0, 0.82 (0.58 to 1.16), 0.87 (0.57 to 1.34), and 0.99 (0.56 to 1.74; *P* for trend=0.9).

### Dairy Intake and Resting Blood Pressure

From the lowest to the highest category of dairy intake, there was a graded inverse association between dairy intake and SBP (*P* for trend=0.003) and little effects with DBP with a 2.6-mm Hg lower SBP comparing the highest with the lowest quartile of dairy intake in a multivariable model (Table 4). Restricted to subjects whose energy intake from saturated fat was below the population median (11.2%) made the dairy-SBP association even stronger (3.5-mm Hg lower SBP in the highest dairy category compared with the lowest group; *P* for linear trend=0.001; Table 4).

### Influence of Total Linolenic Acid on the Dairy-HTN Association

Compared with subjects who consumed <2 servings per day of dairy products and <0.68 g per day of total linolenic acid (median), higher consumption of linolenic acid was associated with a 19% lower prevalence odds of HTN in a multivariable model; consumption of ≥2 servings per day of dairy products was associated with a 26% lower HTN prevalence odds; and higher intake of both dairy products and

**TABLE 4. Adjusted Means of SBP and DBP by Dairy Consumption in the NHLBI Family Heart Study**

Sex-, Age-, and Energy-Adjusted Quartiles of Dairy Consumption (Median Daily Servings)	N	SBP±SE		DBP±SE	
		Model 1*	Model 2†	Model 1*	Model 2†
Q1 (0.4) low	1123	119.4±0.5	121.0±0.7	69.9±0.3	70.2±0.4
Q2 (1.1)	1227	117.8±0.5	118.3±0.7	69.2±0.3	68.7±0.4
Q3 (1.8)	1269	117.5±0.4	118.4±0.7	69.2±0.3	69.5±0.4
Q4 (3.1) high	1178	116.8±0.6	117.5±0.9	69.0±0.3	69.1±0.5
<i>P</i> for linear trend		0.003	0.01	0.09	0.24

\*Adjusted for age, gender, field center, body mass index, energy intake, total linolenic acid, saturated and monounsaturated fat, sodium intake, potassium, magnesium, caffeine, fiber, fruit and vegetable, education (3 groups), current drinking (yes/no), current smoking (yes/no), treatment for HTN, and history of CHD and diabetes mellitus.

†Model 2 adjusted as above but restricted to subjects with energy from saturated fat below median intake (11.2%). *P* for interaction was 0.16 for SBP.

**TABLE 5. Prevalence OR for HTN According to Dietary Linolenic Acid, Dairy Consumption, and Saturated Fat Intake**

Variable	Dairy Consumption (servings per day)	
	<2	≥2
Total linolenic acid		
<0.68 g/day	1.0	0.74 (0.57 to 0.96)
≥0.68 g/day	0.81 (0.60 to 1.09)	0.65 (0.47 to 0.91)
Energy from saturated fat <11.2%		
<0.68 g/day	1.0	0.64 (0.46 to 0.90)
≥0.68 g/day	0.71 (0.46 to 1.09)	0.33 (0.19 to 0.58)
Energy from saturated fat ≥11.2%		
<0.68 g/day	1.0	0.98 (0.60 to 1.59)
≥0.68 g/day	1.05 (0.64 to 1.74)	1.14 (0.70 to 1.85)

Model adjusted for age (deciles), gender, field center, body mass index, energy intake (deciles), saturated and monounsaturated fat, sodium intake, potassium, magnesium, caffeine, fiber, fruit and vegetable, education (3 groups), current drinking (yes/no), current smoking (yes/no), and history of CHD and diabetes mellitus. Median intake of dietary linolenic acid was 0.68 g/day. *P* for 3-way interaction=0.36.

total linolenic acid was associated with a 35% lower prevalence odds of HTN (Table 5). There was no evidence for a significant interaction between total linolenic acid and dairy consumption on HTN (*P* for interaction=0.65). Similarly, we did not observe a significant 3-way interaction among saturated fat, total linolenic acid, and dairy consumption on prevalent HTN (*P* for interaction=0.36).

### Long-Chain Omega-3 Fatty Acids and HTN

There was little and nonsignificant association among age-, gender-, and energy-adjusted quartiles of combined eicosapentaenoic and docosahexaenoic acids and prevalent HTN. In the fully adjusted model, ORs (95% CI) were 1.0 (reference), 0.81 (0.64 to 1.04), 0.92 (0.71 to 1.19), and 0.97 (0.74 to 1.27) from the lowest to the highest category of long-chain omega-3 fatty acids, respectively (*P* for linear trend=0.9). We did not find evidence for effect modification of the dairy-HTN association by long-chain omega-3 fatty acids (*P* for interaction=0.28).

### Discussion

In this cross-sectional study, we found evidence for an inverse association between dairy consumption and prevalent HTN in the total population after adjustment for major determinants of HTN. Of note is that this inverse association between dairy consumption and HTN seemed to be independent of calcium intake and was modified by the amount of saturated fat consumed in that dairy consumption was associated with a lower prevalence of HTN only among subjects consuming <11% of total energy from saturated fat but not in individuals consuming higher amounts of saturated fats (*P* for interaction=0.014). In addition, dairy consumption was inversely associated with SBP but not with DBP in this population. Although both dietary total linolenic acid and dairy consumption were inversely related to prevalent HTN, we did not find evidence for interaction between the 2 food categories with respect to HTN. Long-chain omega-3 fatty

acids were not significantly associated with prevalent HTN in this population.

HTN remains highly prevalent in the US and is associated with a higher societal and economic burden. Thus, constant efforts are underway to design and implement preventive strategies to reduce the incidence of HTN. Other than pharmacological interventions, diet has been recognized as an important modifiable factor in the fight against HTN. The Dietary Approaches to Stop Hypertension Trial demonstrated that a diet rich in fruits, vegetables, whole grains, and low-fat dairy products can lower blood pressure alone or in combination with other lifestyle changes.<sup>11,12,26</sup> Data from the Framingham Children Study also reported beneficial effects of dairy consumption on blood pressure.<sup>9</sup> Similar benefits of dairy products on blood pressure were observed in the Coronary Artery Risk Development In young Adults (CARDIA) Study,<sup>27</sup> the Honolulu Heart Program,<sup>7</sup> and other studies.<sup>28–30</sup> Our findings are consistent with these previous reports. In contrast, a randomized trial of 13 hypertensive volunteers in whom dietary calcium consumption was varied through manipulation of dairy products found no effect of dairy consumption on blood pressure after a 4-week intervention period.<sup>31</sup> It is possible that the relatively small sample size and/or the limited duration of the intervention of this study may have prevented these investigators from observing an effect of calcium on blood pressure.

In the present study, adjustment for dietary calcium made the inverse association between dairy and HTN slightly stronger. On the other hand, dietary calcium was inversely associated with prevalent HTN, but this association was eliminated after adjustment for dairy products. Because most of the studies assessed the effects of specific dietary patterns or food groups on HTN, it is not clear which element(s) or nutrient(s) in the studied diet was responsible for the observed effects. Because dairy products are rich in calcium and other minerals (potassium and magnesium), several investigators have examined the effects of calcium on blood pressure. However, the best available evidence is less supportive of a major lowering effect of calcium supplementation on blood pressure, but rather suggests a minimal effect if any. In a meta-analysis of randomized trials, Bucher et al<sup>10</sup> reported a small reduction in SBP but not DBP with calcium supplementation (1.3-mm Hg reduction with calcium compared with placebo). In another randomized trial, supplementation with 1 and 2 g per day of elementary calcium had no effects on SBP and DBP after 6 months of intervention.<sup>13</sup> Similarly, an intervention with 1 g per day of calcium had no effects on blood pressure after 30 months.<sup>32</sup> These data are consistent with our findings of no association between calcium intake and HTN and that the dairy-HTN association was not mediated through dietary calcium. It is possible that other nutrients (other than calcium) found in dairy products may be responsible for the observed relation. Potassium or magnesium are possible candidates and may partially explain our findings. Alternatively, subjects with lower dairy consumption may substitute other foods with dairy products or may have different dietary habits that could predispose to HTN. If this were the case, then the observed association between dairy and HTN may partly or completely be ac-

counted for by other dietary habits in the lower dairy group. In our study, subjects in the lower dairy group had a higher consumption of butter, hot dogs, burgers, and eggs than subjects in the higher dairy group. These foods may also be surrogates for other lifestyle factors that may predispose to HTN.

The observed association between dairy products and HTN was mainly observed in subjects consuming <11% of total energy from saturated fat. This is consistent with a previous report showing that low-fat dairy (but not high-fat dairy) is associated with lower blood pressure. Lastly, we did not observe an effect modification of the dairy–blood pressure association with total linolenic acid.

The cross-sectional design of this study limits our ability to infer a causal relation. In addition, dairy consumption was self-reported, and it is possible that inaccurate recall of dietary habits might have led to misclassification of dairy intake. In addition, we did not have data on *trans*-fatty acids to evaluate their effects on blood pressure. Our study has several strengths. Because we have collected data on diet, medications, medical history, biomarkers, and anthropometric and lifestyle factors, we were able to adjust for several potential confounders. In addition, the large sample size and the multicenter design are other strengths of the present study.

### Perspectives

Our data found that dairy consumption is inversely associated with prevalent HTN and resting SBP mainly among individuals consuming less saturated fat and independent of dietary calcium. These findings lend support to the recommendation of low-fat dairy consumption as a mean to lower blood pressure. However, given the limitations of this cross-sectional study, our findings should be replicated in an interventional study. Because most randomized trials have provided little evidence for a major calcium effect on blood pressure, future studies are needed to prospectively examine the effects of low-fat dairy products on blood pressure and identify underlying biologic mechanisms, as well as responsible micronutrients. Specifically, randomized trials are needed to test the hypothesis that noncalcium components of dairy products can reduce the risk of HTN, as well as identify those putative components.

### Acknowledgments

This report is presented on behalf of the investigators of the National Heart, Lung, and Blood Institute Family Heart Study. The investigators thank the study participants and staff for their valuable contributions.

### Sources of Funding

This study was supported by the National Heart, Lung, and Blood Institute cooperative agreement grants U01 HL 67893, U01 HL67894, U01 HL67895, U01 HL67896, U01 HL67897, U01 HL67898, U01, HL67899, U01 HL67900, U01 HL67901, U01 HL67902, U01 HL56563, U01 HL56564, U01 HL56565, U01, HL56566, U01 HL56567, U01 HL56568, U01 HL56569, and by the National Heart, Lung, and Blood Institute grant 5K01-HL70444 (L.D.).

### Disclosures

None.

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