# Cardiovascular disease risk factors and n−3 fatty acid status in the adult population of James Bay Cree[1–3]

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**ABSTRACT**

**Background:** Canadian native populations, which traditionally consume large amounts of fish, have lower rates of mortality from heart disease than do Canadian nonnative populations, which have low fish intakes. Fish oils rich in n−3 fatty acids may have a protective effect against cardiovascular disease (CVD) risk factors.

**Objectives:** The purposes were to examine the profile of plasma phospholipid concentrations of the n−3 fatty acids eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) among James Bay Cree and to verify the relation between these concentrations and CVD risk factors.

**Design:** The study population consisted of 917 subjects aged 18–74 y who participated in the 1991 Santé Québec Health Survey. Data were obtained through home interviews and clinic visits. Plasma samples were analyzed for phospholipid fatty acid composition.

**Results:** The mean fish consumption on the day before the survey was 60 g among the adult Cree population. Expressed as a percentage of total fatty acids, relative concentrations of EPA and DHA were 0.65% and 2.80%, respectively. n−3 Fatty acids were higher among coastal residents than among inland residents. A positive association was observed between plasma HDL and n−3 fatty acids. EPA and EPA+DHA were inversely associated with triacylglycerols. Among subjects aged 50–74 y, an inverse association between EPA and EPA:AA and total:HDL cholesterol was observed.

**Conclusions:** n−3 Fatty acids may favorably influence some CVD risk factors. The Cree population must be encouraged to maintain their traditional fish-based diet, which may be one of the factors protecting them against mortality from CVD. *Am J Clin Nutr* 2002;76:85–92.

**KEY WORDS** n−3 Fatty acids, eicosapentaenoic acid, docosahexaenoic acid, fish intake, cardiovascular disease risk factor, cholesterol, LDL, HDL, triacylglycerol, blood pressure, glucose, insulin, Cree, Natives

## INTRODUCTION

Cardiovascular disease (CVD) is a major cause of death, disability, and illness in Canada, and large differences in rates of death from ischemic heart disease (IHD) have been observed across the country. In Canada, native populations (both Inuit and Indians) have historically had IHD death rates much lower than those of nonnative populations (1). Numerous studies have reported that a diet rich in fish and marine mammals protects against CVD (2–6). In fact, there are few cases of arterial thrombosis and CVD in populations that consume large amounts of marine foods (4, 7–12). These beneficial effects are attributed to the n−3 fatty acids found in fish, shellfish, and marine mammals. In particular, dietary fish oils are specifically rich in eicosapentaenoic acid (EPA; 20:5n−3) and docosahexaenoic acid (DHA; 22:6n−3). Despite this dietary protection, evidence points to increasing death rates among native populations from IHD and stroke. The increasing prevalence of such risk factors for CVD as high blood pressure (BP), diabetes, obesity, and smoking may account, in part, for this trend, but the partial abandonment of a traditional lifestyle and diet has also been associated with the increasing prevalence of risk factors for CVD (13, 14).

Located over a vast territory of 300 000 $km^2$ in northern Quebec, between the 49th and 55th parallels, the James Bay Cree population is distributed among 9 bands and was estimated at 13 594 people in 1996 (15). Before contact with Europeans and thereafter Americans, Canadian Northern Indians such as the Cree were subsistence hunters (16). The precontact Indian diet, which comprised wild meat, fish, fat, and vegetation, provided proper amounts of the required nutrients (17). The Cree of James Bay, as is the case with other peoples of the Canadian North, have adapted their diet to the many changes brought about by contact with the Euro-American culture (16, 18). Thus, a purely traditional diet has been replaced by a semitraditional diet or a settlement diet. The Santé Québec Health Survey conducted among the Cree population in 1991 indicated that traditional foods contributed only 12% and 28%, respectively, of the energy

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and protein intakes (19). Traditional eating habits among Cree have changed in response to many factors, such as their settlement in permanent communities, an increase in salaried employment, the growth of modern air transportation, and the increased availability of and access to market foods. Moreover, news on the presence of mercury in fish has indirectly affected lifestyle and the perception of food quality safety and has been linked to a reduction in fish consumption (20, 21).

The first objective of this study was to examine the profile of relative concentrations in plasma phospholipid of n−3 fatty acids, particularly EPA and DHA, in a representative sample of James Bay Cree. The second objective was to verify the relation between concentrations of n−3 fatty acids and various CVD risk factors.

## SUBJECTS AND METHODS

### Study design

In 1991, as a part of the federal-provincial Canadian Heart Health Initiative, Santé Québec—an organization of the Quebec Ministry of Health and Social Services—conducted a health survey among James Bay Cree. The primary objective of the survey was to collect relevant information on the physical, social, and psychosocial health of this population (22). Several steps were taken to gather information. First, face-to-face interviews were conducted in homes by an interviewer using a questionnaire on lifestyle habits (diet, smoking, and socioeconomic characteristics). Next, respondents completed a confidential questionnaire that included questions on alcohol and drug consumption. Among the same participants, a clinical session was conducted, in which blood samples were taken and BP, height, weight, and waist and hip girth were measured. Blood samples were frozen at −20°C and, within 10 d, shipped to the Lipid Research Laboratory of St Michael Hospital (Toronto), where plasma lipids and lipoprotein were measured. Finally, another face-to-face at-home interview was conducted by a nurse to collect data on 24-h recalls of dietary intake. Stored frozen plasma samples were used to determine phospholipid fatty acid composition. Information on demographics, the prevalence of CVD risk factors, and fish intake was obtained from the Santé Québec data files (19, 22).

### Study population

This study was performed with the approval of the Clinical Research Deontology Committee of Laval University. The target population of the survey comprised all Cree private households located in the 9 communities of the James Bay region (22). A Cree household was defined as a home including at least one Cree individual. The sample frame was developed from the lists obtained from the housing departments of each of the 9 Cree community Band Councils. The Quebec Bureau of Statistics chose a design that would afford an acceptable degree of precision for any prevalence ≥10% for all communities combined. Of the 1115 household respondents aged between 18 and 74 y, 943 underwent the clinical measurements and blood tests. Plasma phospholipid concentrations of fatty acids were analyzed in the available 917 blood samples.

### Plasma lipids, glucose, and insulin

Participants in the clinical session were asked to fast for 12 h before giving blood samples. Concentrations of plasma total cholesterol, triacylglycerols, LDL cholesterol, and HDL cholesterol were analyzed according to methods of the Lipid Research Clinics Program (23). Cholesterol and triacylglycerol concentrations were determined in plasma and in lipoprotein fractions by use of an Auto-Analyzer II (Technicon Instruments Corporation, Tarrytown, NY). The HDL fraction was obtained after precipitation of LDL in the infranatant fluid with heparin and manganese chloride. Plasma glucose was measured enzymatically, and fasting insulin concentrations were measured with a commercial double-antibody radioimmunoassay (LINCO Research, St Louis) that showed little cross-reactivity (<0.2%) with human proinsulin and CVs of ≤5.5% (24).

### Plasma phospholipid fatty acids

Plasma samples used for fatty acid analyses were stored at −80°C until they were analyzed (in 1998). For the determination of the fatty acid composition of plasma phospholipids, 200-μL aliquots of plasma were extracted after the addition of chloroform:methanol (2:1, vol:vol), in the presence of a known amount of internal standard (diheptadecanoyl phospholipid) (25). The total phospholipid was isolated from the lipid extract by thin-layer chromatography with the use of heptane:isopropyl ether:acetic acid (60:40:3, vol:vol:vol) as the developing solvent. After transmethylation with boron trifluoride and methanol, the fatty acid profile was determined by capillary gas-liquid chromatography. Fatty acid concentrations in plasma phospholipids were expressed as a percentage of the total area of all fatty acid peaks from 14:0 to 24:1. The plasma phospholipid concentrations of fatty acids are expressed as relative percentages of total fatty acids by weight.

### Blood pressure

Four BP measurements were taken by a trained survey nurse according to recommendations of the consensus conference on the treatment of mild hypertension in Canada (26). Standard mercury sphygmomanometers, 15-in stethoscopes, and appropriately sized cuffs were used. Pressure readings were taken at the beginning and the end of both the home interviews and the clinical visits. These values were reported as the arithmetic mean of the 4 readings.

### Lifestyle assessment and anthropometry

A face-to-face interview with each participant was conducted in his or her home by a nurse who used a questionnaire covering lifestyle habits (eg, alcohol intake, smoking status). The participants also attended a clinical session where anthropometric measurements such as height, weight, and waist and hip girth were recorded. The mean (±SD) body mass index (BMI; in $kg/m^2$) of the subjects was 30.2 ± 6.0 and the mean waist girth was 99.2 ± 14.9 cm; the coefficient correlation between these 2 indexes was 0.85 ($P$ = 0.0001). The accumulation of adipose tissue in the abdominal area, as measured by the waist girth, was used as a measurement of abdominal obesity (27–29). For the waist circumference, the measuring tape was positioned horizontally at the level of noticeable waist narrowing. The measurement was taken at the end of a normal expiration and was recorded to the nearest millimeter. Abdominal obesity was defined as waist girth ≥100 cm for subjects aged <40 y and ≥90 cm for subjects aged ≥40 y (30).

### Dietary assessment

Daily fish intake data were obtained by using a 24-h dietary recall questionnaire administered by a trained nurse during a face-to-face at-home interview (19). The interview permitted recording of a detailed and precise description of foods consumed

**TABLE 1**
Relative concentrations of n−3 fatty acids in plasma phospholipids according to geographic place of residence of James Bay Cree[1]

| Fatty acids | Geometric $\bar{x}$: Coastal residents ($n$ = 592) | Geometric $\bar{x}$: Inland residents ($n$ = 325) | Geometric $\bar{x}$: Total ($n$ = 917) | 95% CI | Arithmetic $\bar{x}$ ± SD (range) |
|---|---|---|---|---|---|
| EPA (% by wt of total fatty acids) | 0.71 | 0.58[2] | 0.65 | (0.63, 0.68) | 0.86 ± 1.86 (0.09–7.35) |
| DHA (% by wt of total fatty acids) | 3.00 | 2.53[2] | 2.80 | (2.73, 2.87) | 3.02 ± 2.79 (0.71–8.20) |
| EPA+DHA (% by wt of total fatty acids) | 3.78 | 3.17[2] | 3.52 | (3.42, 3.62) | 3.88 ± 4.31 (0.88–13.77) |
| AA (% by wt of total fatty acids) | 9.30 | 8.46[2] | 8.95 | (8.82, 9.08) | 9.16 ± 4.49 (3.28–18.05) |
| EPA:AA | 0.08 | 0.07[3] | 0.07 | (0.07, 0.08) | 0.09 ± 0.16 (0.01–0.59) |
| n−3 PUFAs (% by wt of total fatty acids)[4] | 4.96 | 4.26[2] | 4.66 | (4.55, 4.78) | 5.00 ± 4.74 (1.25–15.00) |
| n−6 PUFAs (% by wt of total fatty acids)[5] | 30.40 | 31.27[2] | 30.87 | (30.70, 31.05) | 30.82 ± 6.12 (20.38–38.81) |
| n−3:n−6 PUFAs | 0.16 | 0.14[2] | 0.15 | (0.15, 0.16) | 0.17 ± 0.19 (0.06–0.66) |

[1] EPA, eicosapentaenoic acid; DHA, docosahexaenoic acid; AA, arachidonic acid; PUFA, polyunsaturated fatty acid.
[2,3] Significantly different from coastal residents (ANOVA): [2] $P$ = 0.0001, [3] $P$ = 0.02.
[4] 18:3 + 18:4 + 20:3 + 20:4 + 20:5 + 22:5 + 22:6.
[5] 18:2 + 18:3 + 20:2 + 20:3 + 20:4 + 22:2 + 22:4 + 22:5.

in the preceding 24 h. Models of standardized portions were used to define and describe amounts of food eaten by the respondents.

### Data analysis

All statistics presented in this paper were obtained from weighted data to reestablish the equiprobability of an individual's being selected for the sample and to take into account nonresponse by age, sex, and geographic stratum. To do this, each respondent was given a value (weight) corresponding to the number of persons he or she represented in the Cree population (22). All data presented in this paper are representative of the entire Cree adult population. Crude $n$ values are presented for information only.

The statistical analysis sought first to provide a description of plasma phospholipid concentrations of n−3 fatty acids. Subjects were grouped according to geographic residence (coastal or inland areas) and according to biological and lifestyle factors. The statistical distribution of plasma fatty acid concentrations was first checked and was not found to coincide with normal distributions. The distribution was skewed, and thus geometric means were used to describe fatty acid concentrations. Arithmetic means are also presented to facilitate comparisons with other surveys. Analysis of variance (ANOVA; on the logarithm of plasma fatty acids) and Scheffe's test (for variables with ≥3 categories) were used for comparisons between groups. Results are also presented as arithmetic means ± SDs and as geometric means and 95% CIs. ANOVA was used to compare arithmetic means of CVD risk factors according to age and sex. The potential interaction effect of age and sex was checked by using a two-factor ANOVA with interaction term. The association between the plasma phospholipid concentrations of n−3 fatty acids, particularly EPA and DHA, and the levels of CVD risk factors was assessed by multiple linear regression analysis. Adjustments were made for the potentially confounding effects of age, sex, waist girth, smoking, alcohol intake, and prescribed drugs for hypercholesterolemia, high BP, or diabetes. All statistical analyses were performed with the SAS software package (SAS Institute, Cary, NC) (31), and statistical significance was set at $P \leq 0.05$.

## RESULTS

The study population was composed of 422 men ($\bar{x}$ ± SD age: 36.0 ± 13.9 y) and 495 women ($\bar{x}$ ± SD age: 35.6 ± 4.1 y) aged 18–74 y. The geographic distribution of the survey subjects was such that 65% lived in the coastal communities of James Bay and Hudson Bay and 35% lived in inland villages. Twenty-one percent of the Cree population reported having eaten fish the day before the survey (data not shown). For the entire adult population, mean fish consumption was 60 g, whereas heavy fish consumers had eaten an average of 291 g fish on the day before the survey. Fish intake varied according to geographic residence: subjects from coastal communities consumed fish in higher quantities (78 g) than did those from inland communities (34 g). Fish consumption did not vary according to sex but increased significantly with age ($P$ = 0.001).

The relative concentrations of n−3 fatty acids in plasma phospholipids in the study population according to geographic place of residence are shown in **Table 1**. For the entire population, geometric means of EPA, DHA, and EPA+DHA were 0.65%, 2.80%, and 3.52%, respectively. EPA:AA, n−3:n−6 fatty acids, and relative concentrations of EPA, DHA, EPA+DHA, AA, and n−3 polyunsaturated fatty acids (PUFAs) were higher in coastal residents than in inland residents. Inversely, inland residents had significantly higher concentrations of n−6 PUFAs than did coastal residents ($P$ = 0.0001).

The relation between relative concentrations of n−3 fatty acids and potential confounding variables is shown in **Table 2**. EPA:AA, n−3:n−6 fatty acids, and concentrations of EPA, DHA, and EPA+DHA did not vary according to sex, but there was a significant increase in the concentrations with age. Subjects with greater waist girth had higher concentrations of n−3 fatty acids than did subjects with normal waist girth. Nonsmokers showed higher concentrations of n−3 fatty acids than did smokers, and subjects who consumed one or more alcoholic drinks per week had lower concentrations of n−3 fatty acids than did alcohol abstainers. Subjects using medication for problems associated with CVD (high BP, hypercholesterolemia, or diabetes) had higher EPA:AA and n-3:n-6 fatty acid values and higher concentrations of EPA, DHA, and EPA+DHA than did nonusers.

The mean values for the CVD risk factors according to age and sex are shown in **Table 3**. Except for plasma insulin, mean CVD risk factors increased significantly with age. Mean concentrations of total cholesterol and LDL were significantly higher in men than in women. Women had higher HDL concentrations and a lower ratio of total to HDL cholesterol than did men. Concentrations of

**TABLE 2**
Relative concentrations of n−3 fatty acids in plasma phospholipids according to potential confounding[1]

| Confounding variables | EPA | DHA | EPA+DHA | EPA:AA | n−3:n−6 PUFAs |
|---|---|---|---|---|---|
| | *% by wt of total fatty acids* | *% by wt of total fatty acids* | *% by wt of total fatty acids* | | |
| Sex | | | | | |
| Men ($n$ = 422) | 0.67 (0.63, 0.72) | 2.78 (2.73, 2.87) | 3.51 (3.37, 3.66) | 0.07 (0.07, 0.08) | 0.15 (0.14, 0.16) |
| Women ($n$ = 495) | 0.64 (0.60, 0.68) | 2.82 (2.67, 2.88) | 3.53 (3.40, 3.66) | 0.07 (0.07, 0.08) | 0.15 (0.15, 0.16) |
| $P$[2] | 0.32 | 0.54 | 0.89 | 0.62 | 0.60 |
| Age | | | | | |
| 18–34 y ($n$ = 536) | 0.50[a] (0.48, 0.53) | 2.40[a] (2.34, 2.48) | 2.95[a] (2.87, 3.04) | 0.06[a] (0.05, 0.06) | 0.13[a] (0.12, 0.13) |
| 35–49 y ($n$ = 220) | 0.74[b] (0.68, 0.81) | 3.03[b] (2.89, 3.17) | 3.84[b] (3.65, 4.05) | 0.08[b] (0.08, 0.09) | 0.17[b] (0.16, 0.17) |
| 50–74 y ($n$ = 161) | 1.23[c] (1.10, 1.37) | 4.01[c] (3.82, 4.21) | 5.36[c] (5.05, 5.69) | 0.12[c] (0.11, 0.13) | 0.23[c] (0.22, 0.25) |
| $P$[2] | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 |
| Waist girth | | | | | |
| Normal ($n$ = 397) | 0.52 (0.49, 0.55) | 2.45 (2.37, 2.53) | 3.02 (2.92, 3.12) | 0.06 (0.05, 0.06) | 0.13 (0.12, 0.13) |
| Elevated ($n$ = 505) | 0.80 (0.75, 0.85) | 3.10 (2.99, 3.21) | 3.98 (3.82, 4.14) | 0.09 (0.08, 0.09) | 0.17 (0.16, 0.18) |
| $P$[2] | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 |
| Smoking status | | | | | |
| Smoker ($n$ = 352) | 0.54 (0.51, 0.58) | 2.51 (2.41, 2.61) | 3.10 (2.98, 3.23) | 0.06 (0.06, 0.07) | 0.13 (0.13, 0.14) |
| Nonsmoker ($n$ = 547) | 0.74 (0.69, 0.78) | 3.01 (2.92, 3.11) | 3.83 (3.69, 3.97) | 0.08 (0.08, 0.09) | 0.17 (0.16, 0.17) |
| $P$[2] | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 |
| Alcohol intake | | | | | |
| None ($n$ = 464) | 0.76[a] (0.71, 0.82) | 3.14[a] (3.04, 3.25) | 3.99[a] (3.83, 4.14) | 0.08[a] (0.08, 0.09) | 0.17[a] (0.17, 0.18) |
| 1–19 drinks/7 d ($n$ = 116) | 0.56[b] (0.49, 0.63) | 2.57[b] (2.42, 2.73) | 3.20[b] (2.99, 3.41) | 0.06[b] (0.06, 0.07) | 0.14[b] (0.13, 0.14) |
| ≥20 drinks/7 d ($n$ = 234) | 0.54[b] (0.49, 0.58) | 2.39[b] (2.28, 2.51) | 2.98[b] (2.83, 3.14) | 0.06[b] (0.06, 0.07) | 0.13[b] (0.12, 0.13) |
| $P$[2] | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 |
| Medication for CVD risk factors | | | | | |
| Yes ($n$ = 85) | 0.98 (0.84, 1.15) | 3.62 (3.30, 3.97) | 4.69 (4.23, 5.19) | 0.11 (0.09, 0.12) | 0.21 (0.19, 0.23) |
| No ($n$ = 832) | 0.63 (0.60, 0.66) | 2.72 (2.65, 2.79) | 3.41 (3.32, 3.51) | 0.07 (0.07, 0.07) | 0.15 (0.14, 0.15) |
| $P$[2] | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 |

[1] Geometric $\bar{x}$; 95% CI in parentheses. EPA, eicosapentaenoic acid; DHA, docosahexaenoic acid; AA, arachidonic acid; CVD, cardiovascular disease; PUFA, polyunsaturated fatty acid. Means (by category) within a column with different superscript letters are significantly different, $P \leq 0.05$ (Scheffe's test).
[2] ANOVA.

triacylglycerols did not vary according to sex. Systolic and diastolic BPs were higher in men than in women. In contrast, mean concentrations of glucose and insulin were higher in women than in men. In verifying the potential interaction between age and sex on CVD risk factors, interactions were primarily explained by differences between arithmetic means for each age group, which were not constant among men and women.

The regression (β) coefficients from multiple linear regression analysis using levels of CVD risk factors as dependent variables and relative concentrations of n−3 fatty acids as predictor variables are shown in **Table 4**. n−3 Fatty acids showed positive and significant associations with total and LDL cholesterol, except for EPA:AA, which was not associated with LDL-cholesterol concentrations. EPA, DHA, and EPA+DHA concentrations and EPA:AA and n−3:n−6 PUFAs showed positive associations with HDL-cholesterol concentrations. n−3 Fatty acids were not significantly associated with the ratio of total:HDL cholesterol. EPA and EPA+DHA were inversely associated with triacylglycerol concentrations. In contrast, n−3 fatty acids were positively associated with systolic and diastolic BPs. No significant association was observed between n−3 fatty acids and plasma glucose and insulin.

Additional regression analyses were performed (data not shown) with an interaction term to check for the possibility of residual modifying effects of age and sex on the observed associations. No modification was found for total cholesterol, LDL, triacylglycerols, diastolic BP, and plasma glucose and insulin, whereas an effect of age for HDL and total:HDL cholesterol and an effect of sex for systolic BP were found. Hence, separate regression analyses were conducted by age groups for HDL and total:HDL cholesterol and by sex for systolic BP. Positive associations between n−3 fatty acids and HDL were still found among subjects in the 35–49 y and 50–74 y age groups, but not among subjects in the 18–34 y age group. There was no significant association between n−3 fatty acids and total:HDL cholesterol for subjects in the 18–34 y and 35–49 y age groups. However, for subjects in the 50–74 y age group, an inverse association was observed between EPA and EPA:AA and total:HDL cholesterol. Finally, positive associations between n−3 fatty acids and systolic BP were still found among women but not among men.

## DISCUSSION

One of the purposes of this investigation was to determine plasma phospholipid concentrations of n−3 fatty acids in a representative sample of the Cree population. Our results showed that EPA and DHA concentrations in the Cree population were lower than those in Japanese and Inuit populations but higher than those in Americans and Quebeckers overall (11, 32–35). Fish are caught and consumed year-round by the Cree population (19). Numerous reports have shown that n−3 fatty acids in phospholipids do reflect fish intake (4, 5, 36, 37). In the current study, the relation between concentrations of n−3 fatty acids and fish consumption was not examined because fish consumption data were obtained from a single 24-h dietary recall, which is rarely

**TABLE 3**
Cardiovascular disease (CVD) risk factors among James Bay Cree according to sex and age[1]

| CVD risk factors | Sex: Men ($n$ = 422) | Sex: Women ($n$ = 495) | Age: 18–34 ($n$ = 536) | Age: 35–49 ($n$ = 220) | Age: 50–74 ($n$ = 161) | ($n$ = 917) | $P^2$: Sex | $P^2$: Age | $P^2$: Sex × age |
|---|---|---|---|---|---|---|---|---|---|
| Total cholesterol (mmol/L) | 5.0 ± 0.04 | 4.7 ± 1.9 | 4.6 ± 1.9 | 5.0 ± 1.9 | 5.3 ± 2.1 | 4.8 ± 2.0 | 0.0001 | 0.0001 | 0.21 |
| LDL cholesterol (mmol/L) | 3.1 ± 2.1 | 2.7 ± 1.6 | 2.7 ± 1.7 | 3.0 ± 1.9 | 3.3 ± 2.1 | 2.9 ± 1.8 | 0.0001 | 0.0001 | 0.60 |
| HDL cholesterol (mmol/L) | 1.2 ± 0.8 | 1.3 ± 0.7 | 1.3 ± 0.7 | 1.2 ± 0.7 | 1.4 ± 0.8 | 1.3 ± 0.7 | 0.009 | 0.0004 | 0.009 |
| Total:HDL cholesterol | 4.3 ± 3.1 | 3.8 ± 2.3 | 3.9 ± 2.7 | 4.3 ± 2.8 | 4.2 ± 2.9 | 4.0 ± 2.8 | 0.0001 | 0.0001 | 0.004 |
| Triacylglycerols (mmol/L) | 1.4 ± 2.2 | 1.4 ± 1.6 | 1.3 ± 1.6 | 1.6 ± 2.5 | 1.3 ± 1.9 | 1.4 ± 1.9 | 0.90 | 0.0001 | 0.005 |
| Systolic blood pressure (mm Hg) | 123.3 ± 32.5 | 120.1 ± 41.7 | 116.5 ± 28.4 | 122.3 ± 32.2 | 137.0 ± 48.0 | 121.7 ± 37.9 | 0.0005 | 0.0001 | 0.0001 |
| Diastolic blood pressure (mm Hg) | 77.5 ± 23.3 | 74.0 ± 24.3 | 72.8 ± 22.8 | 79.8 ± 21.2 | 79.7 ± 25.1 | 75.7 ± 24.2 | 0.0001 | 0.0001 | 0.01 |
| Glucose (mmol/L) | 5.0 ± 3.5 | 5.4 ± 4.6 | 4.7 ± 2.4 | 5.7 ± 5.0 | 6.1 ± 6.0 | 5.2 ± 4.2 | 0.0001 | 0.0001 | 0.02 |
| Insulin (pmol/L) | 95.5 ± 66.0 | 123.5 ± 204.4 | 103.1 ± 197.6 | 117.5 ± 192.3 | 109.8 ± 160.4 | 107.8 ± 190.7 | 0.003 | 0.16 | 0.20 |

[1] Weighted arithmetic $\bar{x}$ ± SD.
[2] Two-factor ANOVA.

representative of an individual's regular intake (38). Nevertheless, fish intake data obtained from the 24-h dietary recall indicated that intake varied according to age group, with intake among subjects in the 50–74 y age group being twice that in the 18–24 y age group (19). These findings are consistent with our results, which showed concentrations of n−3 fatty acids in older Cree to be higher than those in younger Cree. The influence of age on fish consumption patterns among Cree observed here agrees with the results of other studies conducted among other northern native populations (39–44). Older Cree are more likely to eat traditional foods, including fish, than are younger members of the population (45).

Furthermore, our results showed that fish intake and concentrations of n−3 fatty acids were higher among coastal Cree communities than among inland communities, which reflects the greater availability and consequent intake of marine fish in these coastal areas. Studies conducted among other populations have shown similar results (11, 44, 46–51). Hirai et al (35) reported that the rates of death from both cerebrovascular accidents and IHD were significantly lower among Japanese inhabitants of fishing areas than among inhabitants of farming regions. Separate regression analyses performed among Cree living in coastal and inland villages (data not shown) showed an inverse and beneficial association between EPA and plasma triacylglycerols among coastal residents but not among those from inland villages. Moreover, among coastal residents aged ≥35 y, concentrations of EPA were inversely associated with total:HDL cholesterol, whereas no similar significant association was found among inland residents. EPA was still positively associated with HDL among coastal and inland Cree aged ≥35 y. It is not known whether the mortality rate for IHD varies between coastal and inland Cree communities. However, in 1992–1996, among the total population in the Cree region, the age-standardized mortality rate (per 100 000 person-years) for IHD was 92.8 compared with 140.2 for the province of Quebec as a whole (15). In addition, the prevalence of dyslipidemia is lower among Cree than among Quebeckers, despite the

**TABLE 4**
Regression (β) coefficients from multiple linear regression analysis with cardiovascular disease (CVD) risk factor as dependent variables and relative concentrations of fatty acids as predictor variables[1]

| CVD risk factors (dependent variables) | n−3 Fatty acid predictor variables: Log EPA | Log DHA | Log EPA+DHA | Log EPA:AA | Log n−3:n−6 PUFAs |
|---|---|---|---|---|---|
| Total cholesterol | 0.33 | 0.70 | 0.66 | 0.27 | 0.62 |
| *P* | 0.002 | 0.0004 | 0.0003 | 0.02 | 0.001 |
| LDL cholesterol | 0.26 | 0.64 | 0.55 | 0.18 | 0.54 |
| *P* | 0.01 | 0.0006 | 0.001 | 0.10 | 0.003 |
| HDL cholesterol | 0.16 | 0.20 | 0.24 | 0.13 | 0.23 |
| *P* | 0.0001 | 0.008 | 0.0004 | 0.003 | 0.001 |
| Total:HDL cholesterol | −0.23 | 0.002 | −0.24 | −0.18 | −0.27 |
| *P* | 0.12 | 0.99 | 0.34 | 0.27 | 0.31 |
| Log triacylglycerol | −0.06 | −0.07 | −0.09 | −0.02 | −0.06 |
| *P* | 0.02 | 0.15 | 0.05 | 0.49 | 0.17 |
| Log systolic blood pressure | 0.03 | 0.06 | 0.06 | 0.03 | 0.06 |
| *P* | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 |
| Log diastolic blood pressure | 0.03 | 0.07 | 0.07 | 0.04 | 0.07 |
| *P* | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 |
| Log glucose | 0.01 | 0.04 | 0.03 | −0.001 | 0.009 |
| *P* | 0.41 | 0.12 | 0.17 | 0.97 | 0.67 |
| Log insulin | 0.05 | −0.003 | 0.04 | 0.08 | 0.05 |
| *P* | 0.19 | 0.97 | 0.56 | 0.06 | 0.45 |

[1] Each model included age, sex, waist girth, smoking, alcohol intake, and prescribed drugs for CVD risk factors. $n$ = 917. EPA, eicosapentaenoic acid; DHA, docosahexaenoic acid; AA, arachidonic acid; PUFA, polyunsaturated fatty acid.

higher prevalence of obesity, cigarette smoking, diabetes, and hyperinsulinemia observed among Cree (22).

Many factors—such as genetic predisposition, lifestyle, and the amounts and types of fat in the diet—may account for the differences in mortality rates and in the prevalence of dyslipidemia between the Cree and Quebeckers (1). Several prospective studies have reported inverse relations between fish consumption and reduced risk of IHD (10, 52–59). In the current study, we observed a protective effect of n−3 fatty acids on triacylglycerols and HDL, which play an independent role in the development of IHD (60–63). Cree consume fish more frequently than do Quebeckers overall. The fish intake of the Cree was estimated to be 60 g/d, whereas the corresponding intake among all Quebeckers was 15 g/d (64). Because of their higher fish intake, the Cree population had higher plasma phospholipid concentrations of EPA+DHA than did all Quebeckers (geometric $\bar{x}$: only 1.70%) (32).

In addition to the quantity of fish consumed, the type of fish consumed and its n−3 fatty acid content must be taken into account. In a previous study, our team measured n−3 fatty acids in a variety of northern Quebec fish, such as lake whitefish, brook trout, and lake trout, that are most often eaten by the Cree population (43). The EPA+DHA content in fish varied from 200 to 1470 mg/100 g, and we found that freshwater fish as well as marine fish are good sources of these fatty acids. In contrast, Quebeckers overall consume mostly commercial fish (including lean-flesh fish such as cod and plaice) as well as some species originating from aquaculture, which may contain less n−3 fatty acids than do wild fish (32). Therefore, in support of the protective role of n−3 fatty acids against IHD, we postulate that the traditional diet of the Cree, which provides substantial daily amounts of EPA and DHA, may be related in part to the differences in death rates from IHD between the Cree and Quebeckers overall.

Our results showed positive associations for all n−3 fatty acids with diastolic BP in both sexes and with systolic BP in women. In their meta-analysis of controlled trials, Morris et al (65) reported that n−3 fatty acids had no effect on BP among subjects with normal BP. In that study, the mean systolic and diastolic BPs were 122 and 76 mm Hg, respectively, which is within normal ranges. Morris et al (65) also indicated that the hypotensive effect of n−3 fatty acids may be strongest in hypertensive subjects. It seems likely that the daily fish intake of the Cree was not high enough to show a beneficial effect of EPA+DHA on BP. In fact, most studies reporting the BP-reducing effect of n−3 fatty acids were performed with fish oil supplements (dose of n−3 fatty acids = 3 g/d) (65).

In the current study, there was no evidence of a protective effect of n−3 fatty acids on plasma glucose and insulin. According to Puhakainen et al (66), differences in the dose of n−3 fatty acids may account for differences in the effects on glycemia. As mentioned above, Cree (particularly females) tend to have elevated plasma insulin concentrations. Greenlund et al (67) also reported elevated insulin concentrations among native Americans (101.8 pmol/L for men and 120.2 pmol/L for women). It is well documented that the prevalence of type 2 diabetes among native populations, which was low before the 1940s, has been increasing in recent decades (13, 67–72). A more sedentary lifestyle, the abandonment of a purely traditional diet, an increased energy intake (especially in the form of carbohydrates), high rates of obesity, and higher genetic susceptibility may all be implicated in the emergence of type 2 diabetes among the Cree population (13, 67, 70). The fasting insulin concentration is considered to be a good indicator of insulin resistance (24, 73). High insulin concentrations and insulin resistance are associated with hypertriglyceridemia and low HDL (24, 74, 75). Our results agree with these findings (data not shown). Moreover, our data showed no modifying or confounding effect of insulin on the associations between n−3 fatty acids and triacylglycerol and HDL concentrations. Storlien et al (76) indicated that n−3 fatty acids play a beneficial role in insulin action. Several authors agree that diabetic or insulin-resistant subjects can receive substantial benefits from small amounts of n−3 fatty acids because of their lowering effect on triacylglycerols and their elevating effect on HDL (76–80). Hence, knowing the risks associated with hyperinsulinemia, we must encourage the Cree population to maintain their traditional diet, which is rich in n−3 fatty acids.

This study showed that n−3 fatty acids have beneficial effects on HDL, triacylglycerols, and total:HDL cholesterol among the Cree population of northern Quebec. In addition, plasma concentrations of n−3 fatty acids were higher among older Cree than among younger Cree, which suggests that the former consume more traditional foods, such as fish. During the past 50 y, James Bay Cree have faced major changes in their traditional lifestyle and diet. Very little information has been reported on the benefits of fish consumption. Thus, the Cree population must be encouraged to maintain or increase their consumption of traditional foods, ie, fish, which contribute importantly to the intake of n−3 fatty acids. The results of our study will allow health professionals to confidently promote the health benefits of fish consumption to the James Bay Cree.

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