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Associations between Diet and Cardiometabolic Risk among Yup'ik Alaska Native People using Food Frequency Questionnaire Dietary Patterns

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Abstract

Background and Aims—In previous analyses, we identified three dietary patterns from food frequency questionnaire data among a sample of Yup'ik Alaska Native people living in Southwest Alaska: a "subsistence foods" dietary pattern and two market-based dietary patterns "processed foods" and "fruits and vegetables". In this analysis, we aimed to characterize the association between the dietary patterns and cardiometabolic (CM) risk factors (lipids, blood pressure, glucose, adiposity).

Methods and Results—We used multilevel linear regression to estimate the mean of each CM risk factor, comparing participants in the 4th to the 1st quartile of each dietary pattern (n=637). Models were adjusted for age, sex, past smoking, current smoking, and physical activity. Mean log triglyceride levels were significantly higher among participants in the 4th compared to the 1st quartile of the processed foods dietary pattern (β=0.11). Mean HbA1c percent was significantly lower (β=−0.08) and mean diastolic blood pressure (DBP) mm Hg was significantly higher (β=2.87) among participants in the 4th compared to the 1st quartile of the fruits and vegetables dietary pattern. Finally, mean log triglyceride levels and mean DBP mm Hg were significantly lower among participants in the 4th compared to the 1st quartile of the subsistence foods dietary pattern (β=−0.10 and β=−3.99 respectively).

Conclusions—We found increased CM risk, as reflected by increased triglycerides, associated with eating a greater frequency of processed foods, and reduced CM risk, as reflected by lower triglycerides and DBP, associated with eating a greater frequency of subsistence foods.

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Keywords

food frequency questionnaire; FFQ; Yup'ik; Alaska Native; dietary pattern; cardiometabolic

Introduction

American Indian and Alaska Native (AN) people have long suffered from health disparities, (1) and these health disparities continue despite efforts to reduce them. Between 1990 and 2009, all-cause mortality was 65% higher in AN people relative to United States (US) whites.(1) Cardiovascular and metabolic diseases are substantial contributors to this increased mortality in AN people.(1) A number of lifestyle factors including physical activity, stress, depression, smoking, alcohol consumption, and diet may contribute to cardiometabolic (CM) disease risk in AN people.(2)

Many indigenous populations, including AN people, are undergoing nutritional transitions, characterized by the substitution of traditional foods for market-based processed foods.(3,4) The traditional diet of some AN people, including Yup'ik people residing in remote communities in the Yukon-Kuskokwim Delta of Southwest Alaska, is abundant in marine mammals and fish that include high levels of omega-3 polyunsaturated fatty acids. These may have beneficial effects in preventing cardiovascular disease risk by lowering circulating triglycerides and inflammatory markers and increasing high-density lipoprotein cholesterol (HDL-C) and apolipoprotein A-I.(5–7) Thus, this nutritional transition in Yup'ik people could have adverse effects in terms of CM disease, (8–12) potentially further amplifying current health disparities.

In this analysis, we use dietary patterns previously identified from a food frequency questionnaire (FFQ) in a sample of Yup'ik people to characterize associations between diet and CM risk factors.

Methods

Study sample

This study took place as part of the Center for Alaska Native Health Research (CANHR) studies for which detailed study recruitment methods have been published elsewhere.(13,14) In brief, CANHR conducts recurring cross-sectional research in 10 purposefully selected communities from the 58 remote Yup'ik communities in the Yukon-Kuskokwim Delta.(15) Within these communities, study participants were recruited using convenience sampling methods in which all individuals who self-identified as Alaska Native or who were married to an Alaska Native descendent, were greater than 14 years of age, and were non-pregnant, were eligible to participate. Our sample included 637 individuals who participated in CANHR studies between September 2009 and May 2013, were 18 years of age or older, were not pregnant, who self-reported their ethnicity as Yup'ik, and had complete data required to determine the dietary patterns, as described below. For individuals who had participated in more than one research visit, we used the data from their most recent visit with both FFQ and activity data available for analysis.

Informed consent was obtained from participants prior to data collection. This study was approved by the University of Alaska Fairbanks and University of Washington Institutional Review Boards and the Yukon-Kuskokwim Health Corporation Human Studies Committee.

Data collection

Diet—Dietary data were collected using a Yup'ik specific FFQ developed by CANHR researchers and local community research assistants.(15) Participants reported how frequently they typically consumed each food during the previous 12 months. For traditional subsistence foods it was further elicited whether they ate the food seasonally or year-round. Serving size was not collected in order to reduce participant burden and because it does not substantially improve nutritional ranking of study participants.(16)

Briefly, 3 dietary patterns were identified using a 2-stage exploratory factor analysis (15) and then reproduced using a confirmatory factor analysis.(17) The resulting dietary patterns included 2 market-based dietary patterns, a "processed foods" pattern and a "fruits and vegetables" pattern, as well as a "subsistence foods" dietary pattern that captured traditional diet. The "processed foods" dietary pattern was measured using the following foods from the FFQ: salty snacks, sweetened cereals, pizza, sweetened drinks, hot dogs and lunch meat, fried chicken, and canned tuna; the "fruits and vegetables" dietary pattern was measured using fresh citrus, potato salad, citrus juice, corn, green beans, green salad, and market berries in akutaq (Eskimo ice cream); and finally the "subsistence foods" dietary pattern included seal or walrus soup, non-oily fish, wild greens, and bird soup (Supplemental Table A).

Dietary pattern scores were estimated as the average of the natural log transformed frequency of consumption for each food measuring the dietary pattern.(17) The greater the dietary pattern score, the greater the frequency of consumption of the foods used to measure that dietary pattern. Dietary pattern scores were grouped into quartiles in which the 1^{st} represented the lowest frequency of consumption for that dietary pattern and the 4^{th} quartile represented the highest frequency of consumption of foods used to measure that dietary pattern.

Cardiometabolic risk factors—Participants were asked to fast for 8–12 hours prior to providing blood samples for lipid determinations (low-density lipoprotein cholesterol [LDL-C], HDL-C, triglycerides [TG]), fasting blood glucose (FBG) levels, and glycated hemoglobin (HbA1c). Lipid concentrations were measured with the Poly-Chem System Chemistry Analyzer in the Nutritional Assessment Laboratory at the University of California Davis. FBG was measured using whole blood tested immediately with a Cholestech LDX analyzer and HbA1c was measured using the Bayer HbA1c DCA 2000+ analyzer.

Systolic (SBP) and diastolic (DBP) blood pressure was obtained using the OMRON HEM907 automated blood pressure cuff. We used the mean of the last 2 of the 3 measures that were collected, unless the final measure was not available in which case the mean of the first 2 measures was used.

Waist circumference (WC) was measured by trained staff using protocols from the NHANES III Anthropometric Procedures Manual (18) as previously described (2). If the 2 WC measures differed by more than 2 cm, then a third measure was taken and the final measure was the average of the 2 closest measures.

Covariates—At the same visit when diet and CM risk factors were obtained, data on potential confounding factors were also collected. Specifically self-reported age, sex, smoking, and medication use for lowering lipids, for controlling diabetes, and for controlling hypertension were obtained. In addition, study participants wore an Actiheart combined heart rate/movement monitoring device for 4-consecutive days. Heart rate and movement data were used to determine monitor wear time. Counts per day (CPD) using only the movement data, specifically the daily sum of vertical acceleration measured at the chest, were used to estimate physical activity. In unpublished data in a subsample of this cohort we found CPD is significantly correlated with PAEE measured using the criterion standard doubly labeled water method (r=0.51, 95% CI: 0.13 to 0.75).

Statistical analysis

To improve the distribution of the CM risk factors, we log transformed HDL-C, TG, FBG, and WC. We excluded from specific analyses participants: with CM risk factors >4 standard deviations from the mean; participants who were not fasting for LDL-C, HDL-C, TG, and FBG analyses; or taking a medication to treat a specific CM risk factor. That is, participants taking cholesterol lowering medication were excluded from the LDL-C, HDL-C, and TG analyses (n=41), participants taking hypertension medication were excluded from SBP and DBP analyses (n=102), and participants taking diabetes medication were excluded from the HbA1c and FBG analyses (n=6). Thus, sample sizes varied for the analyses due to these exclusions and also missing data for each measure, as indicated in the tables. All analyses were performed using SAS (9.4) and Stata 13. P-values < 0.05 were considered statistically significant.

To characterize the association between dietary patterns and CM risk factors we used multilevel linear regression to estimate the mean of each CM risk factor among participants in the 1st quartile compared to the other 3 quartiles included in the model as binary terms. For ease of interpretation we only report the differences between the 1st and 4th quartiles as the primary analysis. We also tested for trend by including the dietary pattern quartile in the model as a grouped-linear term. Clustering at the community level was accounted for by fitting a random intercept for each of the 10 communities using maximum likelihood(19) and covariates were included in the model to adjust for potential confounding factors.

Sex, past smoking, and current smoking were modeled as binary variables. Cigarette smoking was included as past and current (anyone smoking within previous year), with the reference group as never to represent the different risk among current versus previous smokers.(20,21) Age was modeled as a spline with 2 knots (19) and physical activity counts per day were log transformed to improve normality, and was included in the model as a centered linear term.

Results

The characteristics of study participants are shown in Table 1. They ranged in age from 18 to 93 years, with a mean age of 39.9 years. Men comprised 46.2% of the participants. Nearly two-thirds of participants had smoked. Forty-seven percent of study participants had LDL-C ≥130 mg/dL, 34% of participants had a WC above the high-risk threshold (>102 for men and >88 for women), and 9.4% of participants were above the high-risk threshold for 3 or more of the following risk factors: HDL-C; TG; SBP and DBP; FG; and WC (Supplemental Table B). Unadjusted mean cardiometabolic risk factor levels across dietary pattern quartiles are reported in Supplemental Table C.

Neither LDL-C nor log HDL-C was significantly associated with any of the dietary patterns. Log TG was significantly associated with the processed foods and subsistence foods dietary patterns. Mean TG levels were 12% (P=0.046) higher among participants in the 4^{th} compared to the 1^{st} quartile of processed foods (Table 2), with an increasing trend at greater dietary pattern quartiles (P=0.031). In addition, mean log TG were inversely associated with the subsistence food dietary pattern, with mean log TG 10% lower among participants in the 4^{th} compared to 1^{st} quartile (P=0.049).

Mean SBP was not significantly associated with any of the dietary patterns (Table 2). Mean DBP was 2.87 mm Hg higher among participants in the 4^{th} compared to 1^{st} quartile of the fruits and vegetables dietary pattern (P=0.014). In addition mean DBP was inversely associated with the subsistence food dietary pattern, with mean DBP 3.99 mm Hg lower among participants in the 4^{th} compared to 1^{st} quartile (P<0.001, P-trend<0.001).

Mean HbA1c was inversely associated with the fruits and vegetables dietary pattern, with a 0.08% lower HbA1c among participants in the 4^{th} compared to the 1^{st} quartile (P=0.013, P-trend=0.007) (Table 2). Neither FBG nor mean log WC were associated with any of the 3 dietary patterns.

No significant associations were observed between any of the dietary patterns and mean log WC (Table 2).

Discussion

Dietary patterns derived from FFQ data were associated with CM disease risk in this sample of Yup’ik people. Specifically, we found evidence of increased CM risk related to the processed foods dietary pattern based on the higher TG levels, and reduced CM risk related to the subsistence foods dietary pattern based on the lower TG and DBP values. The association between the fruits and vegetables dietary pattern and CM disease risk was less clear.

The 12% lower TG measure in the lowest compared to the highest quartile of the processed foods dietary pattern is similar to the magnitude of change in TG measures observed among statin users.(22) This association is consistent with findings from a study using a biomarker of market food intake (23) in Yup’ik people, but differs from market-based dietary patterns determined from FFQ data among Inupiat people.(24) That is, Nash et al., identified a positive association between $\delta^{13}C$ (a biomarker strongly associated with total market food intake) and TG and no association between $\delta^{13}C$ and HbA1c, FBG, and WC, all consistent with our findings from the same Yup'ik study population.(23) However Nash et al., also reported $\delta^{13}C$ as negatively associated with LDL-C, HDL-C and positively associated with SBP and DBP, (23) associations not observed in this study. Using FFQ data Johnson-Down et al., identified a positive association between a junk food dietary pattern and SBP among Cree people.(25) Also using FFQ data, Eilat-Adiar et al., identified 2 dietary patterns in Inupiat people that share similarities with our processed foods dietary pattern, a “beverages and sweets” pattern and “western foods” pattern, and neither was significantly associated with HDL-C, TG, or SBP.(24)

To our knowledge, there is only one other study that reported CM risk factor associations with fruits and vegetables in an AN population. Eilat-Adiar et al., (24) used FFQ data to identify a “healthy purchased” dietary pattern which includes fruits and vegetables, and this dietary pattern was not associated with LDL-C, HDL-C, TG, or SBP. In contrast, our fruits and vegetables dietary pattern suggested a possible positive association with DBP and a negative association with HbA1c. The inverse association with HbA1c is consistent with studies in other populations, in which dietary patterns favoring fruits and vegetables were found to be beneficial (26) for diabetes prevention. However, the 0.08% difference in HbA1c between the highest and lowest quartile is not a clinically meaningful difference.(27) The higher DBP in the 4^{th} compared to 1^{st} quartile of the fruit and vegetable dietary pattern, although not substantial, was not as we expected. The reason for this association is not clear. However, the types of fruits and vegetables available in these remote communities are typically canned (added sodium and sugar) rather than fresh, which may provide a partial explanation for the higher DBP.

A number of other studies have characterized the association between traditional foods and CM risk in indigenous circumpolar populations. These studies have consistently found traditional foods to be positively associated with LDL-C, HDL-C, and FBG and negatively associated with TG and SBP.(7,24,28– 30) Of these associations, we only observed the inverse TG association, while we also observed a negative association with DBP. The 3.99 mm Hg difference in DBP between the first and fourth quartile is comparable to the reduction in DBP expected for a person with a baseline DBP of 90 to 95 mm Hg taking one hypertensive drug at half standard dose.(31) The association between a traditional diet and DBP was first identified in the same Yup'ik study population by O'Brien et al. using the $\delta^{15}N$ biomarker elevated in traditional marine foods, and is consistent with findings from non-indigenous populations based on fish oil intake.(7) However O'Brien et al. also found $\delta^{15}N$ to be positively associated with LDL-C and HDL-C and inversely associated with TG and SBP.(7) We only found the inverse association with TG, possibly because of the different composition of our subsistence food dietary pattern that includes wild greens and bird soup, as well as marine foods.

In our analysis the differences in dietary pattern factors scores, and thus dietary pattern quartiles, could be the result of participants substituting more processed foods for less subsistence foods, or it could be the result of eating more food overall. As the FFQ did not capture serving size, it was challenging to account for the latter possibility. To better differentiate between substitution of foods and overall eating more food, we conducted a sensitivity analysis using the same model with the addition of a summary measure of the annual frequency of consumption of the 18 foods used to determine the dietary patterns as a covariate and indicator of overall consumption quantity. With one exception, we found no meaningful differences in the associations observed between dietary patterns and CM risk factors with the summary measure included (data not shown), indicating that our findings are likely not strongly influenced by those individuals who eat more overall.

Strengths of this study include the use of the same FFQ over the 5-year study period, variability in dietary patterns between individuals, and the use of reproducible and reliable dietary patterns. Our findings generally align with the findings from other indigenous circumpolar populations. However, we found fewer significant associations particularly when compared with the studies using biomarkers to measure diet.(7,23) This may be due to measurement error in the dietary patterns, possibly attenuating the results. Other limitations include our inability to assess temporality due to the cross-sectional nature of the data, the potential lack of generalizability given the convenience sampling method employed, the exclusion of participants taking medications for CM diseases, and potential bias due to unmeasured confounding because alcohol use data was not collected. We also acknowledge the potential issue of multiple comparisons but elected not to report a more conservative P-value given the exploratory nature of our research.

Overall we found associations between increased CM risk, based on TG, associated with eating a greater frequency of processed foods, and reduced CM risk, based on TG and DBP, associated with eating a greater frequency of subsistence foods. The association between the fruits and vegetable dietary pattern and CM risk was less clear, and will require further investigation. These findings align with other research and support efforts to encourage a diet high in traditional subsistence foods as a way to further reduce CM disease related health disparities in this underserved population.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Abbreviations

AN	Alaska Native
CM	cardiometabolic

FFQ	Food Frequency Questionnaire
CANHR	Fairbanks Center for Alaska Native Health Research
LDL-C	low-density lipoprotein cholesterol
HDL-C	high-density lipoprotein cholesterol
TG	triglycerides
SBP	systolic blood pressure
DBP	diastolic blood pressure
HbA1c	glycated hemoglobin
FBG	fasting blood glucose
WC	waist circumference

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Highlights

- We modeled associations between dietary patterns and cardiometabolic risk.
- We used three dietary patterns from a sample of Yup'ik people.
- Greater cardiometabolic risk associated with processed foods.
- Reduced cardiometabolic risk associated with subsistence foods.
- Fruit and vegetable associations unclear, require further research.

Table 1

Participant characteristics and cardiometabolic risk factors, Yup'ik study participants, September 2009 – May 2013

	n	Overall
Participant characteristics		
Age in years, mean (standard deviation [SD])	637	39.9 (17.7)
Male sex, n(%)	637	292 (46.2)
Never smoker, n(%)	637	215 (33.7)
Past smoker, n(%)	637	198 (31.1)
Current smoker, n(%)	637	224 (35.2)
Physical activity per 1000 counts a day, mean (SD)	595	49.8 (32.5)
Cardiometabolic risk factors		
LDL-C (mg/dL), mean (SD)*	577	125.4 (33.2)
HDL-C (mg/dL), mean (SD)†‡	578	63.0 (18.4)
TG (mg/dL), mean (SD)†*	577	83.5 (42.4)
SBP (mm Hg), mean (SD)£	534	115.8 (12.8)
DBP (mm Hg), mean (SD)§	535	67.7 (9.5)
HbA1c (%), mean (SD)||	630	5.6 (0.3)
FBG (mg/dL), mean (SD)†#	619	91.5 (10.1)
WC (cm), mean (SD)†**	635	89.1 (14.9)

Abbreviations: LDL-C = low-density lipoprotein cholesterol, HDL-C = high-density lipoprotein cholesterol, TG = triglycerides, SBP = systolic blood pressure, DBP = diastolic blood pressure, HbA1c = glycated hemoglobin, FBG = fasting blood glucose, and WC = waist circumference.

*excludes participants with missing data (n=7), who were not fasting when the sample was taken (n=11), who self-reported taking lipid lowering medications (n=41), and who had a measure >4 standard deviations from the mean (n=1)

†values presented here are not log transformed for ease of interpretation, but were log transformed for the analysis

‡excludes participants with missing data (n=7), who were not fasting when the sample was taken (n=11), and who self-reported taking lipid lowering medications (n=41)

£excludes participants who self-reported taking hypertension medication (n=102) and who had a measure >4 standard deviations from the mean (n=1)

§excludes participants who self-reported taking hypertension medication (n=102)

||excludes participants who self-reported taking diabetes medication (n=6) and who had a measure >4 standard deviations from the mean (n=1)

#excludes participants who were not fasting when the sample was taken (n=10), who self-reported taking diabetes medication (n=6) and who had a measure >4 standard deviations from the mean (n=2)

**excludes participants with missing measures (n=2)

Table 2

Associations between dietary pattern quartiles (only 4th quartile reported) and Cardiometabolic risk factors, using mul8level analysis accounting for community and adjusted for covariates† (n=637), Yup'ik study participants, September 2009 – May 2013

	Processed Foods			Fruits and Vegetables			Subsistence Foods		
	β	P	P-trend	β	P	P-trend	β	P	P-trend
Cardiometabolic risk factors	**4th v. 1st (ref) quartile**		**All 4 quartiles**	**4th v. 1st (ref) quartile**		**All 4 quartiles**	**4th v. 1st (ref) quartile**		**All 4 quartiles**
Lipids									
LDL-C (mg/dL) (n=530)	−4.65	0.25	0.24	0.92	0.80	0.89	3.34	0.37	0.21
Log HDL-C (n=531)	−0.01	0.69	0.65	−0.03	0.36	0.49	0.04	0.16	0.10
Log TG (n=530)	0.11	0.046	0.031	0.07	0.17	0.05	−0.10	0.049	0.06
Blood pressure									
SBP (mm Hg) (n=492)	−0.50	0.75	0.96	2.37	0.10	0.27	−1.05	0.47	0.26
DBP (mm Hg) (n=493)	−0.78	0.56	0.60	2.87	0.014	0.06	−3.99	<0.001	<0.001
Blood glucose									
HbA1c (%) (n=577)	−0.03	0.43	0.28	−0.08	0.013	0.007	0.04	0.21	0.35
Log FBG (n=567)	0.00	0.85	0.84	−0.01	0.64	0.52	0.01	0.58	0.71
Adiposity									
Log WC (n=583)	0.03	0.15	0.23	0.02	0.15	0.17	0.02	0.32	0.64

Abbreviations: LDL-C = low-density lipoprotein cholesterol, HDL-C = high-density lipoprotein cholesterol, TG = triglycerides, SBP = systolic blood pressure, DBP = diastolic blood pressure, HbA1c = glycated hemoglobin, FBG = fasting blood glucose, and WC = waist circumference.

β and p-values for the 2nd and 3rd quartile not reported.

†Adjusted for age, sex, current smoking, past smoking, and physical activity counts per day.