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Sex-specific associations of nutrition with hypertension and systolic blood pressure in Alaska Natives findings from the GOCADAN study

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Abstract

Objectives—To examine sex-specific associations of nutritional factors with prevalent hypertension (HTN) and systolic blood pressure (SBP) in Alaska Natives. Diet is known to affect SBP, a major risk factor for cardiovascular disease.

Study design—Cross-sectional analysis of participants without diabetes in the Genetics of Coronary Artery Disease in Alaska Natives study.

Methods—Macronutrients such as fat, carbohydrate and protein and micronutrients such as sodium were investigated. HTN was defined as SBP \geq 140 mmHg, diastolic blood pressure \geq 90 mmHg and/or taking anti-HTN medication. Analyses were stratified by sex and covariates included age, body mass index (BMI), energy intake, smoking and physical activity.

Results—Mean age was 42 years for men (n=456) and women (n=602). Men with HTN (n=106) compared to men without HTN consumed a higher proportion of calories from total (p=0.01), saturated (p<0.01) and trans fatty acid (p=0.03) fats. Women with HTN (n=99) compared to women without HTN consumed more total (p=0.03) and monounsaturated (p=0.04) fat, higher protein (p=0.02) and lower total (p<0.01) and simple (p<0.01) carbohydrates. After covariate adjustment, men not on anti-HTN medications (n=407) had significantly higher average SBP with increasing quartiles of trans fatty acid intake (p for linear trend=0.01) and sodium intake (p for

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linear trend=0.02). For women not on anti-HTN medications (n=528), after covariate adjustment, average SBP decreased with increasing quartiles of omega 3 fatty acid intake (p for linear trend <0.01).

Conclusions—Prospective evaluation of the sex-specific associations of nutritional factors with HTN and SBP on outcomes is needed along with novel interventions to lower the risk of cardiovascular disease.

Keywords

nutrition; Alaska Native; sex; systolic blood pressure; epidemiology

INTRODUCTION

Nutrition affects blood pressure and the modification of specific dietary factors has the potential to prevent hypertension (HTN) and/or lower the risk of complications related to blood pressure such as cardiovascular disease (CVD) (1). The risk of CVD increases throughout the range of blood pressure (BP) (2,3) and systolic BP (SBP) is a strong independent risk factor for CVD (2). Therefore, nutritional assessment is important among those with and without established hypertension.

Alaska Natives, once thought to have very low CVD, have experienced considerable increases in CVD prevalence and CVD risk factors (4–7). There have been some reports of nutritional associations, particularly of fatty acids, with CVD risk factors such as the metabolic syndrome, diabetes and lipids among Alaska Natives (8–11). A more Westernized dietary pattern among Alaska Natives is related to a worst-case profile of CVD risk factors (12,13), though sex differences have not been described.

The relationship of nutritional factors, both macronutrients and micronutrients, with HTN and SBP has not been fully examined in Alaska Natives. Previous work among American Indians has shown sex differences in the relations among diet and CVD risk factors (14). Understanding the nutritional factors associated with HTN and SBP in Alaska Natives and whether sex differences in the relationships exist could have implications for prevention and control of a major CVD risk factor. Using data from the Genetics of Coronary Artery Disease in Alaska Natives (GOCADAN) study, we conducted a secondary data analysis to (1) examine by sex the associations of nutritional factors, both macronutrients such as fats, proteins and carbohydrates; and micronutrients such as sodium, potassium, magnesium and calcium with prevalent HTN in Alaska Natives without diabetes and (2) examine, by sex, the effects of the nutritional factors on SBP among those not on anti-hypertensive medicines before and after adjustment for potential confounders, including age, total calorie intake, body mass index (BMI), smoking status and physical activity.

MATERIAL AND METHODS

Study design and setting

The Genetics of Coronary Artery Disease in Alaska Natives (GOCADAN) study investigates the genetic and non-genetic determinants of cardiovascular disease and its risk

factors in Alaska Natives. Details of the study design and methods have been published previously (15). Briefly, a total of 1,214 Alaska Natives, predominantly Inupiat Eskimo, men and women 18 yrs of age from extended families, were recruited from October 2000 through April 2004 in the Norton Sound region on the northwest coast of Alaska. Participants completed an interviewer-administered survey of demographics and medical history and underwent a complete physical examination. The exam included the collection of blood, urine and anthropometric measurements such as height, weight and waist-to-hip ratio.

From the 1,214 GOCADAN participants, we excluded those with diabetes (n=40), without nutritional data (n=41), age <18 years (n=1) or missing data on systolic blood pressure (n=10). We also excluded those with extremes of calorie intake defined as <500 or >8,000 kilocalories in a day (n= 68) (16,17). Thus our study sample included 1,058 participants, or 87% of the baseline cohort. There were no significant differences in covariates of interest among those included in our analysis (n=1058) versus those excluded (n=156) (chi-squared analysis).

This study was approved by the Research and Ethics Review Board of the Norton Sound Health Corporation and by relevant institutional review boards.

Measures

Systolic blood pressure—The primary outcomes for our analysis were HTN and SBP. Right brachial artery BP was measured 3 times, in the seated position with the arm supported, using an appropriately sized and positioned cuff, following a 5-minute rest with a Baum mercury sphygmomanometer (W.A. Baum Co., Inc., Copiague, NY). The mean of the second and third SBP measurements was used for the analysis. Participants were categorized as having prevalent hypertension (HTN) if they had a SBP \geq 140 mmHg, diastolic BP \geq 90 mmHg or were taking antihypertensive medication (without an alternative documented indication) at the time of the exam (18).

Nutritional factors—Dietary information was collected via a validated food frequency questionnaire (FFQ), which evaluated consumption in the previous year (17,19). The FFQ was validated using one 24-hour recall collected at the same time as the FFQ (17,19). The questionnaire inquired about 97 food items, including major traditional foods and foods commonly available in small village stores (17,19). Nutrient calculations were performed using Nutrition Data System for Research (NDR-R) software, version 4.06, developed by the Nutrition Coordinating Center, University of Minnesota, Minneapolis, MN, with Food and Nutrient Database 34, released May 2003. This data base contains nutrient information on Alaskan foods. The nutritional factors chosen a priori for this analysis included total kilocalories, total carbohydrates, simple and complex carbohydrates, total protein, total fat, saturated fatty acids (SFA), monounsaturated fatty acids (MUFA), trans fatty acids (TFA), omega-3 fatty acids, omega-6 fatty acids, sodium, potassium, magnesium, calcium, phosphorus and caffeine. We chose these nutritional factors to encompass both macro and micro nutrients that might plausibly influence BP.

Demographics and covariates—Age was calculated in years based on the verified date of birth during the GOCADAN interview and the examination date. Self-reported years of education were dichotomized as <12 years of school versus ≥12 years of school or general equivalency diploma. BMI was calculated using measured weight and height according to a standard formula and metric conversion [BMI=weight (lb)/height² (in)*704.5kg in²/lb m²]. We dichotomized BMI as non-obese (BMI<30 kg/m²) and obese (BMI ≥30 kg/m²). Physical activity was calculated in metabolic equivalents (METs) from self-reported leisure time activities (20). Blood samples were obtained following a 12-hour overnight fast (15). Lipid measurements were obtained for total cholesterol (total triglyceride [TG], high-density lipoprotein cholesterol [HDL-C] and low-density lipoprotein cholesterol [LDL-C]) analysed via an auto analyser (15). Smoking status was obtained by self-report during the structured interview portion of the examination and was dichotomized as never/former or current smoker.

Statistical analysis

For the baseline demographics and clinical characteristics, continuous variables with normal distributions were presented as means (standard deviations), variables with highly skewed distributions were presented as medians (first quartiles, third quartiles) and categorical variables were presented as frequencies (proportions). The differences between men and women were compared by t-test, non-parametric rank sum test or chi-square test as appropriate.

Percent energy from carbohydrates, total fat and protein was calculated for each participant. Percent energy from carbohydrates was further characterized as percent energy from simple carbohydrates and from complex carbohydrates. Percent energy from total fat was also further characterized as percent energy from saturated fatty acids, mono-unsaturated fatty acids and trans fatty acids. Given the high consumption of fish among Alaska Natives and in order to capture polyunsaturated fatty acids, we included omega-3 fatty acid and omega-6 fatty acid intakes separately, each presented as grams per day (17). Sodium, potassium, magnesium, calcium, phosphorus and caffeine are presented as milligrams per day. The natural log transformed variables for omega-3 fatty acids and caffeine were used in all analyses because of skewness. We examined each of the nutritional factors by sex. Descriptive statistics were obtained and compared by t-test between 2 groups.

To assess whether differences among those with and without prevalent HTN (by sex) differ in dietary intake, we examined each of the nutritional factors by HTN status in men and in women. Because the participants were members of large and inter-related families, we also performed the analyses using a method developed by Wang et al. to assess the potential impact of relatedness (21).

Lastly, we used analysis of variance (ANOVA) to assess the potential relationships between nutritional factors and SBP (by sex) in those not treated with anti-hypertensive medications. We first estimated, by sex, the mean SBP and standard deviation for each quartile of dietary intake in a univariate model. We then estimated, in single multivariate models stratified by sex, the adjusted mean SBP and standard deviation for each quartile of dietary intake, adjusting for the following covariates: age, BMI, total energy intake, smoking status and

physical activity. The test of the linear trend across increasing quartiles of nutritional factors was conducted using the statement CONTRAST in the general linear models procedure (PROC GLM) in SAS.

SAS version 9.1 (SAS Institute, Cary, NC) was used for all data manipulation and statistical analysis. All probability values were 2-tailed, and values <0.05 were considered significant.

RESULTS

The mean age was 42 years for men and women and 57% (n=602) were women (Table I). Men had a lower BMI compared to women and obesity prevalence differed. LDL-C and TG did not differ between men and women, but HDL-C was higher in women. Smoking rates were high but did not differ significantly between sexes. HTN was more common among men than women (23% vs. 16%, $p=0.006$).

Total calorie intake was significantly higher among men, who consumed on average 3,474 kilocalories a day, compared to 2,859 kilocalories a day among women. Men also consumed a higher amount of omega-6 fatty acids but no sex difference was observed for omega-3 fatty acid intake (Table II). Men consumed higher amounts of sodium, potassium, magnesium, calcium, phosphorus and caffeine compared to women.

In comparing those with and without HTN, men with HTN (n=106) consumed a higher percentage of calories from fat (39% vs. 37%, $p=0.0148$), with a significantly higher proportion of those calories coming from saturated fatty acids, monounsaturated fatty acids and trans fatty acids compared to men without HTN (Table III). Men with HTN also had a higher average caffeine intake compared to men without HTN. Women with HTN (n=99) also consumed more total fat (39% vs. 37%, p -value=0.023), with a significantly higher proportion being from monounsaturated fatty acids compared to women without HTN. Women with HTN consumed more protein, and less total and simple carbohydrates. There were no differences in sodium or other micronutrient intake among men or women with and without HTN. These associations did not change with adjustment for relatedness.

A total of 49 men had been prescribed an antihypertensive medication. In covariate-adjusted regression analyses among men not on anti-hypertensive medications (n=407), average SBP was higher with increasing quartiles of trans fatty acids and of sodium (Table IVa). A similar, but non-significant trend was observed for monounsaturated fatty acids.

A total of 74 women had been prescribed an anti hypertensive medication. In covariate-adjusted regression analyses among women not on anti hypertensive medications (n=528), average SBP was lower with increasing quartiles of omega-3 fatty acids (Table IVb). However, in women, there was no association of average SBP with either sodium or monounsaturated fatty acid intake.

DISCUSSION

Overall, we observed a high energy intake among both men and women. In our study among Alaska Natives, intake of sodium was higher among both men (4,830 mg/day) and women

(3,776 mg/day) compared to the average intake of sodium reported for men (4,178 mg/day) and women (2,933 mg/day) in the U.S. aged >20 years in 2005–2006 (22). Our average SBP among men and women were a few mmHg higher than previously reported in another population of Alaska Natives in this region (23). We found differences in nutritional intake by hypertensive status. Men with prevalent HTN compared to those without consumed a higher percentage of calories from total fat, specifically saturated fatty acids and trans fatty acids, and more caffeine. Women with prevalent HTN compared to women without had a significantly higher percentage of calories from fat, but the increase was mainly in monounsaturated fatty acids.

To evaluate relations between nutrients and blood pressure, adjusting for possible confounders, we analysed associations of nutritional factors and SBP in those not on anti-hypertensive medications. There was a significant increase in SBP with increasing quartiles of sodium and trans fatty acids among Alaska Native men. Though we did not find the same relationship for sodium and trans fatty acids among women, we did find a significantly lower average SBP for each increase in quartiles of omega-3 fatty acid intake among Alaska Native women.

Dietary patterns have changed considerably among Alaska Natives with Western contact, loss of ancestral lands and climate change. An extensive dietary survey was undertaken in the late 1980s throughout the state of Alaska that found Alaska Native adults consumed more energy, protein and fat, but less calcium, fruits and vegetables than did the general U.S. adult population (24). Others have documented a loss of the traditional diet low in carbohydrate and high in protein, often from marine sources, being replaced increasingly with store-bought calorie-dense nutrient-poor foods (25). Previous analyses of GOCADAN nutritional data showed that the principal sources of energy, carbohydrate, fat, saturated fatty acids and fiber are store-bought foods (17). Dietary intake also varies with age, with elders consuming a diet higher in traditional Alaska Native foods compared to younger adults (17). Our present results show that both men and women, whether or not they have hypertension, are not following current dietary guidelines for controlling BP (1). Sodium and saturated fat intakes are above recommended values and potassium is below the recommended dietary guidelines for Americans (26).

Our regression analyses, after adjustment for relevant covariates, showed that several nutrients are significantly related to SBP. There is concern that changing diet and other lifestyle factors have led to a rise in CVD among some Alaska Native groups since a more traditional dietary pattern has been related to a better profile of CVD risk factors (12,13). In GOCADAN, a more Westernized dietary pattern was related to a higher average BP (12). Previous reports have found a positive association between high omega-3 fatty acids and improved components of metabolic syndrome, but not with either BP or lipids, among Alaska Eskimos (8,10). Similarly, increased saturated fatty acid intake has been associated with prevalent carotid plaque in this cohort (27). In the present analysis we demonstrated relationships of nutritional factors with prevalent HTN and SBP; while our previous analyses confirmed that HTN is an independent correlate of CVD and of carotid atherosclerosis (28,29).

Though the diet and other factors are unique to our study population, the relations of nutritional factors and BP we observed are consistent with those reported in other populations. There was an association of higher BP with higher sodium intake as previously reported (30), though only among men. The evidence for the association of salt intake, often the major source of sodium in the diet, and risk of CVD is strong (1,30–33). The renin-angiotensin system has a central role in long-term BP control by modulating renal sodium homeostasis (34,35). A relationship between high trans fatty acid intake and risk of hypertension has been reported (36,37). This is in accord with our observed association between lower BP and higher omega-3 fatty acid intake, albeit only in women. Our findings are similarly consistent with the International Study of Macro- and Micro-Nutrients and Blood Pressure which found an inverse relationship between higher intakes of omega-3 fatty acids derived from food sources and BP, including in non-hypertensive persons; however, sex differences were not described (38).

The sex differences which we observed are likely multifactorial, with differences in preference of intake, physiological response to nutrients and genetics playing a role. Sex differences in BP response to a salt load have been described in rat models and are thought to be related to differences in endothelial response and renal hemo-dynamics (39–41). HTN is also more common in men and postmenopausal women than in premenopausal women, and putative vascular protective effects of endogenous estrogen have been suggested (42).

While there are significant strengths of our study with the use of a validated, culturally appropriate dietary questionnaire and rigorous epidemiologic methods of data acquisition, there are important limitations as well. This was a cross-sectional study and therefore we cannot assess causality or account for change in outcomes or covariates over time. Though the questionnaire has been validated and used in other Alaska Native populations, recall bias is possible and therefore misclassifications may occur (17,24). True sodium intake is difficult to ascertain; furthermore, added table salt is not accounted for in our dietary data, and thus sodium intake for some participants is likely under-reported. Our data and methods do not allow us to exclude psychosocial or behavioural differences, such as stating an answer to please an interviewer, which might impact accuracy of the FFQ in a sex-specific manner. Measures of basal metabolic rate were not performed in GOCADAN. Estimates of vitamin and mineral supplements were not included and therefore actual dietary intake of certain nutritional factors examined may be greater, although the data from GOCADAN indicate that vitamin and mineral supplementation is not common. Lack of association among those with HTN and such factors as saturated fatty acids may reflect adherence to lifestyle modifications recommended by their health care providers. We cannot account for those newly identified with disease or for any effect dietary counselling (that might have taken place) had on their intake and thus these results.

The American Heart Association (1) and the Institute of Medicine (41) recently released a statement on dietary approaches to prevent and treat HTN. Based on the current state of the evidence, five recommendations were made – weight loss; reduced salt intake; a dietary pattern rich in fruits, vegetables and low-fat dairy products, but reduced in saturated fatty acid and cholesterol; increased potassium intake; and moderation of alcohol intake among those who drink (<2 drinks per day for men; <1 drink per day for women) (1). The

recommendation for sodium in the Dietary Guidelines for Americans from the U.S. Department of Health and Human Services as well as that from the American Heart Association is 2,400 milligrams daily for adults. Our data indicate that Alaska Natives with hypertension are not following these guidelines. Adoption of these recommendations should be stressed in this population for prevention and treatment of HTN, though with the caveat that the evidence used to make the recommendations did not include Alaska Natives. Evaluation of such interventions and how they affect this unique population is needed. Public health and public policy measures aimed at reducing sodium intake are needed. Future dietary intervention studies among Alaska Native peoples are needed to examine the potential benefit of these interventions in controlling SBP in this population that is experiencing a rise in cardiovascular disease.

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Table I

Demographic and clinical characteristics of GOCADAN participants (n=1058).

Demographic and clinical characteristics	Men (n=456)	Women (n=602)	p-value
Age (years)	42 ± 15	42 ± 16	0.77
High school education or higher, n (%)	363(80)	469(78)	0.46
Height (inches)	67 ± 3	62 ± 2	<0.0001
Weight (pounds)	170 ± 36	155 ± 35	<0.0001
Body mass index (kg/m ²)	27 ± 5	28 ± 6	<0.0001
Waist-to-hip ratio	0.9 ± 0.1	0.8 ± 0.1	<0.0001
Physical activity (MET/week)*	52 (24–101)	47 (21–94)	0.10
Systolic blood pressure	122 ± 13	117 ± 15	<0.0001
Diastolic blood pressure	78 ± 9	74 ± 9	<0.0001
Total cholesterol (mg/dL)	196 ± 40	203 ± 41	0.01
High density lipoprotein (mg/dL)	55 ± 18	64 ± 18	<0.0001
Low density lipoprotein (mg/dL)	117 ± 36	114 ± 36	0.31
Triglycerides (mg/dL)*	106 (79–146)	107 (77–153)	0.87
Obesity (BMI ≥ 30 kg/m ²), n (%)	92 (20)	223 (37)	<0.0001
Hypertension, n (%)	106 (23)	99 (16)	0.01
Current smoker, n (%)	281 (62)	353 (59)	0.33

Data are mean±standard deviation or number (%).

* Median (1st quartile, 3rd quartile).

Table II

Nutritional intake characteristics among GOCADAN participants by sex (n=1058).

Nutritional factor	Men (n=456)	Women (n=602)	p-value
Total energy (total kilocalories/day)	3474 ± 1573	2859 ± 1436	<0.01 *
% energy from total carbohydrates	49 ± 11	49 ± 11	0.51
% energy from simple carbohydrates	27 ± 12	28 ± 12	0.19
% energy from complex carbohydrates	22 ± 6	21 ± 6	0.20
% energy from total protein	15 ± 4	15 ± 4	0.07
% energy from total fat	37 ± 8	37 ± 9	0.79
% energy from saturated fat	13 ± 4	13 ± 4	0.85
% energy from MUFA ^a	14 ± 4	14 ± 4	0.72
% energy from trans fatty acids	2 ± 1	2 ± 1	0.92
Omega-3 fatty acids (grams/day) ^b	1.7 (0.7–3.4)	1.6 (0.7–3.2)	0.10
Omega-6 fatty acids (grams/day)	23 ± 13	20 ± 13	<0.01 *
Sodium (mg/day)	4830 ± 2354	3776 ± 1890	<0.01 *
Potassium (mg/day)	3943 ± 1927	3236 ± 1836	<0.01 *
Magnesium (mg/day)	418 ± 199	339 ± 178	<0.01 *
Calcium (mg/day)	1202 ± 772	974 ± 702	<0.01 *
Phosphorus (mg/day)	1948 ± 988	1561 ± 865	<0.01 *
Caffeine (mg/day) ^b	752 (362–1382)	566 (210–1033)	<0.01 *

Data are mean±standard deviation.

* p-value<0.05.

^aMUFA = monounsaturated fatty acids.^bMedian (1st quartile, 3rd quartile); tested after log-transformation.

Table III
Relationships of nutritional intake among Alaska Native men and women with and without hypertension.

Nutritional factor	Men (n=456)		Women (n=612)	
	No hypertension (n=350)	Hypertension (n=106)	No hypertension (n=503)	Hypertension (n=99)
Total energy (total kilocalories/day)	3469 ± 1591	3491 ± 1519	2896 ± 1451	2672 ± 1351
% energy from total carbohydrates	49 ± 11	47 ± 10	50 ± 11	46 ± 11
% energy from simple carbohydrates	27 ± 12	25 ± 11	29 ± 12	24 ± 10
% energy from complex carbohydrates	22 ± 7	22 ± 7	21 ± 7	22 ± 7
% energy from total protein	15 ± 4	15 ± 3	14 ± 4	16 ± 5
% energy from total fat	37 ± 8	39 ± 9	37 ± 9	39 ± 8
% energy from saturated fat	13 ± 4	14 ± 3	13 ± 4	13 ± 4
% energy from MUFA ^a	14 ± 4	15 ± 4	14 ± 4	15 ± 4
% energy from trans fatty acids	2.0 ± 0.9	2.3 ± 1.3	2.0 ± 1.0	2.1 ± 0.9
Omega-3 fatty acids (grams/day) ^b	1.5 (0.7–3.2)	1.9 (0.8–4.2)	1.5 (0.7–3.1)	2.2 (0.9–4.2)
Omega-6 fatty acids (grams/day)	23 ± 12	24 ± 14	20 ± 13	19 ± 13
Sodium (mg/day)	4816 ± 2384	4878 ± 2263	3797 ± 1908	3669 ± 1805
Potassium (mg/day)	3897 ± 1977	4097 ± 1753	3199 ± 1814	3422 ± 1943
Magnesium (mg/day)	416 ± 201	425 ± 196	334 ± 178	335 ± 184
Calcium (mg/day)	1214 ± 797	1162 ± 685	982 ± 710	933 ± 661
Phosphorus (mg/day)	1955 ± 1013	1926 ± 908	1571 ± 879	1509 ± 796
Caffeine (mg/day) ^b	747 (330–1387)	860 (517–1292)	552 (183–1041)	671 (354–993)

Data are mean ± standard deviation.

* p-value < 0.05.

^aMUFA = monounsaturated fatty acids.

^bMedian (1st quartile, 3rd quartile), tested after log-transformation.

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Table IVa

Association of mean systolic blood pressure by quartiles of dietary intake among Alaska Native men not on anti-hypertensive medications (n=407).

	Quartiles of dietary intake				P for trend
	1st quartile	2nd quartile	3rd quartile	4th quartile	
Total energy intake (kcal)					
Univariate model	119 ± 1.1	121 ± 1.3	122 ± 1.3	121 ± 1.2	0.21
Multivariate model ^a	120 ± 2.3	120 ± 1.5	122 ± 1.3	121 ± 2.6	0.77
% energy from carbohydrate					
Univariate model	122 ± 1.3	121 ± 1.3	121 ± 1.1	119 ± 1.2	0.16
Multivariate model ^a	121 ± 1.2	120 ± 1.2	121 ± 1.2	120 ± 1.2	0.40
% energy from simple carbohydrate					
Univariate model	121 ± 1.2	121 ± 1.2	120 ± 1.3	121 ± 1.2	0.90
Multivariate model ^a	121 ± 1.2	121 ± 1.2	120 ± 1.2	121 ± 1.3	0.96
% energy from complex carbohydrate					
Univariate model	120 ± 1.3	123 ± 1.3	121 ± 1.1	119 ± 1.1	0.53
Multivariate model ^a	120 ± 1.2	122 ± 1.2	121 ± 1.3	120 ± 1.2	0.99
% energy from protein					
Univariate model	121 ± 1.3	120 ± 1.2	121 ± 1.1	121 ± 1.3	0.73
Multivariate model ^a	121 ± 1.3	120 ± 1.2	120 ± 1.2	121 ± 1.3	0.60
% energy from total fat					
Univariate model	119 ± 1.2	121 ± 1.1	120 ± 1.2	123 ± 1.4	0.04*
Multivariate model ^a	120 ± 1.2	120 ± 1.3	120 ± 1.2	122 ± 1.2	0.38
% energy from saturated fat					
Univariate model	120 ± 1.2	119 ± 1.1	122 ± 1.2	122 ± 1.5	0.07
Multivariate model ^a	119 ± 1.2	120 ± 1.2	122 ± 1.2	121 ± 1.2	0.34
% energy from MUFA ^b					
Univariate model	118 ± 1.2	122 ± 1.1	119 ± 1.1	124 ± 1.4	0.01*
Multivariate model ^a	119 ± 1.2	122 ± 1.2	118 ± 1.2	123 ± 1.2	0.07
% energy from trans fatty acids					

	Quartiles of dietary intake				P for trend
	1st quartile	2nd quartile	3rd quartile	4th quartile	
Univariate model	119 ± 1.2	120 ± 1.3	122 ± 1.1	123 ± 1.3	0.01 *
Multivariate model ^a	119 ± 1.2	120 ± 1.2	121 ± 1.2	123 ± 1.2	0.01 *
Omega-3 fatty acids, grams/day					
Univariate model	120 ± 1.2	120 ± 1.3	120 ± 1.2	123 ± 1.3	0.07
Multivariate model ^a	121 ± 1.3	121 ± 1.3	119 ± 1.2	121 ± 1.4	0.90
Omega-6 fatty acids, grams/day					
Univariate model	120 ± 1.2	120 ± 1.2	122 ± 1.2	122 ± 1.3	0.08
Multivariate model ^a	119 ± 1.6	119 ± 1.3	122 ± 1.2	122 ± 1.6	0.21
Sodium, mg					
Univariate model	118 ± 1.3	121 ± 1.3	122 ± 1.2	122 ± 1.2	0.05
Multivariate model ^a	116 ± 1.6	121 ± 1.3	122 ± 1.2	123 ± 1.7	0.02 *
Potassium, mg					
Univariate model	119 ± 1.0	122 ± 1.3	122 ± 1.2	120 ± 1.3	0.68
Multivariate model ^a	120 ± 1.6	122 ± 1.3	122 ± 1.2	118 ± 1.6	0.57
Magnesium, mg					
Univariate model	120 ± 1.1	121 ± 1.3	122 ± 1.3	120 ± 1.2	0.64
Multivariate model ^a	120 ± 1.6	121 ± 1.3	122 ± 1.3	119 ± 1.6	0.68
Calcium, mg					
Univariate model	119 ± 1.2	122 ± 1.2	122 ± 1.2	120 ± 1.3	0.54
Multivariate model ^a	120 ± 1.4	122 ± 1.2	122 ± 1.2	119 ± 1.5	0.84
Phosphorus, mg					
Univariate model	119 ± 1.2	122 ± 1.2	122 ± 1.3	121 ± 1.2	0.34
Multivariate model ^a	119 ± 1.7	121 ± 1.3	122 ± 1.3	120 ± 1.8	0.62
Caffeine, mg					
Univariate model	121 ± 1.2	122 ± 1.2	122 ± 1.3	119 ± 1.3	0.48
Multivariate model ^a	121 ± 1.4	121 ± 1.2	121 ± 1.2	119 ± 1.3	0.25

* p-value <0.05.

^aMultivariate model: adjusted for age, BMI, total energy intake, smoking and physical activity.

^bMUFA=monounsaturated fatty acids.

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Association of mean systolic blood pressure by quartiles of dietary intake among Alaska Native women not on anti-hypertensive medications (n=528).

Table IVb

	Quartiles of dietary intake				P for trend
	1st quartile	2nd quartile	3rd quartile	4th quartile	
Total energy intake (kcal)					
Univariate model	116 ± 1.1	116 ± 1.2	114 ± 1.0	113 ± 1.2	0.07
Multivariate model ^a	113 ± 1.8	115 ± 1.3	115 ± 1.1	116 ± 2.1	0.53
% energy from carbohydrate					
Univariate model	116 ± 1.2	115 ± 1.6	114 ± 1.1	114 ± 1.1	0.15
Multivariate model ^a	115 ± 1.1	114 ± 1.1	114 ± 1.1	115 ± 1.1	0.66
% energy from simple carbohydrate					
Univariate model	116 ± 1.2	115 ± 1.1	114 ± 1.2	113 ± 1.0	0.06
Multivariate model ^a	114 ± 1.1	114 ± 1.1	115 ± 1.1	115 ± 1.1	0.50
% energy from complex carbohydrate					
Univariate model	113 ± 1.1	115 ± 1.2	114 ± 1.2	116 ± 1.1	0.09
Multivariate model ^a	113 ± 1.1	116 ± 1.1	115 ± 1.1	115 ± 1.1	0.48
% energy from protein					
Univariate model	114 ± 1.1	115 ± 1.2	115 ± 1.2	115 ± 1.2	0.29
Multivariate model ^a	115 ± 1.1	115 ± 1.1	115 ± 1.1	114 ± 1.1	0.61
% energy from total fat					
Univariate model	114 ± 1.0	114 ± 1.2	114 ± 1.3	117 ± 1.2	0.21
Multivariate model ^a	115 ± 1.1	115 ± 1.1	114 ± 1.1	115 ± 1.1	0.55
% energy from saturated fat					
Univariate model	115 ± 1.0	114 ± 1.2	115 ± 1.1	115 ± 1.3	0.78
Multivariate model ^a	116 ± 1.1	113 ± 1.1	115 ± 1.1	114 ± 1.1	0.32
% energy from MUFA ^b					
Univariate model	114 ± 1.0	115 ± 1.2	114 ± 1.2	116 ± 1.2	0.25
Multivariate model ^a	115 ± 1.1	114 ± 1.1	114 ± 1.1	114 ± 1.1	0.57
% energy from trans fatty acids					
Univariate model	114 ± 1.1	114 ± 1.2	115 ± 1.3	115 ± 1.1	0.30

	Quartiles of dietary intake					P for trend
	1st quartile	2nd quartile	3rd quartile	4th quartile		
Multivariate model ^a	114 ± 1.1	115 ± 1.1	115 ± 1.1	114 ± 1.1	114 ± 1.1	0.98
Omega-3 fatty acids, grams/day						
Univariate model	117 ± 1.1	114 ± 1.1	114 ± 1.3	114 ± 1.1	114 ± 1.1	0.19
Multivariate model ^a	118 ± 1.1	114 ± 1.1	113 ± 1.1	113 ± 1.2	113 ± 1.2	<0.01 [*]
Omega-6 fatty acids, grams/day						
Univariate model	116 ± 1.1	115 ± 1.2	114 ± 1.0	114 ± 1.2	114 ± 1.2	0.17
Multivariate model ^a	116 ± 1.3	114 ± 1.1	115 ± 1.1	115 ± 1.4	115 ± 1.4	0.72
Sodium, mg						
Univariate model	114 ± 1.1	117 ± 1.2	114 ± 1.1	113 ± 1.2	113 ± 1.2	0.25
Multivariate model ^a	113 ± 1.4	116 ± 1.2	115 ± 1.1	114 ± 1.5	114 ± 1.5	0.99
Potassium, mg						
Univariate model	114 ± 1.1	116 ± 1.1	115 ± 1.1	113 ± 1.3	113 ± 1.3	0.53
Multivariate model ^a	115 ± 1.3	116 ± 1.1	115 ± 1.1	112 ± 1.5	112 ± 1.5	0.18
Magnesium, mg						
Univariate model	114 ± 1.1	116 ± 1.2	115 ± 1.1	113 ± 1.3	113 ± 1.3	0.60
Multivariate model ^a	116 ± 1.4	116 ± 1.1	115 ± 1.1	113 ± 1.5	113 ± 1.5	0.38
Calcium, mg						
Univariate model	117 ± 1.2	114 ± 1.1	114 ± 1.1	113 ± 1.2	113 ± 1.2	0.04 [*]
Multivariate model ^a	116 ± 1.3	114 ± 1.1	114 ± 1.1	114 ± 1.3	114 ± 1.3	0.53
Phosphorus, mg						
Univariate model	115 ± 1.2	115 ± 1.1	115 ± 1.2	114 ± 1.2	114 ± 1.2	0.23
Multivariate model ^a	114 ± 1.4	115 ± 1.2	115 ± 1.1	115 ± 1.5	115 ± 1.5	0.63
Caffeine, mg						
Univariate model	112 ± 1.0	115 ± 1.0	117 ± 1.3	115 ± 1.2	115 ± 1.2	0.06
Multivariate model ^a	116 ± 1.2	115 ± 1.1	115 ± 1.1	113 ± 1.2	113 ± 1.2	0.11

^{*} p-value <0.05.

^a Multivariate model: adjusted for age, BMI, total energy intake, smoking and physical activity.

^b MUFA=monounsaturated fatty acids