THE OFFICIAL JOURNAL OF THE BRITISH DIETETIC ASSOCIATION

Journal of Human Nutrition and Dietetics

Journal of Human Nutrition and Dietetics

RESEARCH PAPER

Dietary adequacy of Inuit in the Canadian Arctic

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Keywords
nutrients, dietary adequacy, Inuit, traditional foods, 24-h recalls.

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doi:10.1111/j.1365-277X.2010.01099.x

Abstract

Background: Food intake amongst Canadian Inuit is currently in transition with a concurrent increase in diet-related chronic disease. There is a lack of current data on nutrient intake and dietary adequacy in this population. The present study aimed to assess dietary intake and adequacy amongst Inuit adults in a community in Nunavut, Canada.
Methods: Random sampling of 130 households in a remote Inuit community in the Kitikmeot region of Nunavut, Canada, was used for this cross-sectional study. Up to three 24-h dietary recalls were collected on nonconsecutive days, capturing weekday and weekend consumption. Data were analysed to estimate energy and nutrient intake, to determine dietary adequacy, and to summarise the most commonly reported foods and the top food contributors to selected nutrients.
Results: The response rate was 69%, with 75 Inuit adults participating (mean (standard deviation (SD)) age 44 (SD = 17) years). Mean (SD) daily energy intake was 9.3 (4.4) MJ and 8.7 (3.5) MJ for men and women, respectively. Intakes of dietary fibre, calcium, total folate and vitamins A, D and E were below the Dietary Reference Intakes (Estimated Average Requirements where available) for 60–100% of all men and women. Traditional foods contributed substantially to protein and iron intake, whilst shop-bought foods were primary contributors to total fat, carbohydrate and sugar intake.
Conclusions: The present study reports an in-depth assessment of total dietary quality amongst Inuit adults in Nunavut, Canada. The results obtained indicate inadequate intakes of several essential nutrients, as well as a reliance on a non-traditional diet. A nutrition intervention is needed to prevent a continued rise in diet-related chronic disease incidence.

Introduction

The traditional diet of Inuit living in Nunavut includes wild game (e.g. polar bear, muskox, and caribou), marine animals (e.g. Arctic char, trout, seal, walrus, and whale), birds (e.g. ptarmigan and geese) and seasonal wild berries (Draper, 1977; Young *et al.*, 2000). In addition to consuming the meat of the animal, Inuit traditionally consumed nutrient-rich organs, such as liver and bone marrow. In the past, this contributed to an overall healthful diet and relative lack of chronic disease (Bjerregaard *et al.*, 2004). The hunter–gatherer lifestyle of this Aboriginal population was a central component of the social, cultural and economic aspects of Inuit life (Condon *et al.*, 1995, 1998; Takano, 2005).

The past 50 years have brought enormous social change to the Canadian Arctic (Sharma, 2010a), including the development of a wage economy and the shift from hunting and gathering to grocery shopping as the primary mode of obtaining food (Kuhnlein *et al.*, 2004). Such a rapid transition away from the traditional Inuit diet may lead to an increased prevalence of nutrient deficiencies

and chronic diseases, such as cardiovascular disease, diabetes and cancer (Receveur *et al.*, 1997; Whiting & Mackenzie, 1998; Circumpolar Inuit Cancer Review Working Group *et al.*, 2008; Damman *et al.*, 2008).

Various risk factors for chronic disease, such as obesity, are increasing amongst Inuit (Bjerregaard & Young, 1998; Government of Nunavut Department of Health and Social Services, 2004; Kuhnlein *et al.*, 2004). Compared with the Canadian national average, Inuit-inhabited areas have life expectancies that are 12.6 years lower (approximately 67 years in 2001) and higher rates of several chronic diseases (Health Canada, 2007; Wilkins *et al.*, 2008), which could be associated with a decrease in dietary adequacy amongst Inuit. A similar nutrition transition is being documented in other Aboriginal populations in Canada and Alaska (Nobmann *et al.*, 1992; Kuhnlein *et al.*, 2004). However, there is currently a gap in the literature on dietary quality amongst Inuit in Nunavut. To effectively monitor the transition, it is necessary to establish comprehensive baseline nutritional data. The present study aimed to provide a summary of dietary adequacy amongst Inuit adults in one community in Nunavut, Canada, which may later be used to assess dietary change over time.

Materials and methods

Recruitment and data collection

Sampling methods and the setting for this study have been described elsewhere (Sharma, 2010a). In brief, quantitative 24-h dietary recalls were collected in one remote community in Nunavut, Canada, between July and October 2008. Nutritional decision-makers, those primarily responsible for food getting and preparation in each household, were targeted for participation as a result of their increased knowledge of food in the home and their capacity to affect positive change with regard to nutrition in the household (Anderson, 2007).

Institutional Review Board approval was obtained from the Committee on Human Studies at the University of Hawaii and the Office of Human Research Ethics at the University of North Carolina at Chapel Hill, and the Nunavut Research Institute licensed the study.

Data collection methods have been described in detail elsewhere (Sharma, 2010a). In brief, each participant was asked to complete two recalls on weekdays and one on a weekend day, yielding three 24-h recalls from nonconsecutive days. Interviewers asked systematic questions to assist participants in recalling all foods and drinks consumed in the previous 24-h period. Three-dimensional food models (NASCO, Fort Atkinson, WI, USA), packages of commonly consumed shop-bought foods, standard units (e.g. slice of bread) and local household utensils (cups, bowls and spoons) were used to assist participants in reporting the amounts of foods consumed. Most of the foods reported in the recalls were weighed by a trained field coordinator using an electronic Aquatronic Baker's Dream Scale (Salter Houseware, Tonbridge, Kent, UK). Additionally, 17 recipes for nine different traditional dishes were collected in the study community.

Statistical analysis

Dietary recalls were entered and analysed in NUTRIBASE CLINICAL NUTRITION MANAGER, version 7.17 (CyberSoft Inc., Phoenix, AZ, USA), and Canadian food composition tables were used for nutrient analysis. Recipes were created in NUTRIBASE for mixed dishes not available in the Canadian database. SAS statistical software, version 9.1 (SAS Institute Inc., Cary, NC, USA) was used to conduct descriptive analyses of the recall data.

Mean energy and nutrient intakes were calculated for each participant. One person reported energy intake >20.9 MJ (>5000 kcal). Rather than exclude the participant, whose values may have been inconsistent with a typical lifestyle, the participant was included in analyses to preserve the sample size. Within-person variation was calculated and used to adjust mean intakes. However, the results obtained did not significantly differ, and unadjusted results are therefore presented. Participants with only one 24-h recall were included in the analysis because their exclusion did not significantly change the mean nutrient intake adjusted for within-person variation, which was calculated using the participants with multiple recalls.

Daily energy and nutrient intakes were compared with the Dietary Reference Intakes (DRIs), primarily the Recommended Dietary Allowances or Adequate Intakes, for men and women aged 19–50 years (Institute of Medicine of the National Academies, 2005).

Dietary adequacy was assessed by comparison of the mean intake for each participant to the DRIs (Institute of Medicine of the National Academies, 2005). Estimated Average Requirements were used when available; Adequate Intakes were used instead for dietary fibre, vitamin D and calcium. The percentage of participants below the recommendations was calculated for specific nutrients, stratified by gender and age (19–30, 31–50, 51–70 and >70 years). Results were combined for the two younger age groups (19–30 and 31–50 years) and the two older age groups (51–70 and >70 years) for women, and all participants were combined for men as a result of the small sample size.

The most frequently reported consumed foods and the top ten foods contributing to daily intake of energy, total fat, protein, total carbohydrates, total sugar, dietary fibre,

calcium and iron were determined. The contribution of traditional foods to energy, protein, total fat, iron, calcium and vitamins A, B_6, B_{12} and D was also analysed. A traditional food was defined as one acquired through subsistence practices (e.g. hunting, fishing, gathering), such as caribou and seal.

Results

A total of 75 participants (seven men and 68 women) aged 19–89 years completed up to three 24-h recalls; seven participants completed only one recall, one participant completed only two recalls, and 67 participants completed all three days of recall. The mean (SD) age was 42 (19) and 44 (16) years for men and women, respectively. The response rate was 69%.

Nutrient intake

Mean (SD) daily energy intake was 9.3 (4.4) MJ for men and 8.7 (3.5) MJ for women (Table 1). Mean daily intakes for men and women were lower than the recommendations for dietary fibre, total folate, calcium and vitamins B_6, D and E. Mean daily vitamin A and zinc intakes were below the recommendations for men.

When comparing individual mean daily intakes of selected nutrients with the DRIs, none of the participants met the recommendations for dietary fibre or vitamin E (Table 2). Calcium and vitamins A and D were inadequately consumed by ≥60% of men and women of all ages, whilst vitamin B_6 and iron were adequately consumed by ≥70% of the participants.

Frequency of consumption of traditional versus shop-bought foods

Non-nutrient-dense, shop-bought food items were reported more frequently by participants than traditional foods (data not shown). The most frequently consumed food groups in all 24-h recalls combined were tea and coffee, reported 525 times by 92% of participants; juice (including sweetened and unsweetened juices and other non-alcoholic, non-carbonated beverages), reported 201 times by 75% of participants; and bread, which was reported 110 times by 67% of participants. These foods were followed in frequency by sugar/syrup/honey, caribou, butter/margarine/lard, sweets/desserts (including sweets, biscuits, cakes and pastries), carbonated drinks, and coffee whitener. The most common traditional foods were caribou (consumed by 64%), local fish (including Arctic char; consumed by 47%), seal (consumed by 21%) and muktuk (whale skin and fat; consumed by 17%). Fruit and vegetable consumption was relatively low, with only 68% of participants reporting any fruit or vegetable consumption during the recalled days.

Food sources of energy and selected nutrients

The top ten foods contributing to energy and selected nutrients are presented in Tables 3 and 4. The primary contributors to energy intake were juice, caribou/other game and bread, which provided approximately 25% of daily energy. Butter/margarine/lard, sausage/lunchmeat and crisps/popcorn contributed more than 29% of total fat. Juice, carbonated drinks and sugar/syrup/honey were the top three sources of total carbohydrate, contributing approximately 42% of intake. Bread, potato dishes and crisps/popcorn provided 35% of total dietary fibre intake. Juice, carbonated drinks and sugar/syrup/honey provided almost 80% of total sugar intake. Juice was the primary contributor to total energy, carbohydrate and sugar, and was the second greatest contributor to calcium intake. However, vitamins A, B_{12} and D, protein and iron were consumed primarily through traditional food sources, such as caribou, seal, wild birds and local fish (Fig. 1).

Discussion

The present study provides data on dietary quality of Inuit adults in a remote community in Nunavut, Canada, and identifies several dietary inadequacies (i.e. dietary fibre, calcium, total folate and vitamins A, C, D and E, as well as zinc amongst men). Participants reported frequent consumption of non-nutrient-dense shop-bought foods high in sugar and fat and an infrequent fruit and vegetable intake. Low fruit and vegetable intake has been found in previous studies of this and similar populations (Sharma *et al.*, 2009, 2010b).

Previous work was conducted in this population (Sharma *et al.*, 2010b). The earlier study was conducted two years previously with one 24-h recall per participant in two communities with the aim of developing a culturally appropriate quantitative food frequency questionnaire (Sharma *et al.*, 2010b). The present study is an in-depth analysis of dietary adequacy in one of the communities using a series of up to three recalls per participant. Between the two studies, intakes of dietary fibre, percentages of energy from macronutrients, and energy (amongst men) were similar. The top three contributors to energy were the same, as were the top five most commonly reported foods, although they ranked in a different order. However, the present study found that up to 13% and 36% of women did not meet the DRIs for iron and zinc, respectively, compared with the previous report of up to 35% and 83%, respectively. The use of multiple dietary recalls per participant allows for a more complete assessment of dietary

Table 1 Daily energy and nutrient intake amongst Inuit adults in Nunavut, Canada*

	Men (n = 7)			Women (n = 68)		
	Mean (SD)	Median (IQR)	Dietary reference intake	Mean (SD)	Median (IQR)	Dietary reference intake
Energy (MJ)	9.3 (4.4)	8.9 (7.2)	9.2†	8.7 (3.5)	8.2 (8.2)	7.5†
% of energy from fat	31.8 (9.7)	32.3 (17.6)	20–35‡	29.8 (6.4)	29.5 (7.6)	20–35‡
% of energy from carbohydrates	52.9 (13.6)	52.9 (30.5)	45–65‡	47.8 (12.5)	48.3 (16.4)	45–65‡
% of energy from protein	15.3 (6.9)	16.0 (7.7)	10–35‡	22.2 (10.3)	20.3 (15.8)	10–35‡
Total fat (g)	80.2 (49.2)	82.1 (58.2)	–	68.6 (30.7)	65.8 (36.3)	–
Saturated fat (g)	25.7 (16.8)	23.7 (12.1)	<10% of energy*	21.7 (11.7)	19.7 (14.0)	<10% of energy*
Protein (g)	74.3 (34.4)	64.9 (55.1)	–	106.1 (56.6)	90.3 (63.4)	–
Carbohydrate (g)	305.8 (178.9)	313.8 (111.5)	–	255.9 (150.6)	216.1 (215.7)	–
Total sugars (g)	145.4 (103.5)	128.3 (65.6)	<25% of energy*	131.9 (101.3)	108.6 (134.2)	<25% of energy*
Dietary fibre (g)	8.9 (5.7)	8.6 (8.4)	38§	7.9 (4.1)	7.9 (5.6)	25§
Monounsaturated fat (g)	26.3 (17.0)	28.8 (27.7)	–	22.7 (12.0)	20.1 (14.9)	–
Polyunsaturated fat (g)	11.4 (8.3)	12.4 (15.7)	–	9.2 (4.9)	8.2 (5.1)	–
Omega-3 fatty acid (g)	0.6 (0.4)	0.6 (0.7)	–	1.3 (1.5)	0.8 (1.5)	–
Omega-6 fatty acid (g)	4.7 (3.4)	4.4 (7.0)	–	4.2 (3.0)	3.5 (3.2)	–
Cholesterol (mg)	248.8 (176.5)	180.4 (110.0)	As low as possible	261.4 (235.2)	186.3 (190.8)	As low as possible
Vitamin A (μg-RAE¶)	390.1 (445.6)	302.7 (374.9)	900**	887.9 (2554.0)	345.9 (480.9)	700**
Thiamin (mg)	1.5 (0.8)	1.6 (1.6)	1.2**	1.5 (0.9)	1.3 (0.7)	1.1**
Riboflavin (mg)	2.5 (1.5)	2.7 (2.1)	1.3**	2.4 (1.4)	2.2 (1.4)	1.1**
Niacin (mg)	22.9 (14.4)	21.2 (22.6)	16**	23.6 (13.0)	21.2 (13.0)	14**
Vitamin B_6 (mg)	1.2 (0.8)	1.1 (1.2)	1.3**	1.1 (0.6)	1.0 (0.9)	1.3**
Vitamin B_{12} (μg)	3.9 (2.1)	4.7 (4.1)	2.4**	7.4 (9.3)	4.4 (7.4)	2.4**
Vitamin C (mg)	226.7 (412.3)	40.5 (259.7)	90**	173.7 (187.9)	87.4 (230.5)	75**
Vitamin D (IU)††	76.0 (73.7)	76.9 (116.1)	200§	125.8 (229.8)	43.3 (121.9)	200§
Vitamin E (mg)‡‡	2.1 (1.6)	1.5 (2.2)	15**	1.8 (1.5)	1.4 (1.5)	15**
Total folate (μg-DFE§§)	336.7 (243.6)	342.6 (416.9)	400**	232.1 (137.1)	209.7 (144.0)	400**
Calcium (mg)	993.4 (1453.9)	583.3 (338.5)	1000§	699.5 (430.9)	606.8 (537.2)	1000§
Iron (mg)	14.0 (7.0)	12.7 (13.0)	8**	21.3 (13.6)	16.8 (15.2)	18**
Zinc (mg)	8.6 (4.4)	6.6 (8.3)	11**	12.9 (9.5)	9.8 (9.4)	8**

*The Dietary Reference Intakes are presented in this table using Adequate Intake, Recommended Dietary Allowance, Acceptable Macronutrient Distribution Ranges and recommendation on sugar and saturated fat intake for men and women aged 19–50 years (Joint WHO/FAO Expert Consultation, 2003; Institute of Medicine of the National Academies, 2005).

†Estimated energy required to maintain energy balance for men and women 31–50 years at the very low physical activity-sedentary level; 1 MJ = 238.8 kcal.

‡Acceptable Macronutrient Distribution Ranges.

§Adequate Intake.

¶RAE, retinol activity equivalents.

**Recommended Dietary Allowance.

††As cholecalciferol in the absence of adequate exposure to sunlight.

‡‡As α-tocopherol.

§§DFE, dietary folate equivalent.

SD, standard deviation; IQR, interquartile range.

adequacy over time, and may account for the slight differences in results between this and the previous study. In addition, the studies were conducted at different times of year (spring versus summer/autumn), which may capture different periods of traditional food availability and may therefore account for the slight differences.

The shift away from nutrient-dense traditional foods has had a large impact on the dietary adequacy of Inuit in the Arctic, as well as other Northern Aboriginal populations. Juice, added sugar and shop-bought, high-fat foods were major contributors to dietary intake in the present study. Although the traditional Inuit diet is relatively high in fat from animal sources, such as muktuk (whale fat and skin) and seal oil, the predominant foods contributing to total fat intake were shop-bought, including butter/margarine/lard and crisps/popcorn. Sources of fat in the current diet is an issue of concern because processed foods often contain trans fatty acids

and are poor sources of the nutrients that accompany traditional fat sources, such as vitamins A and D (Kuhnlein *et al.*, 2006). Traditional foods were found to be important contributors to protein, iron and vitamins B_{12}, A and D, although vitamins A and D were consumed below recommended levels by most participants. Nutrient deficiencies of calcium and vitamins A and D have been observed amongst Native American women (Lebrun *et al.*, 1993), as well as in similar Arctic populations in Canada (Blanchet *et al.*, 2000; Sharma *et al.*, 2009).

Table 2 Dietary adequacy among Inuit adults in Nunavut (% below the Dietary Reference Intakes by age group)*

	Men† (*n* = 7)	Women (*n* = 68)	
	≥19 year	19–50 year (*n* = 45)	>50 year (*n* = 23)
Dietary fibre (g)‡	100	100	100
Calcium (mg)‡	86	76	96
Total folate (μg-DFE§)¶	43	78	78
Vitamin A (μg-RAE**)¶	86	60	78
Vitamin B_6 (mg)¶	0	11	30
Vitamin C (mg)¶	71	27	52
Vitamin D (IU)‡,††	86	91	91
Vitamin E (mg)‡‡	100	100	100
Iron (mg)¶	14	13	0
Zinc (mg)¶	71	36	17

*Institute of Medicine of the National Academies, 2005; Joint WHO/FAO Expert Consultation, 2003.
†Men were not presented by age group because only one participant was older than 50 years.
‡Adequate Intake used for comparison.
§DFE, dietary folate equivalents.
¶Estimated Average Requirement used for comparison.
**RAE, retinol activity equivalents.
††As cholecalciferol in the absence of adequate exposure to sunlight.
‡‡As α-tocopherol.

The nutrients most inadequately consumed in this community, including dietary fibre, calcium, total folate and vitamins A, C, D and E, were likely consumed in adequate amounts in the traditional Inuit diet (Nobmann *et al.*, 1992; Receveur *et al.*, 1997; Blanchet *et al.*, 2000; Kuhnlein *et al.*, 2004, 2006). Inadequacies of these nutrients may lead to increased risk for both chronic diseases, such as cancer (Fairfield & Fletcher, 2002), and infectious diseases as a result of depressed immune function (Chandra, 1996; Scrimshaw & SanGiovanni, 1997). Additionally, fruit and vegetable consumption was low in the study population. Although not a prominent part of the traditional Inuit diet, fruit and vegetables may be protective against chronic disease development (Hall *et al.*, 2009). Chronic disease prevalence is likely to continue to increase if dietary adequacy continues to decline in this population. In addition to the burden of disease decreasing both years and quality of life for individuals, the added costs to the Canadian health care system and the income lost through decreased years of productivity will be detrimental to the communities' economies.

Table 3 The ten major food sources of energy and selected nutrients amongst Inuit adults in Nunavut, Canada

Foods	% Contribution to energy	Foods	% Contribution to total fat	Foods	% Contribution to protein	Foods	% Contribution to carbohydrates
Juice	12.3	Butter/margarine/lard	12.5	Caribou/other game*	25.4	Juice	24.3
Caribou/other game*	7.8	Sausage/lunchmeat	9.5	Arctic char*	13.0	Carbonated drinks	9.2
Bread	5.3	Crisps/popcorn	7.5	Other fish†	9.0	Sugar/syrup/honey	8.7
Rice/pasta	5.2	Caribou/other game*	5.6	Seal*	7.4	Bread	7.9
Arctic char*	4.8	Sweets/desserts‡	5.5	Beef	5.4	Rice/pasta	6.6
Bannock	4.7	Arctic char*	5.1	Muktuk*,§	5.2	Sweets/desserts‡	5.9
Sweets/desserts‡	4.6	Beef	5.1	Rice/pasta	3.8	Bannock	5.3
Carbonated drinks	4.2	Bread	4.4	Chicken	3.8	Nontraditional soup¶	4.1
Crisps/popcorn	4.2	Bannock	4.3	Sausage/lunchmeat	3.6	Crisps/popcorn	3.5
Sugar/syrup/honey	4.1	Nontraditional soup¶	4.2	Bread	3.3	Crackers	3.5
Total	57.2	Total	63.7	Total	79.9	Total	79.0

*Denotes traditional food item.
†All fish excluding Arctic char.
‡Including sweets, biscuits, cake and pastries.
§Whale skin and fat.
¶All soups and stews excluding those made with caribou or Arctic char.

Table 4 The ten major food sources of selected nutrients amongst Inuit adults in Nunavut, Canada

Foods	% Contribution to total sugar	Foods	% Contribution to dietary fibre	Foods	% Contribution to calcium	Foods	% Contribution to iron
Juice	43.7	Bread	14.9	Bannock	28.3	Seal*	26.0
Carbonated drinks	18.5	Potato	10.3	Juice	26.4	Caribou/other game*	24.0
Sugar/syrup/honey	17.0	Crisps/popcorn	9.5	Bread	6.6	Bread	6.3
Sweets/desserts†	6.1	Vegetables‡	8.6	Cheese	4.1	Bannock	5.5
Fruit	2.6	Rice/pasta	8.2	Rice/pasta	3.9	Cereal	5.2
Cereals	2.1	Cereals	7.6	Milk§	3.2	Nontraditional soup¶	3.5
Bread	1.9	Bannock	6.7	Pizza	2.9	Rice/pasta	3.2
Rice/pasta	1.2	Fruit	5.8	Sweets/desserts†	2.3	Beef	2.8
Yoghurt	0.9	Nontraditional soup¶	5.5	Cereal	2.1	Other fish**	2.7
Sauces	0.8	Pizza	4.8	Other fish**	2.6	Crackers	2.7
Total	94.8	Total	81.9	Total	82.4	Total	81.9

*Denotes traditional food item.
†Including sweets, biscuits, cake and pastries.
‡All vegetables excluding potatoes.
§Fluid milk excluding evaporated and condensed.
¶All soups and stews excluding those made with caribou or Arctic char.
**All fish excluding Arctic char.

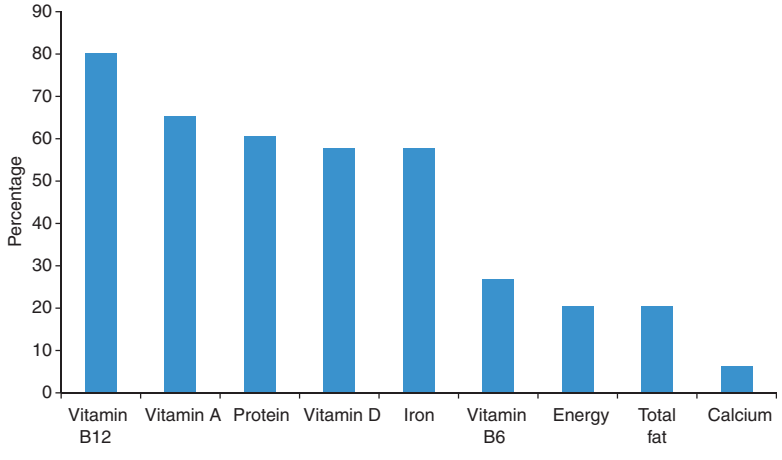

Figure 1 Percentage contribution of traditional foods to daily energy and selected nutrient intakes amongst Inuit adults. Traditional foods are defined as those obtained through subsistence practices, such as hunting and fishing.

Limitations of the present study included an extremely small representation of men. This limited the ability to generalise the results to other Inuit men. However, the present study targeted the nutritional decision-maker, or person primarily responsible for getting and preparing food in each household, most of whom are women. The study was conducted in one community; therefore, the results cannot be generalised to Inuit populations in other communities. The refusal rate was 31%, potentially leading to nonresponse bias. In addition, the study only captured summer and autumn consumption, thereby failing to account for all seasonality inherent in the Inuit diet.

The present study provides the first comprehensive assessment of dietary quality amongst Inuit adults in Nunavut, Canada. Dietary fibre, calcium, folate and vitamins A, D and E were consumed inadequately by 60–100% of all men and women, although most participants consumed iron and vitamins B_6 and B_{12} at recommended levels. Traditional foods contributed substantially to protein and iron intake, whilst non-nutrient-dense shop-bought foods were primary contributors to total fat, carbohydrate and sugar intake. These data are particularly important as a basis for tracking the rapid nutrition transition currently underway in this population at high risk for chronic disease development.

Conflict of interests, sources of funding and authorship

The authors declare they have no conflicts of interest. The project was supported by American Diabetes Association Clinical Research award 1-08-CR-57, the Government of Nunavut Department of Health and Social Services, and Health Canada. SS developed the conception and design of the study. CR oversaw all field activities. BNH and EE contributed to data analysis, and EM was responsible for data collection. All authors were responsible for data interpretation. BNH drafted the manuscript, and all authors critically reviewed its content and have approved the final version submitted for publication.

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